ARUP

Victorian Planning Authority

Ballarat North PSP IWM & Drainage Assessment

Ballarat North PSP IWM Plan

Reference: Issue

Rev 03 | 2 July 2024

Burrumbeet Creek and Lake Burrumbeet

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Job number 296790-00

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Acknowledgement of Country

Arup acknowledges the Traditional Owners of the land on which we work, live and play. We pay our respects to Elders past and present and hold deep respect for the wisdom and diversity of the Wadawurrung people of the Kulin Nation. We extend gratitude to the Wadawurrung Traditional Owners Aboriginal Corporation for their contribution to this project.

ARUP

Contents

Tables

Figures

Appendices

Abbreviations

Abbreviation	Definition
AEP	Above Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
BPEM	Best Practice Environmental Management
CHMP	Cultural Heritage Management Plan
CHW	Central Highlands Water
CoB	City of Ballarat
DEECA	Department of Energy, Environment, and Climate Action
ESO	Environmental Significance Overlay
EVC	Ecological Vegetation Classes
FI	Fraction Impervious
GHCMA	Glenelg Hopkins Catchment Management Authority
GIA	Growth Investigation Area
GMA	Groundwater Management Area
GP	Gross Pollutants
IWM	Integrated Water Management
kL	Kilo litre
LSIO	Land Subject to Inundation
mAHD	Metres relative to the Australian Height Datum
PSP	Precinct Structure Plan
RWH	Rainwater Harvesting
SDS	Strategic Directions Statement
TDS	Total Dissolved Solids
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
VPA	Victorian Planning Authority
VPP	Victorian Planning Provision
WSUD	Water Sensitive Urban Design
WTOAC	Wadawurrung Traditional Owners Aboriginal Corporation
WWTP	Wastewater treatment plant

Executive Summary

"…Water that exists on Wadawurrung Country, must stay on Country as it is part of the holistic wellbeing of that landscape. It supports all aspects of life, from the deep water and the life within, to the banks with the river red gums, to the grass lands and bushland surrounding, the canopies and the birds that live above right through to the sky country that feeds the water back into the landscape"

Wadawurrung Traditional Owners Aboriginal Corporation, 2023

This report sets out the process that Arup undertook to carry out an integrated water management (IWM) and drainage assessment for Ballarat North PSP. A base case scenario was created, to understand the impact of interventions if no Integrated Water Management (IWM) approach is taken, and then plausible future scenarios for the precinct are proposed, where a plethora of IWM interventions are put forward.

The study area is an 832ha proposed residential development located eight kilometres from the Ballarat CBD. The 'core area' of the Ballarat North Precinct Structure Plan (PSP) area has been rezoned to Urban Growth Zone (UGZ). Through the PSP process, the VPA will also determine whether all or a portion of the 'expanded area' will be included in the final PSP. The extent of the 'expanded area' (if any) that may be included in the PSP will be guided by the suite of background work that is being undertaken for this project. That extent will also be rezoned to UGZ at the end of the PSP process.

Central to Arup's approach was stakeholder engagement with the VPA, Glenelg Hopkins Catchment Management Authority, DEECA, Central Highlands Water and the City of Ballarat, alongside consideration of Wadawurrung Traditional Owners Aboriginal Corporation's (WTOAC) IWM Statement (Appendix F). Through this collaborative approach, Arup propose that Ballarat North PSP pushes boundaries to become a water sensitive, water efficient, and an ecologically regenerative precinct. To do so, it is proposed that the following interventions (portfolio 4) are implemented:

Preferred portfolio of options	**Base case (no IWM approach is taken)**	Combined retarding basins and wetland to meet BPEM target and to control post development 1% AEP flows
		Stabilisation of Burrumbeet Creek
	Recommended IWM interventions	Recycled water to homes
		Precinct scale stormwater harvesting for open space irrigation
		Blue-green corridors in PSP
		Provide ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek

The preferred suite of IWM solution requires further exploration from Central Highlands Water (CHW), and City of Ballarat (CoB) to confirm feasibility. In the event, that CHW do not propose a recycled water network to serve the precinct, or if it is not viable to introduce the proposed blue-green corridors, then an **alternative, adaptive plan portfolio** of solutions is recommended which replaces recycled water for rainwater tanks and replaces blue-green corridors with raingardens and bioretention systems / passively irrigated trees:

Alternative portfolio of options	**Base case (no IWM approach is taken)**	Combined retarding basins and wetland to meet BPEM target and to control post development 1% AEP flows
		Stabilisation of Burrumbeet Creek
	Recommended IWM Interventions	Precinct scale stormwater harvesting for open space irrigation
		Provide ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek
		2kL rainwater tanks in homes
		Household raingardens
		Bioretention systems or passively irrigated trees in the streetscape

Base case	Preferred portfolio (4)	Adaptive plan
• Combined retarding basins and wetland to meet BPEM target and to control post development 1% AEP flows • Stabilisation of Burrumbeet Creek	• Base case plus: • Recycled water to homes • Precinct scale stormwater harvesting for open space irrigation • Blue-green corridors in PSP • Provide ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek	• Base case, precinct scale stormwater harvesting for open spaces, providing ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek, PLUS : • **2kL rainwater tanks in homes** • **Household raingardens** • **Bioretention systems or passively irrigated trees in the streetscape**

In order to implement the above, the following recommendations have been put forward.

Theme	Recommendation	Lead responsibility
Flood study	It's acknowledged that GHCMA have concerns regarding the limitations of the current assumptions being made on the flood extent, based on the 2013 flood investigation study. CoB council and the CMA are considering updating this data. For this PSP, it's recommended to undertake additional analysis on flood risk within the site to ensure the flood overlay being used for planning is appropriate and that land use allocations are made accordingly.	VPA in collaboration with GHCMA
Review Water demands and undertake business case	CHW to undertake water demand assessment to feed into the business case for recycled water at the PSP. Undertake a business case to justify investment in recycled water to service Ballarat North PSP	CHW
Continued engagement with WTOAC	VPA, alongside council and Central Highlands Water, should continue to liaise with the WTOAC as the PSP progresses.	VPA, CoB, CHW in collaboration with WTOAC
Vegetation and geomorphology assessment	Undertake a vegetation and geomorphology assessment of Burrumbeet Creek to better understand vegetation and erosion conditions, which will support the preferred IWM interventions and outcomes. Recommendations from this can be used to support plans for ecological remediation which can be taken forward by developers, CoB and GHCMA.	VPA, GHCMA, CoB
Land use	If CoB are in support of blue-green corridors in the PSP, VPA to investigate integrating key green-blue corridors in land use plan and integrate with street and movement network. As this IWM Plan was developed using a high level land use budget for the PSP, it is recommended to refer to Risk and Opportunity Mapping (Water Tech & E2 Design, 2016) for conceptualising assets (such as wetlands and retarding basins) within proximity to active open spaces.	VPA, CoB
Council adoption and maintenance	Before the PSP is finalised, Council should consider their intention to adopt options proposed by this study and inform VPA if they intend to include relevant options in the PSP (blue-green corridor and any streetscape solutions).	CoB Council

The IWM options, portfolios and recommendations in this study have been pulled together using stakeholder participation, as well as the IWM Statement provided by Wadawurrung Traditional Owners Aboriginal Corporation. The portfolios were included for assessment purposes in order to drive a way forward for IWM for this PSP. The VPA supports interventions that can deliver IWM objectives and community benefits, however VPA has no influence once the PSP is developed.

This assessment is conceptual in nature to provide high level direction on IWM options for Ballarat North PSP. It is up to the stakeholders to confirm the final suite of options that is suitable and feasible for the precinct. An adaptive plan is included to assist stakeholders in subsequent IWM planning in the post PSP phase.

1. Introduction and Project Context

Arup was engaged by the Victorian Planning Authority (VPA) to assess Integrated Water Management (IWM) and drainage opportunities for the Ballarat North Precinct Structure Plan (PSP). Ballarat North PSP is intended for mainly residential development.

This report summarises the IWM and drainage opportunities for Ballarat North IWM and recommends a portfolio of IWM solutions for this PSP. The objective of this IWM assessment is to provide concept-level guidance to the VPA and stakeholder which can be incorporated into the development of the PSP.

1.1 What is Integrated Water Management?

IWM recognises the interconnected nature of the water cycle, seeking to manage water across the whole water cycle in a coordinated manner and improve its interactions with the built and natural environment. Traditionally three 'areas' of the water cycle have been managed separately: water supply, wastewater, and stormwater. Roles and responsibilities have similarly focused on the different areas of water management.

Integrated water management recognises the interrelationships between different sources of water, and views water cycle management within a specific environmental, social, cultural and economic context – recognising the needs of local catchments and waterways, communities and industries (Figure 1-1).

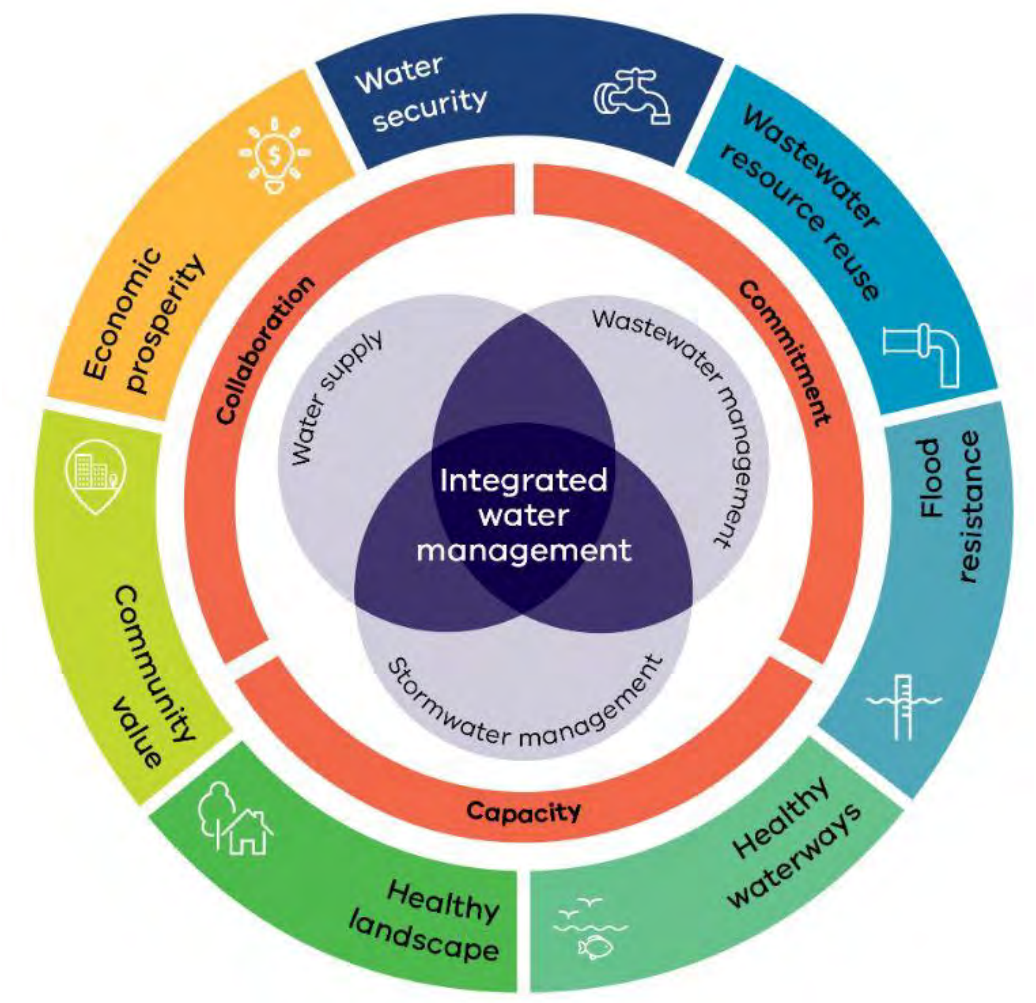
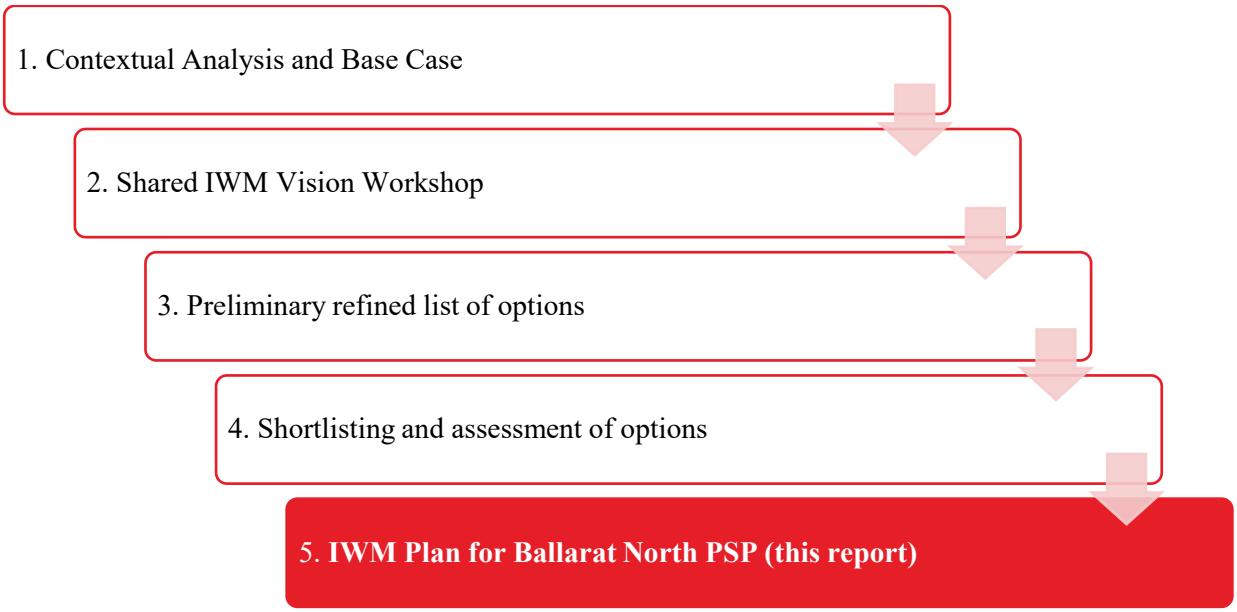


Figure 1-1 Integrated Water Management Cycle

1.2 Methodology

This report is the final output of the IWM and drainage assessment study. The 5- step methodology undertaken for this project is shown below.



Part A of this report provides the Contextual Analysis and Base Case Report.

Part B summarises the context and outputs of the Shared IWM Workshop which was held to understand the desired outcomes for this PSP and propose IWM solutions. This section also lists the IWM solutions identified.

Section 8 discusses the assessment criteria used to assess the options and summarises the results of the analysis.

Section 9 proposes potential portfolios of IWM solutions for Ballarat North PSP.

Finally, Section 10 concludes this assessment with recommendations and a way forward.

1.3 Project Area

Ballarat North PSP is located within the City of Ballarat on the northern boundary of the existing urban extent of Ballarat and south of the locality of Miners Rest as shown in Figure 1-2. The PSP area is predominantly surrounded by farming area, residential area and schools. Ballarat Airport is located approximately 5km southwest of the PSP boundary.

The total site area is approximately 832 ha with a 'Core Area' of 567 ha and an 'Expanded Area' of 265 ha. The Core Area of the precinct was reviewed in Council's 2018 Long-Term Growth Options Investigation paper and the Expanded Area was subsequently identified following community consultation.

The 'Core Area' was identified by Ballarat City Council as the preferred next residential growth area and has been the subject of appropriate strategic technical assessments and engagement with landowners and relevant agencies over several years by Council.

Through the PSP process, the VPA will also determine whether all or a portion of the 'Expanded Area' will be included in the final PSP. The extent of the 'Expanded Area' that will be included in the PSP will be guided by the suite of background work that is being undertaken for this project. Both areas have been included in this assessment.

Some of the key features of the site include Ballarat Town Common, Mount Rowan, Ballarat Grammar Mount Rowan campus, Miners Rest wetland and former Wendouree tip site. Burrumbeet Creek enters the site from the southeast corner, and flows downstream towards the northwest of the PSP boundary. Macarthur Park wetlands is located just west of the PSP boundary and Ballarat North wastewater treatment plant

(WWTP), owned by Central Highland Water (CHW) is located south of the PSP boundary along Gillies Road.

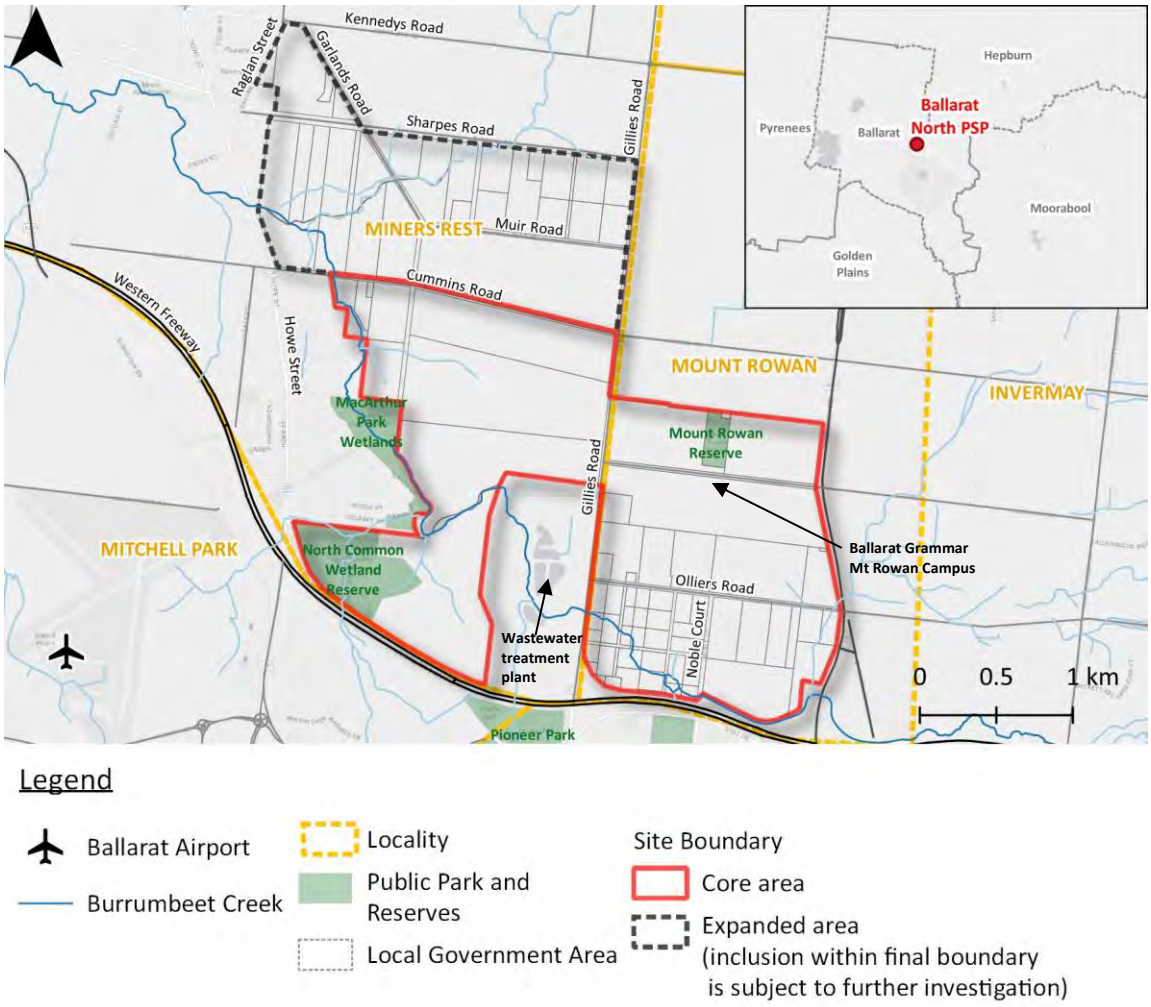


Figure 1-2 Ballarat North PSP site overview

1.4 Key Stakeholders

The key stakeholders for IWM in Ballarat North PSP are summarised in Table 1-1. It is important to note that although the water cycle is interconnected, and an IWM approach recognises the interrelationships between different sources of water, there are various organisations involved who each hold differing responsibilities.

Table 1-1 Key Stakeholders for Ballarat North PSP

Stakeholder	Responsibility	Relevance
Victorian Planning Authority (VPA)	Responsible for development of the precinct structure plan. Undertake strategic planning and coordinated infrastructure.	The VPA will deliver a precinct structure plan for Ballarat North, of which an IWM Plan will feed into.
Glenelg Hopkins Catchment Management Authority (GHCMA)	Responsible for managing land and natural water resources in the northern area of Ballarat. Management and strategies for river health, floodplain management and environmental flows.	GHCMA is the responsible authority for floodplain and river health management. Burrumbeet Creek flows through the PSP and the land surrounding the creek within the PSP is partially in a flood plain.
Central Highlands Water (CHW)	Provides water supply and wastewater services to urban and commercial customers. Manages water and wastewater related infrastructure.	CHW is the responsible authority for supply for water, recycled water provision and sewerage for the Ballarat North PSP area and is a key stakeholder for this study.

Stakeholder	Responsibility	Relevance
City of Ballarat (Council)	Local government responsible for drainage assets, open space, community facilities and streets.	Council sets a vision for the municipality and will implement the PSP, managing drainage assets, open spaces and streets.
Wadawurrung Traditional Owners Aboriginal Corporation (WTOAC)	Wadawurrung people are the traditional owners of the land where Ballarat North PSP is located.	The WTOAC have input into the cultural heritage within the site and parameters for development within the growth area. They also have a spiritual relationship with waterways and have provided an IWM statement as part of this study.
Department of Environment, Energy, and Climate Action (DEECA)	Responsible for defining standards for groundwater, catchments and waterways, as well as various matters related to environment, energy, and climate change.	DEECA oversee the various water corporations in Victoria and work closely with the Central Highlands IWM Forum to prioritise IWM initiatives in the area.

Part A: Contextual Analysis and Base Case

This section outlines the key policies, guidelines and strategies that drive IWM and will ultimately inform potential IWM solutions for Ballarat North PSP.

2. Overarching IWM Strategies and frameworks

2.1.1 Water for Victoria (DEECA, 2016)

Water for Victoria (Victorian State Government, 2016) is a "framework to guide smart water management, bolster the water grid and support more liveable Victorian communities". Water for Victoria identified eight themes and associated actions to implement the policy. One of those themes is "resilient and liveable towns and cities" and State Government provided a commitment to:

- "Adopt integrated water planning across Victoria, with place-based planning supporting community values and local opportunities", and
- "Put integrated water management into practice, working with water corporations to develop a common economic evaluation framework, promoting exemplar projects, building the capacity of the water sector and local government to participate, and continuing research to improve urban water management."

The State Government released a document titled Integrated Water Management Framework for Victoria which supports the establishment of IWM Forums in each region to drive coordinated delivery of IWM. The Central Highlands IWM Forum developed a Strategic Directions Statement (SDS) that includes IWM opportunities relevant to Ballarat North, which is discussed below.

2.1.2 Central Highlands Strategic Direction Statement (Central Highlands IWM Forum, 2022)

The Central Highlands SDS defines a vision for IWM in the area, and defines seven strategic outcomes for IWM:

Outcomes						
Safe, secure and affordable supplies in an uncertain future	**Effective and affordable wastewater systems**	**Avoided or minimised existing and future flood risks**	**Healthy and valued waterways, wetlands and water bodies**	**Healthy and valued landscapes**	**Community values reflected in place-based planning**	**Jobs, economic benefits and innovation**
Objectives						
A diverse range of water supplies and resources which are fit for purpose	Meets public health and environmental standards	Communities and properties that are resilient to local flood risk	Improved water quality	Active and passive recreation supported by water	Diverse landscapes that reflect local conditions and community values	Jobs and local economies, including industry, tourism and agriculture, supported by water
Water quality meets regulatory standards and community expectations	Efficient and effective wastewater systems with servicing needs aligned with future town and land use planning	Appropriate levels of flood protection and mitigation including adaptation for climate change	Improved stream flow patterns	Improved connectivity and access for active transport links	Traditional owner values, needs and aspirations associated with water protected, enhanced and reintroduced	Strong governance and collaboration models that evolve to deliver innovative solutions
Efficiently and effectively manage water usage and demand	Waste-to-resource opportunities are maximised	Proactive planning to prepare for and manage flood risk	Improved biodiversity and amenity of riparian corridors and edges	Urban landscapes retain moisture for cooler, greener cities and towns	Water sensitive communities that are empowered and engaged	
Secure and adaptable water supply portfolios					Local water related risks and issues are understood and managed by community	

SDS also outlines a progress snapshot and project overview of the Central Highlands IWM Forum. This SDS calls out a list of IWM opportunities which are currently underway, those relevant to this project include:

- Opportunity 1: Support for Wadawurrung and Djaara Care-for-Country Opportunities
- Opportunity 2: Enhancing flows to the Moorabool and Leigh Rivers
- Opportunity 11: Expanding Ballarat's Diverse Water Network
- Opportunity 13: Recycled Water for a Green Victoria Park
- Opportunity 15: Miners Rest Flood Mitigation

2.1.3 Ballarat City Integrated Water Management Plan (City of Ballarat, 2018)

The Ballarat City IWM Plan was developed by the City of Ballarat (CoB), Corangamite Catchment Management Authority (CCMA) and Central Highlands Water (CHW) with the support of the Department of Environment, Land, Water and Planning (DELWP). Key IWM themes and objectives are outlined in Figure 2-1.

Figure 2-1 Ballarat City key IWM themes and objectives

The Plan outlines IWM actions relevant to Ballarat North for different time horizons, short, medium and long. The key actions relevant to this PSP include;

- Incorporate the Ballarat City IWM Plan as a reference document within the Ballarat Planning Scheme.
- Utilise preferred IWM strategies (such as stormwater harvesting, recycled water and rainwater tanks) to drive water-wise development in designated areas.
- Design stormwater drainage to water street trees in new developments.
- Harvest stormwater for open space irrigation.
- Restore and plan to protect creeks in new development areas.
- Investigate partnerships for water-wise developments.
- Develop programs to monitor local stormwater yields and water quality.
- Actively explore agricultural recycled water use opportunities.
- Provide input to and influence regional and state-wide water strategies.
- Undertake further investigations into options that are capable of reducing large volumes of runoff and discharge to waterways, such as managed aquifer recharge schemes.

The preferred IWM strategy for the Northern Greenfield Investigation Area (NGIA), of which the Ballarat North PSP lies, was for a non-potable water supply network fed by recycled water from the Ballarat North Wastewater Treatment Plant. Refer to Figure 2-2.

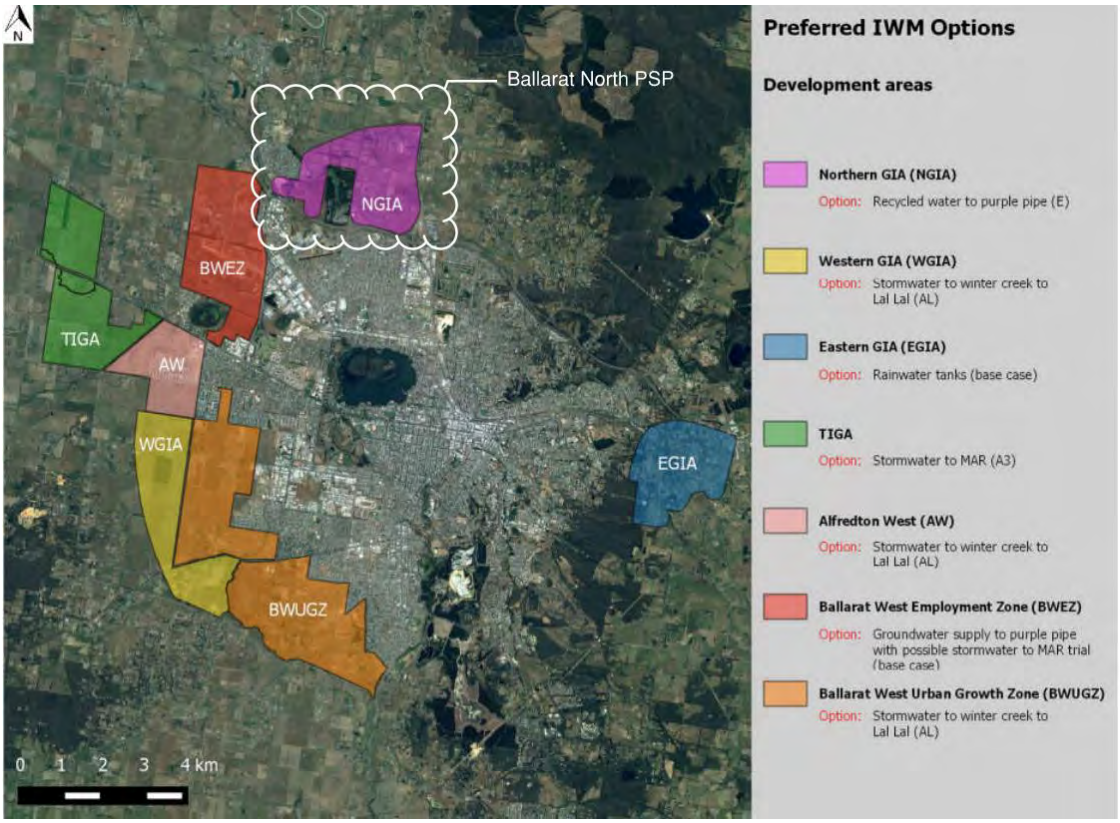


Figure 2-2 Preferred IWM Options in the Ballarat City IWM Plan

2.1.4 Ballarat Strategy: Our Vision for 2040 (City of Ballarat, 2015)

The Ballarat Strategy outlines the vision to achieve a greener, more vibrant and connected Ballarat by 2040. The Strategy outlines the two main platforms for change for Ballarat, the '10 minute city' and 'City in the Landscape' as well as policies and actions under key themes, all of which are relevant to IWM. Specific key policy directions and initiatives include:

- Plant more trees and work with the community to more than double Ballarat's canopy coverage to 40%.
- Support the management and rehabilitation of a network of Living Corridors across Ballarat, to properly manage natural values in urban and township areas.
- Collaborate with the State Government and key regional stakeholders to pursue consistent and improved management of water resources.
- Reduce Councils' annual per capita potable water consumption to 40% below 1999/2000 (pre drought) level.
- Encourage water efficiency and whole-of-cycle-water-management to be integral parts of future developments and public realm improvements.
- Manage stormwater as part of a renewed focus on green infrastructure.
- Manage development in flood prone areas in a best practice and proactive manner.
- Collaborate with the State Government and other key partners to deal with climate change and uncertainty.
- Continue to embed sustainability as a core tenant of everyday decision-making, to support a more sustainable future for Ballarat.

2.1.5 Ballarat Long Term Growth Options Investigation: Northern Growth Investigation Areas (GIA) (City of Ballarat, 2018)

This investigation includes details of planning, environmental and heritage significance overlays, as well as information about landscapes, assets and planning for the GIA. Overlays and information relevant to the Ballarat North site apply, particularly concentrated around Mount Rowan, Burrumbeet Creek and the Ballarat North WWTP.

Erosion Management, Floodway, Environmental Significance and Significant Landscape Overlays are relevant to the site IWM and drainage approach. There are patches of Endangered Ecological Vegetation Classes (EVCs) in the GIA as well as matters of national significance within a 500-metre buffer of the Northern GIA according to the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 register.

Land contamination is relatively low within the GIA, however, a former landfill site exists on the south east of the GIA near Gillies Road and past mining activity locations in the east. This has the potential for contamination, however, this has not been evident within the GIA. There are potential rockfall hazards and instability around Mount Rowan, there is also the potential for highly reactive clay in the GIA, however, this is expected to be managed through best practice measures. It should be noted that at the time of this report, land contamination is being further investigated by the VPA in a separate study. There is high cultural sensitivity along Burrumbeet Creek and in certain land parcels throughout the area. Historic Urban Landscape sites are found near Mount Rowan and Wendouree and Miners Rest.

Requirements for stormwater infrastructure in the area include a new trunk main, retention basins, wetlands and stormwater pipes able to convey post-development 10-year ARI events and pre-development 100 year ARI events.

The Ballarat North WWTP (owned and maintained by CHW) is intended to provide wastewater treatment, but upgrades of existing, and new pump stations and detention assets may be required to service the wider area with a gravity system to cater for peak wet weather flows. Water is currently supplied to Ballarat North by CHW from the Northern Tanks Zone network, fed via the Ballarat North pump station. A new pressure zone is required to service the GIA, including new tank boosters, mains, tanks and pump stations. Trunk mains do not currently exist in the site. Rainwater harvesting and the ability of the Ballarat North WWTP will be necessary to ensure adequate level of service to the Northern GIA and the Miners Rest Area.

2.1.6 Urban Water Strategy (Central Highlands Water, 2022)

CHW is responsible for providing water supply and sewerage services to Ballarat North (among other regional urban areas). Urban water strategies reflect the best available data and modelling, incorporating feedback from water users and the community to plan for future water supply and sewerage needs. They plan for the impact on water resources from population growth, climate change and extreme events such as bushfires, floods and droughts.

CHW continues to support urban growth through the investments it makes within its capital works program. Since the development of the previous UWS in 2017, CHW has made investments to improve water supply, enhance water efficiency, upgrade wastewater assets and instigate fit-for-purpose recycled water projects.

Fit-for-purpose recycled water from the Ballarat North WWTP is supplied to Lake Wendouree to help maintain water levels in the lake, and to irrigate nearby schools and green spaces. The Ballarat North WWTP is experiencing growth pressures and increasing discharge volume capacity is required to manage growth inflows, both through increasing the licenced discharge volume and the recycling capacity. Licenced discharges of treated wastewater currently go to Burrumbeet Creek, Lake Wendouree, Ballarat Grammar and Wendouree Primary School and Ballarat Grammar Educational Farm. Treated wastewater is also reused in the treatment process at the plant.

The opportunity to utilise recycled water in the PSP would therefore benefit CHW, as the residents in the PSP would be able to use the effluent from the plant as a non-potable resource, instead of CHW having to increase the licenced discharge volume.

Figure 2-3 shows the water supply overview for Ballarat and neighbouring towns and Figure 2-4 shows the sewerage system overview for Ballarat North.

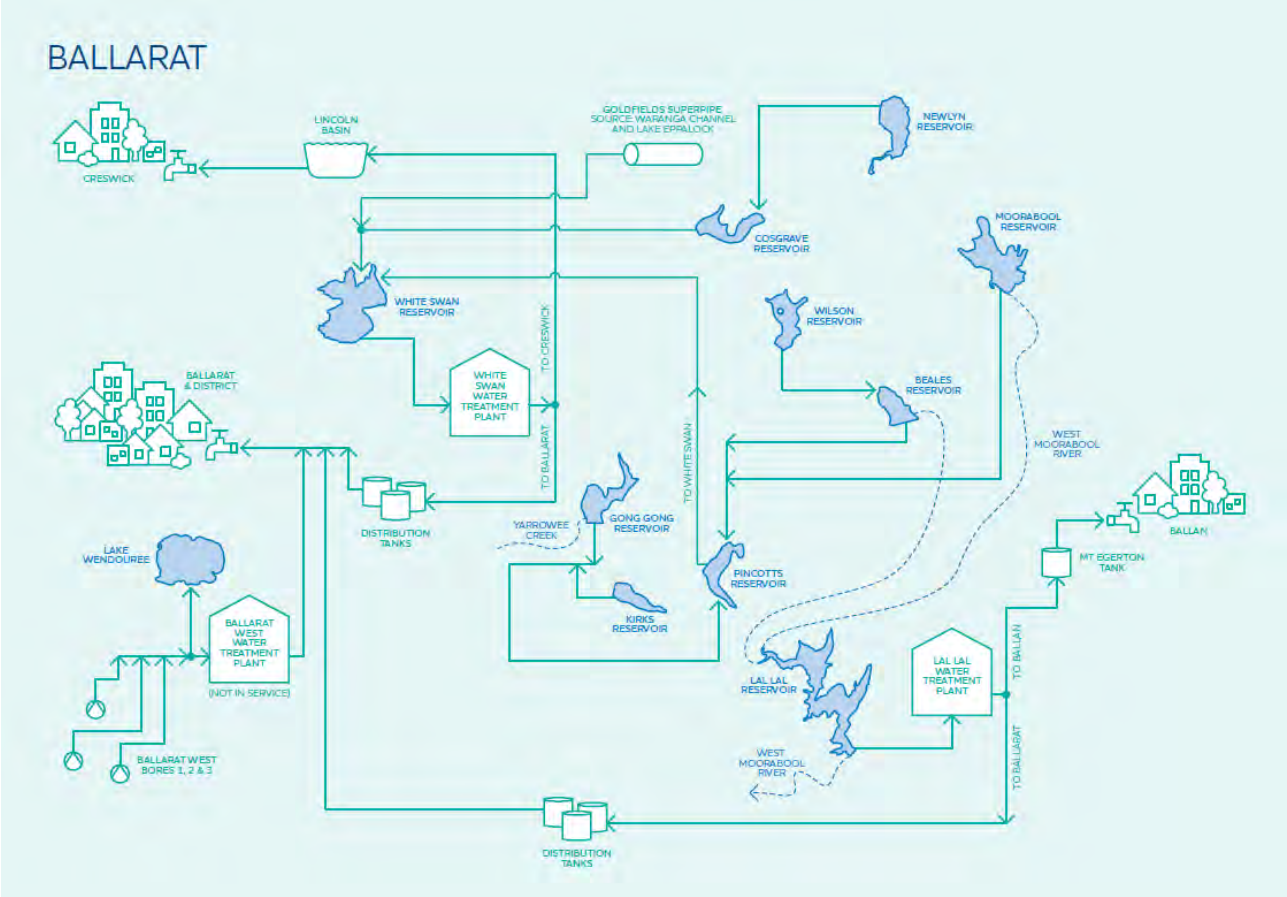


Figure 2-3 Water Supply Overview

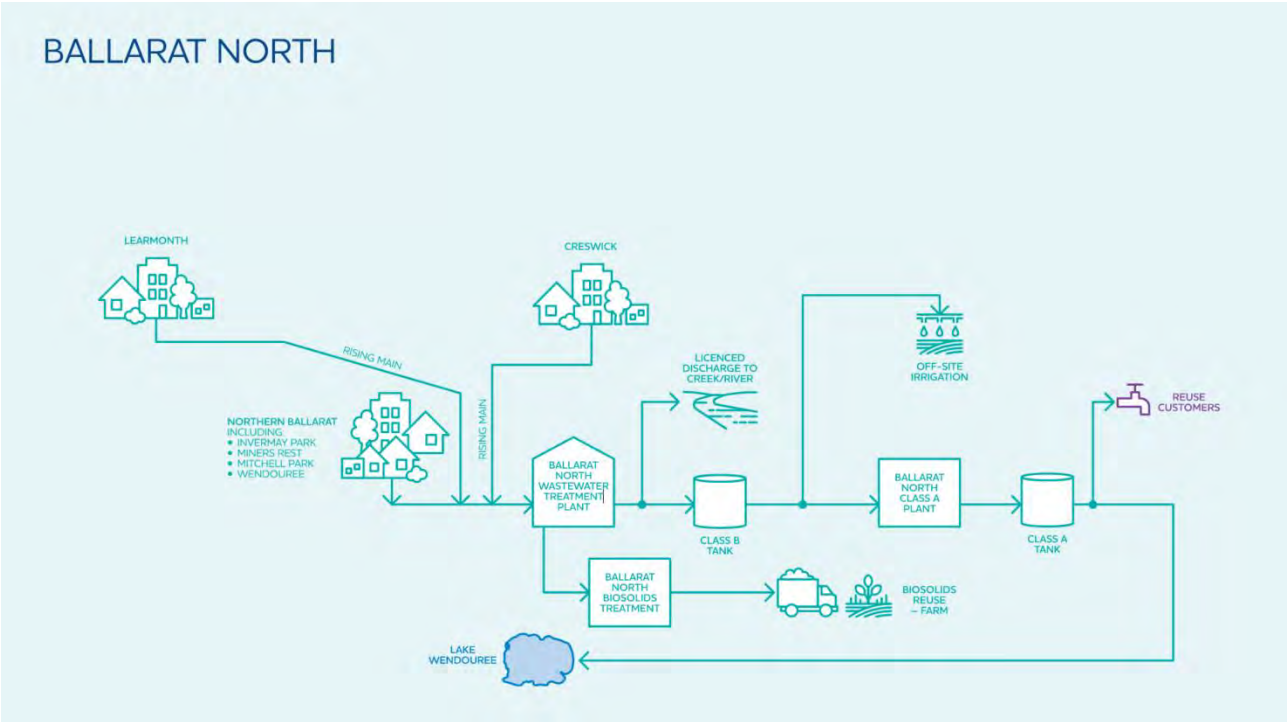


Figure 2-4 Ballarat North Sewerage System Overview

Actions included in CHW's Urban Water Strategy which are relevant to this PSP are listed below;

- In partnership with the City of Ballarat, refresh the water-wise education program and develop a community-focussed water efficiency strategy for Ballarat, including per-capita water usage targets.

- Continue implementing local council-led integrated water management and diverse water options for the Ballarat region.
- Provide support for local council led initiatives to investigate community preferences and test options for water supply and sewerage services in growing communities in the Ballarat area.
- Increase the discharge capacity of the Ballarat North WWTP through increase in recycled water production and use capacity and through an increase in licenced discharge volume to receiving water.

2.1.7 Regional Floodplain Management Strategy (GHCMA, 2017)

Ballarat North is situated within the Glenelg Hopkins Catchment Management Authority (GHCMA) regions, in the upper-most portions of the Hopkins basin. Ballarat North has been identified as a priority flood risk area due to being prone to flash flooding as a result of quick catchment responses to heavy rainfall. Prior attempts to channelise waterways have led to faster flowing and overtopping waterways. Flood controls have recently been introduced through a 2017 Planning Scheme Amendment, specific to the Burrumbeet catchment. Actions to address this flood risk have been proposed for the whole City of Ballarat and specific sites, there are no actions directly within the Ballarat North PSP area, but there is some flood mitigation infrastructure immediately upstream along Burrumbeet Creek. Actions relevant to the whole City of Ballarat include:

- Investigate the viability of a flood warning system for the City of Ballarat. For example, consider methods to turn flood study outputs into tools to assist with flood warning, preparedness and response.
- Undertake community flood education engagement activities and develop flood awareness products for Ballarat, which may include pre-recorded flood education videos, local flood guides, community response plans, community signs and gauge boards.
- Investigate the feasibility of a road inundation assessment (e.g. depth over road flooding) to assist council and Victoria State Emergency Services (VICSES) plan for road closures during flood events and to better plan for potential road damages.
- Investigate options for potential flood warning for the Burrumbeet catchment.
- Update planning scheme to include flood controls for the whole of the City of Ballarat.
- Extend the Environmental Significance Overlay (ESO) to all waterways within the North Central CMA region of the City of Ballarat, to manage risks of future growth and development.

Glenelg Hopkins CMA has released a progress update and review report of the Regional Floodplain Management Strategy Mid-term Implementation Report for the years 2018-2023.

2.1.8 Climate Change Strategy (GHCMA, 2016)

Climate change projections for the Glenelg Hopkins region indicate increasing temperatures across all seasons, with a 4 degree increase by 2090. By 2090, winter rainfall will decrease by up to 30% and the intensity of rainfall events are expected to increase. Altered flora and fauna species function is expected, particularly less groundcover is expected which would lead to an increase in the likelihood of erosion. Pasture production and persistence is expected to decline due to the lower rainfall and increased temperatures, which could lead to a decline in feed stock across the region. However, cropping is increasingly suitable due to lower rainfall.

2.2 Key Policies and Guidance

A summary of key IWM and drainage related policies and legislation are provided in Table 2-1 for context.

Table 2-1 Key Policies and Legislation

Policies & Legislation	Description
Victorian Planning Provisions	Clause 56.07 Integrated Water Management provides objectives and discretionary standards in relation to drinking water supply, reused and recycled water, wastewater management, and stormwater management for subdivisions, including meeting the stormwater quality performance objectives in the Urban Stormwater BPEM Guidelines outlined below. For apartments, Clauses 55.03 and 55.07 also encourage the use of alternative water sources, facilitate stormwater collection, utilisation and drainage; and reduce the impact of stormwater run-off. Amendment VC154 also recently introduced Clause 53.18 which extends the stormwater management requirements for residential subdivision and apartment development to all commercial and industrial and subdivision development, all public use development and all residential multi-dwelling developments.
Urban Stormwater Best Practice Environmental Management (BPEM) Guidelines	The Urban Stormwater 'BPEM' Guidelines (1999) were produced to assist in the protection of stormwater quality. The BPEM guidelines include objectives for stormwater quality to help determine what measures are appropriate to comply with/meet the State Environment Protection Policies (SEPPs). The BPEM included best practice performance objectives (at the post construction phase) of: • 80% retention of the typical urban annual load for suspended solids, • 45% retention of the typical urban annual load for phosphorous, • 45% retention of the typical urban annual load for nitrogen, • 70% reduction of typical urban annual load for Litter; and • Flows: maintain discharges for 1.5-year Average Recurrence Interval (ARI) at pre-development levels. The BPEM guidelines are included within Victorian Planning Schemes, within the Victorian Planning Provisions (VPPs), although it is noted that they were not introduced into the planning provisions until 2006.
Urban Stormwater Management Guidelines (1739.1)	EPA Victoria published urban stormwater management guidelines in 2021, which aims to help improve the management of urban stormwater by highlighting the risk of harm caused by stormwater and help developers who create new impervious surfaces to minimise risks to human health and the environment. The guideline sets out a hierarchy of hazard reduction, which prioritises eliminating the hazard as far as reasonably practicable as the most favourable solution. This includes reducing runoff from impervious surfaces, using permeable or porous paving, capturing and infiltrating stormwater, eliminating pollutants from stormwater from entering waterways etc. Quantitative performance objectives are set in this Guideline, where MUSIC modelling should be carried out to assess performance against these objectives. The water quality objectives remain unchanged from those referenced in BPEM Guidelines (80%, 45%, 45% and 70% reduction in suspended solids, total Phosphorous, total Nitrogen and litter respectively). Furthermore, the Urban Stormwater Management Guidelines provides quantitative stormwater harvesting and infiltration performance objectives for stormwater. This is based on 'Priority' and 'Other' areas as well as the annual rainfall bands. Priority areas have not been specified for this region; therefore the '**Other'** areas apply.

Policies & Legislation	Description
	Mean annual rainfall measured at Ballarat Aerodrome Station 89002 is 631mm, therefore the **adopted targets for this PSP will be 29% harvesting and evapotranspiration and 7% infiltration.** It should be noted that although this guidance document is not currently referenced in the Victorian Planning Provisions, but is administered under the General Environmental Duty (GED).
Precinct Structure Plan 2.0 Guidance	In October 2021, VPA prepared Precinct Structure Planning Guidelines for new communities in Victoria. The objective of the VPA was to "lift the bar" by encouraging higher standards of design and development. One way in which the guidelines do this is by "improving outcomes for the whole water cycle by referencing regional integrated water management plans to resolve development-related water balance challenges". General principles followed by a method for application is outlined in this document. With respect to IWM, the following targets were included: T14– All streets containing canopy trees should use stormwater to service their watering needs. T17– IWM solutions should meaningfully contribute towards the actions and targets from the relevant Catchment Scale Public Realm & Water Plans and any relevant water-related strategies, plan, or guideline.
National Construction Code requirements regarding rainwater tanks	The Building Act sets out the framework for the regulation of building construction, building standards and building safety features in Victoria. Nested beneath the Building Act, as subordinate pieces of legislation, are the Building Regulations 2018 and the Plumbing Regulations 2018. The National Construction Code (NCC) 2019 in Schedule 2 of the plumbing regulations also notes that "the Victorian variation to the energy efficiency provisions of the Building Code of Australia (as incorporated by the Building Regulations) provides that the energy efficiency performance requirement for a new Class 1 building is satisfied if either a rainwater tank is connected to all sanitary flushing systems, or a solar water heater is installed in accordance with these Regulations." A recycled water connection is also accepted as an alternative to a rainwater tank. The NCC 2022 replaced the NCC 2019, which was adopted by states and territories on 1 May 2023 whereby this requirement was superseded. As such, there is currently no specific requirement for rainwater tanks within NCC 2022. Instead, NCC 2022 refers practitioners to regulations made under the Act to provide for water efficiency requirements that may be set in future. The Victorian Government proposes to implement stronger state building and plumbing regulations for water efficiency, to improve the water efficiency of all buildings, subject to a regulatory impact statement and stakeholder and community consultation.
Ballarat Potable Water Demand Target – Supplementary Guide	A compulsory potable water use target of 124 litres per person per day (l/p/d) exists for any residential developments within precinct structure plan areas, greenfield investigation areas, and outside of those areas for all new sub-divisions of 10 lots or greater in Ballarat. CHW does not mandate any specific solution for achieving the potable water reduction target outlined. The onus is on the developer(s) to demonstrate and obtain CHW approval as to how the reduction of water use will be achieved. However, the Supplementary Guide provides a practical example of meeting this target, with the use of a 2kL rainwater tank installed at a new development. Following approval from CHW, rainwater tank installation (2kL or greater) and water efficiency devices were mandated in the development. The Ballarat City Integrated Water Management Plan accepts this approach as a **minimum base case** for residential developments within precinct structure plan areas, 'greenfield investigation areas', and outside of those areas for all new sub-divisions of 10 lots or greater in Ballarat.

	Priority areas (Notes 2, 4, 5, 6)		Other areas (Notes 3, 4, 5, 6)	
rainfall band (ml)	Harvest/evapotranspire (% mean annual impervious run-off)	Infiltrate/filter (% mean annual impervious run-off)	Harvest/evapotranspire (% mean annual impervious run-off)	Infiltrate/filter (% mean annual impervious run-off)
200	93	0	37	0
300	88	0	35	0
400	83	0	33	0
500	77	5	31	4
600	72	9	29	7
700	68	11	27	9
800	64	14	26	11
900	60	16	24	13
1000	56	18	22	14
1100	53	19	21	15
1200	50	21	20	17
1300	48	22	19	18
1400	46	23	18	18
1500	44	25	18	20
1600	42	26	17	21
1700	40	27	16	22
1800	38	28	15	22

3. Contextual Analysis

A review of existing studies and reports was undertaken to understand the existing context of Ballarat North PSP. A summary of the reports reviewed is listed in Appendix A. A multi-layered approach has been used to undertake the contextual analysis of Ballarat North PSP from an IWM perspective. Water systems and infrastructure are managed and implemented at a range of scales, and it is important to understand the context from the 'bottom up', beginning with an understanding of the catchment and landscape, followed by broader utilities and infrastructure, before then considering the contextual priorities and assets at a development and community scale. Five 'layers' have been considered in the contextual analysis (Figure 3-1):

- Catchment, Land & Topography – This includes natural features of the site such as the environment, topography, biodiversity, natural water features, flooding, and geology.
- Underground Infrastructure Networks – This includes below ground infrastructure within the site.
- Precinct Scale Green-Blue Infrastructure – This includes any proposed or existing blue-green infrastructure at a precinct-scale.
- Lot and Street Scale Water-Sensitive Development – This includes any proposed water sensitive features that could be planned and delivered as part of the site development at a lot or street scale.
- People, Place, Information and Economy – This includes any known relevant information relating to people and the economy in this PSP.
- The five layers are shown diagrammatically in Figure 3-1. The PSP primarily considers land use planning and major infrastructure, and hence responds to the three base layers primarily. However, it can also set out principles and recommendations for the remaining two layers, which can be integrated through development of the PSP area.

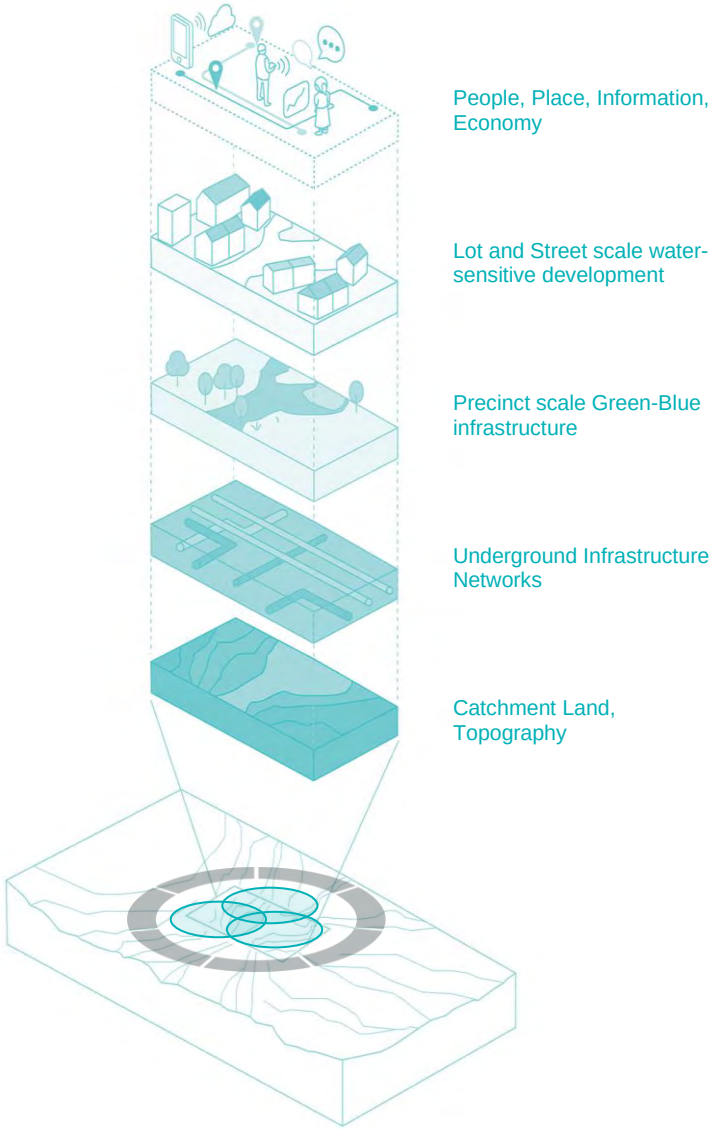


Figure 3-1 Five layers of a contextual analysis

3.1 Catchment, Land and Topography

3.1.1 Catchment and waterways

3.1.1.1 Overview

Ballarat North PSP is located within the major river catchment of Hopkins River and within the sub-catchment of Burrumbeet Creek as shown in Figure 3-2. Burrumbeet Creek has a catchment extending from the northern suburbs of Ballarat and Invermay in the south-east and Learmonth in the north, flowing through Miners Rest and Windermere, and terminating at Lake Burrumbeet. Lake Burrumbeet overflows into Baillie Creek, a tributary of the Hopkins River which ultimately flows out to Warrnambool Bay.

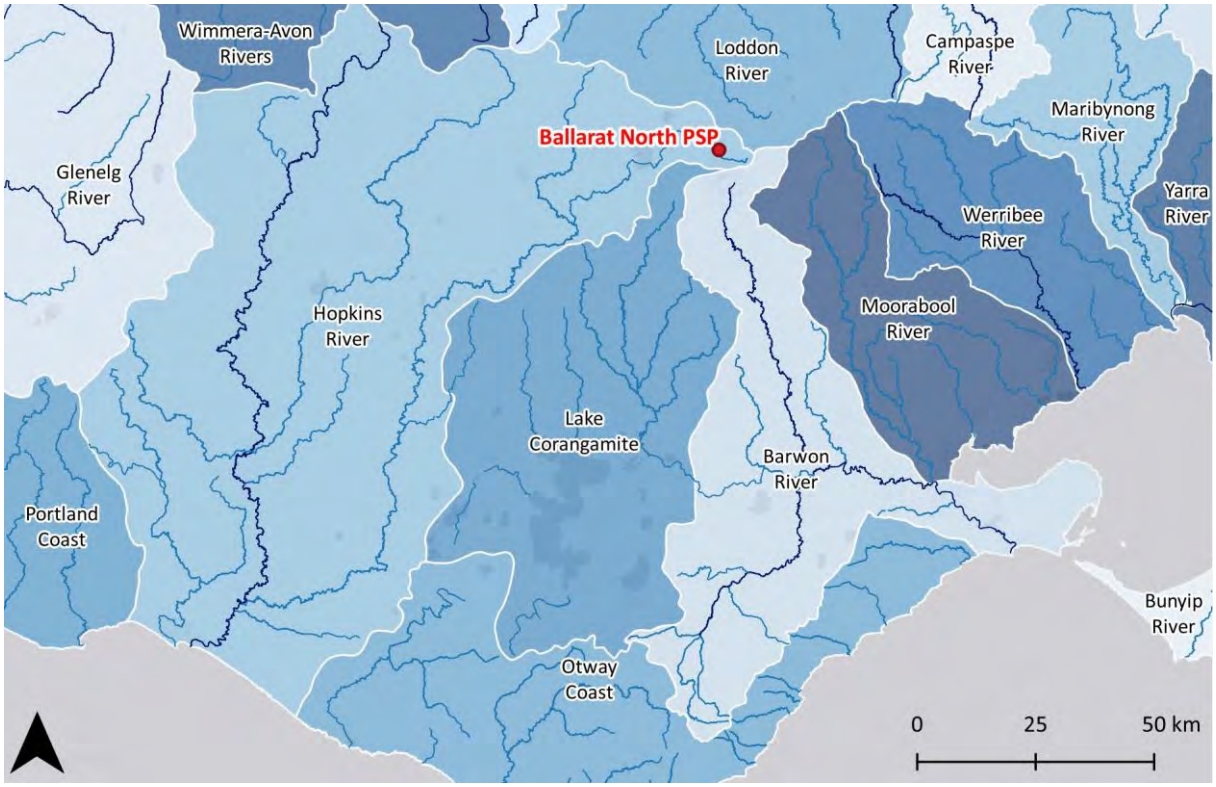


Figure 3-2 Major River Catchments

3.1.1.2 Creek Health

Burrumbeet Creek is regarded to be in 'Poor' condition and is denoted as a waterway where 'improvements should be made when opportunities arise' but is not regarded as a priority waterway by the CMA.

The creek itself, has been assessed as being in poor condition, with little natural habitat, limited species diversity and degraded riparian vegetation. The creek faces a number of environmental threats including algal blooms, direct livestock access (causing bank erosion and contamination), man-made barriers, carp and introduced predator fish. The creek does support a number of species of plants and animals, including wetland birds and native and exotic fish species. The creek has been identified as potential habitat for the endangered Growling Grass Frog, although its presence is unlikely due to the Creek's current poor condition and ongoing use to accommodate stormwater flows.

According to the City of Ballarat's IWM Plan, Burrumbeet Creek is likely to be impacted by flow and water quality changes due to increased stormwater runoff from urban development areas in the north of Ballarat and around Miners Rest. The Ballarat North WWTP previously discharged an average of 6ML/day of water to Burrumbeet Creek, however, this was reduced to 4ML/day for 10 months of the year as part of the Lake Wendouree scheme. However, it is noted that the wastewater discharged from Ballarat North does not constitute "natural" Burrumbeet Creek flow as Ballarat's drinking water supply is predominantly drawn from the Moorabool catchment and therefore already represents an artificial inter basin transfer. Hence it could be argued that the withdrawal of some wastewater better represents natural flow conditions. Flows to the creek

support Lake Burrumbeet and a number of irrigation users which extract from the creek downstream of Ballarat, so there are drivers to maintain flows to the Creek at a certain level. Ideal flows for Burrumbeet Creek have not been defined by previous studies.

3.1.1.3 Flood Risk

Figure 3-3 shows photos taken on a site visit (18th September 2023) of Burrumbeet Creek, and Figure 3-4 shows a photograph provided by the VPA of the creek during a flood event.

Figure 3-3 - Burrumbeet Creek (images captured on 18th September 2023)

Figure 3-4 Photograph of Burrumbeet Creek in the eastern part of Ballarat North PSP during a flood (provided by VPA)

GHCMA commissioned a flood investigation for the Burrumbeet Creek in 2013. A hydrologic analysis of Burrumbeet Creek was undertaken to determine design flood hydrographs for the 20%, 10%, 5%, 2%, 1% and 0.5% annual exceedance probability (AEP) flood events in Burrumbeet Creek as well as the probable maximum flood (PMF) and climate change scenarios. Flood mitigation measures outlined in the study include both structural and non-structural measures. These include:

Structural measures:

- Levee at Miners Rest
- Retarding basin upstream of Miners Rest
- Increase Channel Capacity through excavation
- Reduction in Exotic Vegetation in the Creek Channel

- High flow bypass channel south of Miners Rest
- Increase Capacity of Bridges

Non-structural measures:

- Catchment management (including revegetation)
- Flood awareness, preparedness, warning and response
- Land use planning (including appropriate guidelines/controls for land use and development)

The scope if this study is the core and expanded area shown in Figure 1-2, which forms part of the wider Burrumbeet catchment. The proposed drainage measures (outlined in Section 6 of this report) are designed such that post development flows do not exceed pre-development flows. This has been calculated using the 2013 flood model. The proposed measures are such that flows from the site do not worsen flood impacts up or downstream of the site. It is understood at the time of writing, that GHCMA are encouraging CoB to update the 2013 Burrumbeet Flood Investigation, as well as encouraging the VPA to better understand flooding within the PSP area.

3.1.2 Topography

Ballarat North PSP is relatively flat and has an elevation ranging from 516 m Australian Height Datum (AHD) to 420 m AHD. The highest point of the PSP site is north of Sims Road with the runoff flowing towards Burrumbeet Creek which is the lowest point of the PSP. For the core area of the site, the direction of runoff flow is from the northeast to southeast and west of the site boundary. For the expanded area of the site, the landscape slopes from the east at Gillies Road to west towards Burrumbeet Creek. Figure 3-5 shows the topography of the Ballarat North PSP site.

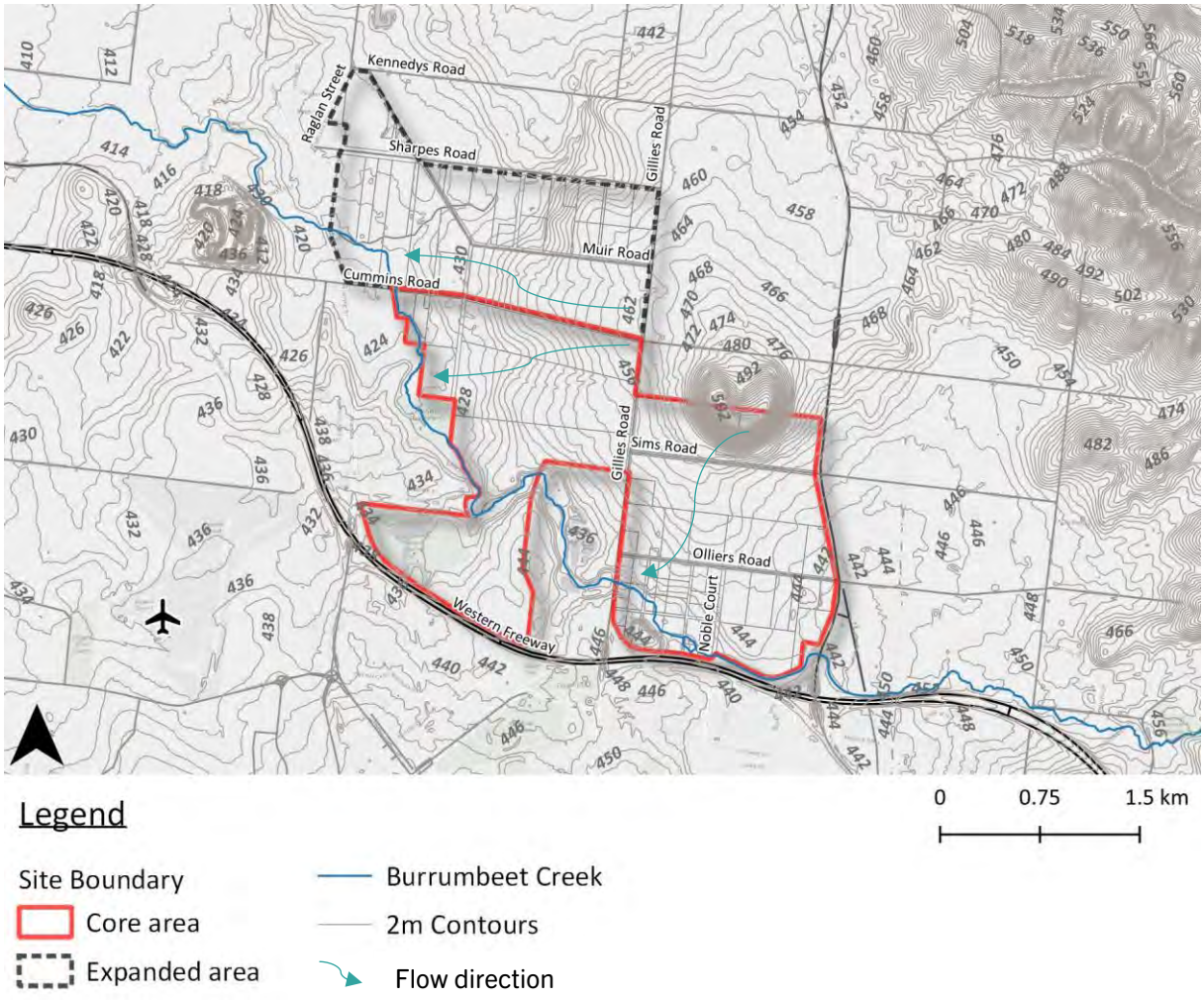


Figure 3-5 Topography of Ballarat North PSP area

3.1.3 Current Land Use

Based on the report by Hansen Partnership Pty Ltd and Arup, the current land uses, activities and land fragmentation (as shown in Figure 3-6) are outlined as follows:

- The majority of the Ballarat North PSP core area is mainly open hectare rural land which accommodates livestock grazing or otherwise underutilised rural land use.
- Land located to the west of Ballarat North WWTP constitutes large open paddocks and environmental land, including part of the alignment of Burrumbeet Creek which runs through the North Common Wetland Reserve, located on the south-western corner of the site boundary. This low-lying land is designated as Crown Land (nominated as public reserve) and is likely to remain undeveloped.
- Generally, the existing rural properties with dwellings function as rural residential lifestyle type activities rather than accommodating active and intensive rural/agricultural uses.
- Land parcels on the eastern side are generally regular and rectangular in shape, averaging between 4 ha and 40 ha in size, following am east/west grind pattern with smaller lots (2-4 ha) on the southern edge.

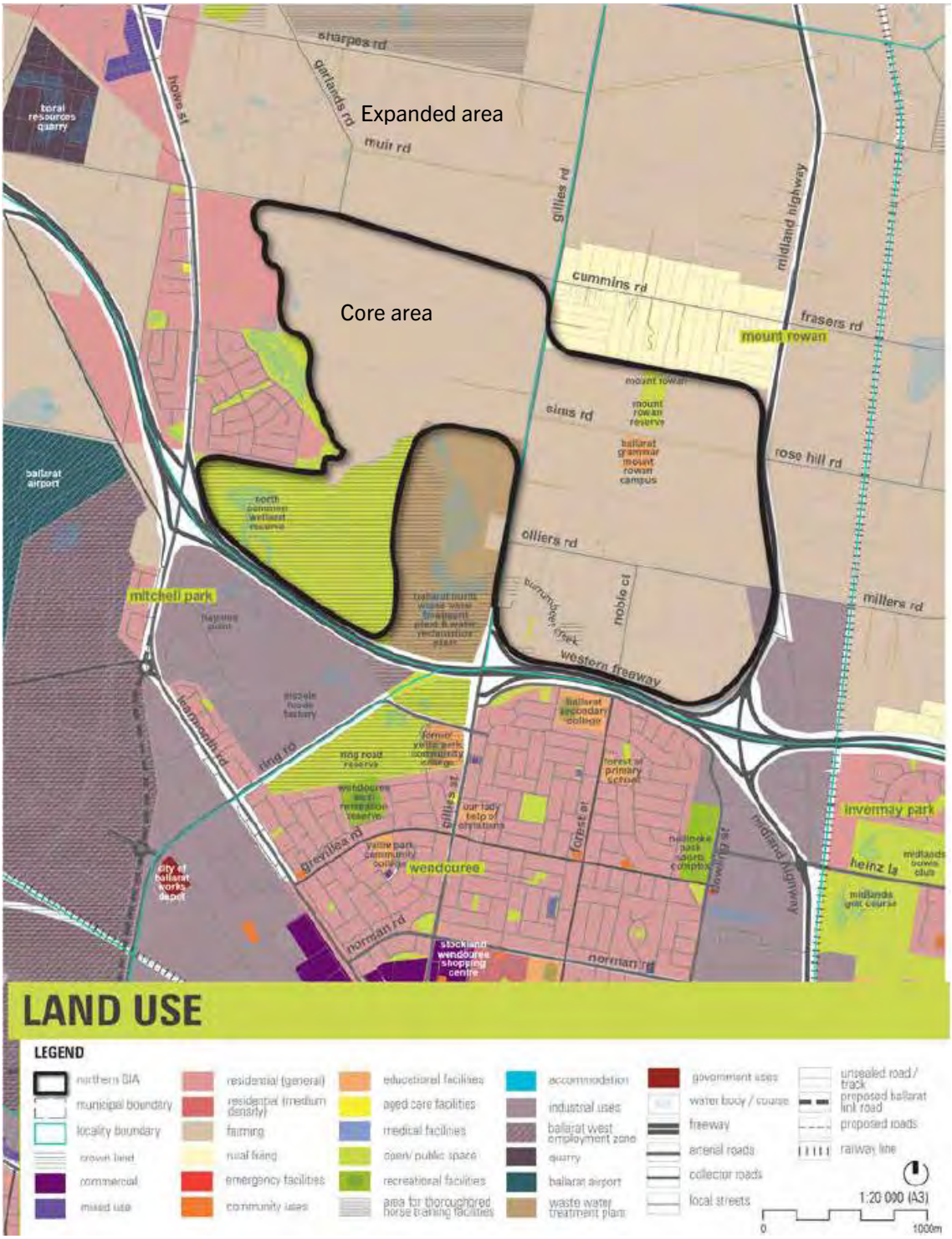


Figure 3-6 Land use from "Ballarat Long Term Growth Options Investigation: Northern Growth Investigation Area (2018)" (Hansen Partnerships Pty Ltd and Arup)

3.1.4 Planning Zones and Overlays

The core and expanded areas of Ballarat North PSP currently lies within the Urban Growth Zone and Farming Zone respectively. Figure 3-7 shows the existing planning overlays within the core and expanded PSP boundaries. The following overlays impact the Ballarat North PSP area:

- Land Subject to Inundation, Floodway Overlay, Environmental Significance Overlay (Schedule 2) and Erosion Management Overlay along the Burrumbeet Creek corridor.
- Significant Landscape Overlay north of Sims Road connected to Mount Rowan.

- Specific Controls Overlay south of Sims Road associated with Ballarat Grammar School Mount Rowan Campus.
- Bushfire Management Overlay and Environmental Significance Overlay (Schedule 4) on CHW wastewater plant site and buffer crossing across into the PSP boundary.
- Vegetation Protection Overlay east of the Ballarat North PSP boundary.
- Design and Development Overlay and Heritage Overlay connected to Ballarat Airport, west of the Ballarat North PSP boundary.

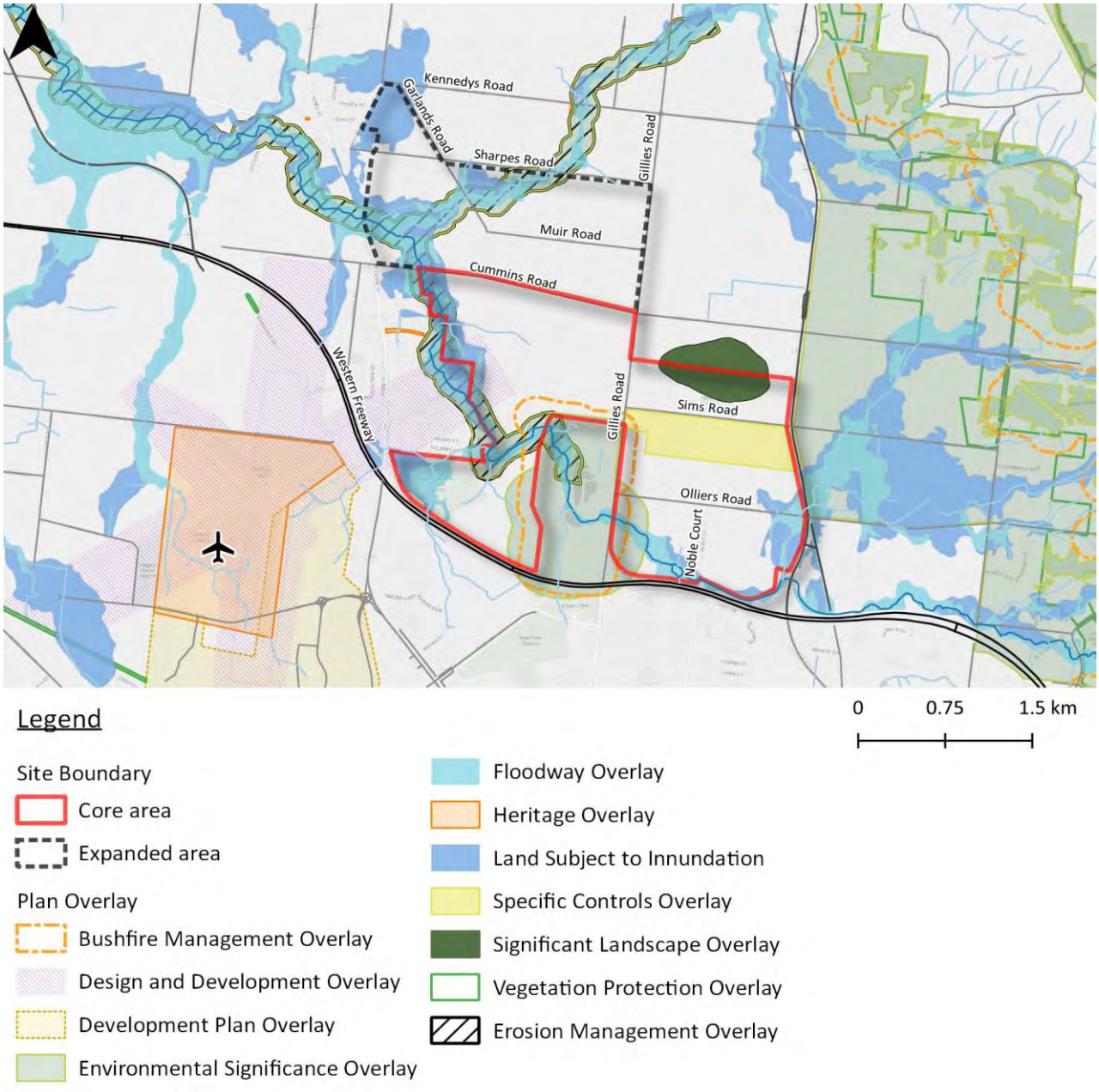


Figure 3-7 Planning Overlay for Ballarat North PSP

3.1.5 Environmental Values

Based on the report by Hansen Partnership Pty Ltd and Arup, there are few constraints of protected flora and fauna within the Ballarat North PSP boundary. As shown in Figure 3-8 there are patches of Native Vegetation Ecological Vegetation Classes (NV EVC) namely Plains Grassy Woodlands within the PSP boundary. The report also states that the majority of this site has a relatively low Strategic Biodiversity Score.

Based on the environmental values assessment carried out by Practical Ecology Pty Ltd (2009), native vegetation adjacent to the PSP boundary consists of widely scattered remnant trees and small patches of grassland or wetland vegetation. The report lists potential habitats for fauna species protected under the Environment Protection and Biodiversity Conservation (EPBC) Act, namely Golden Sun Moth, Striped Legless Lizard and Growling Grass Frogs within proximity to the PSP boundary.

The VPA is undertaking an updated biodiversity assessment including both general and targeted surveys of flora and fauna.

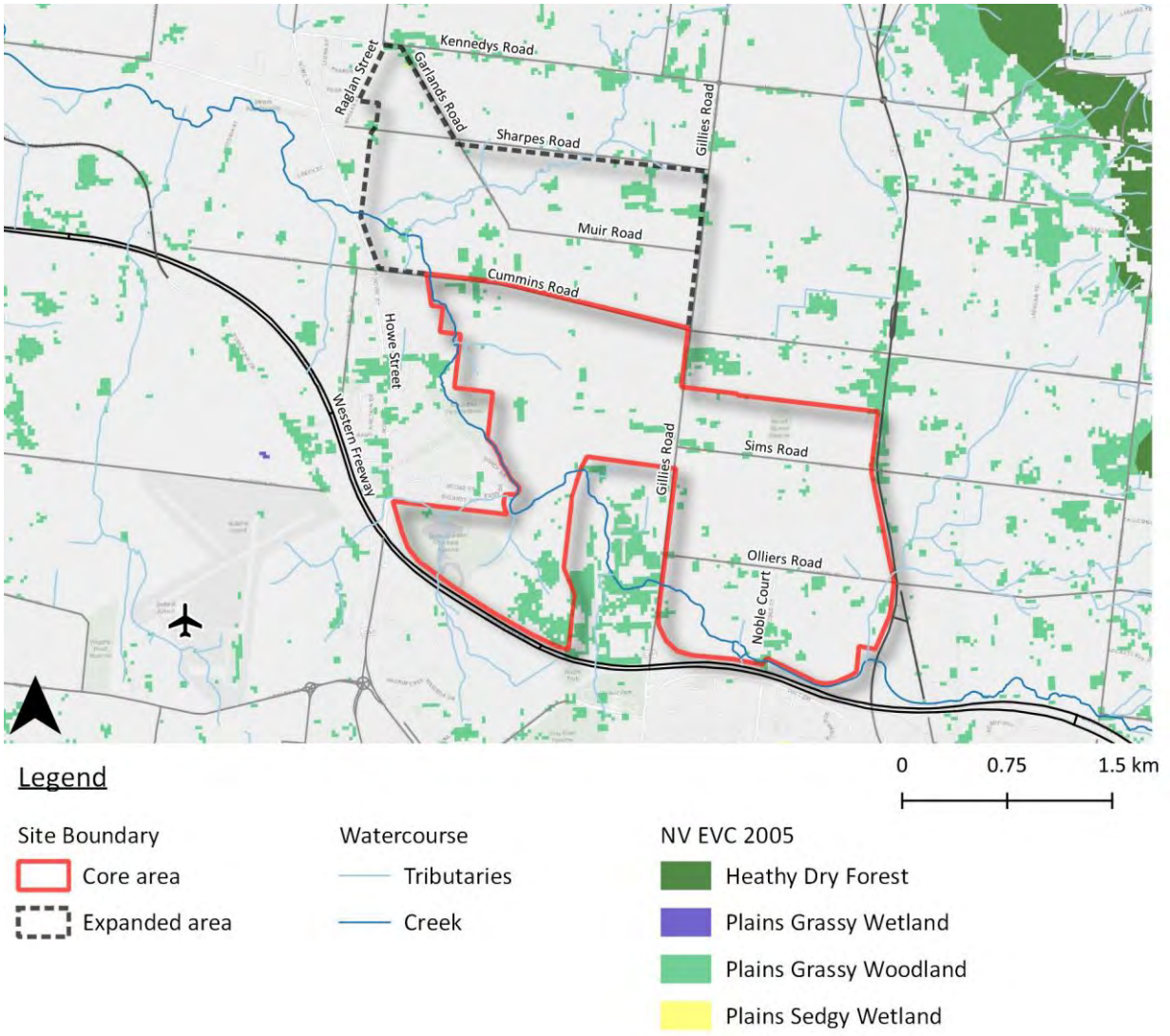


Figure 3-8 Ecological Vegetation Classes for Ballarat North PSP

3.1.6 Groundwater

Figure 3-9 shows the groundwater salinity for the Core and Expanded areas for Ballarat North PSP. The majority of the site has a salinity of 3101 mg/L to 5400 mg/L and the western part of the site has a salinity of 1201-3100 mg/L. Figure 3-9 also shows patches of Potential Terrestrial Groundwater Dependent Ecosystems within the PSP boundary. This data has been extracted from Datashare by DEECA. With respect to groundwater levels. Visualising Victoria's Groundwater indicates that most of the site is close to 5-10 m above the groundwater table whereas northeast and eastern part of the PSP is 20-50 m above the groundwater table as shown in Figure 3-10.

A shallow groundwater table, as located near the creek, would suggest there are limited infiltration or aquifer recharge opportunities. However, localised infiltration would be possible in other parts of the PSP, but this would need to be confirmed following a ground investigation and infiltration test.

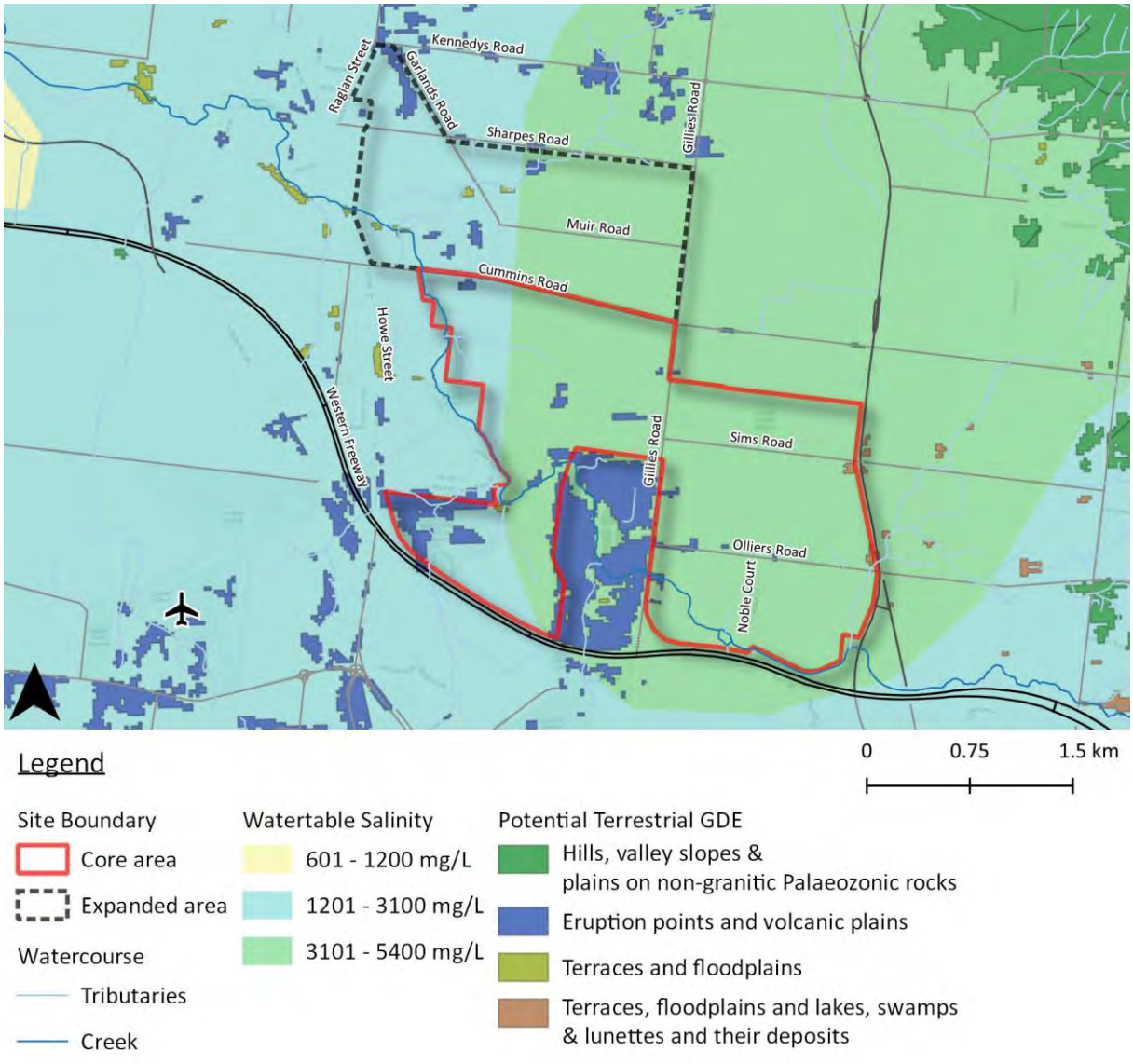


Figure 3-9 Groundwater within and surrounding the Ballarat North PSP

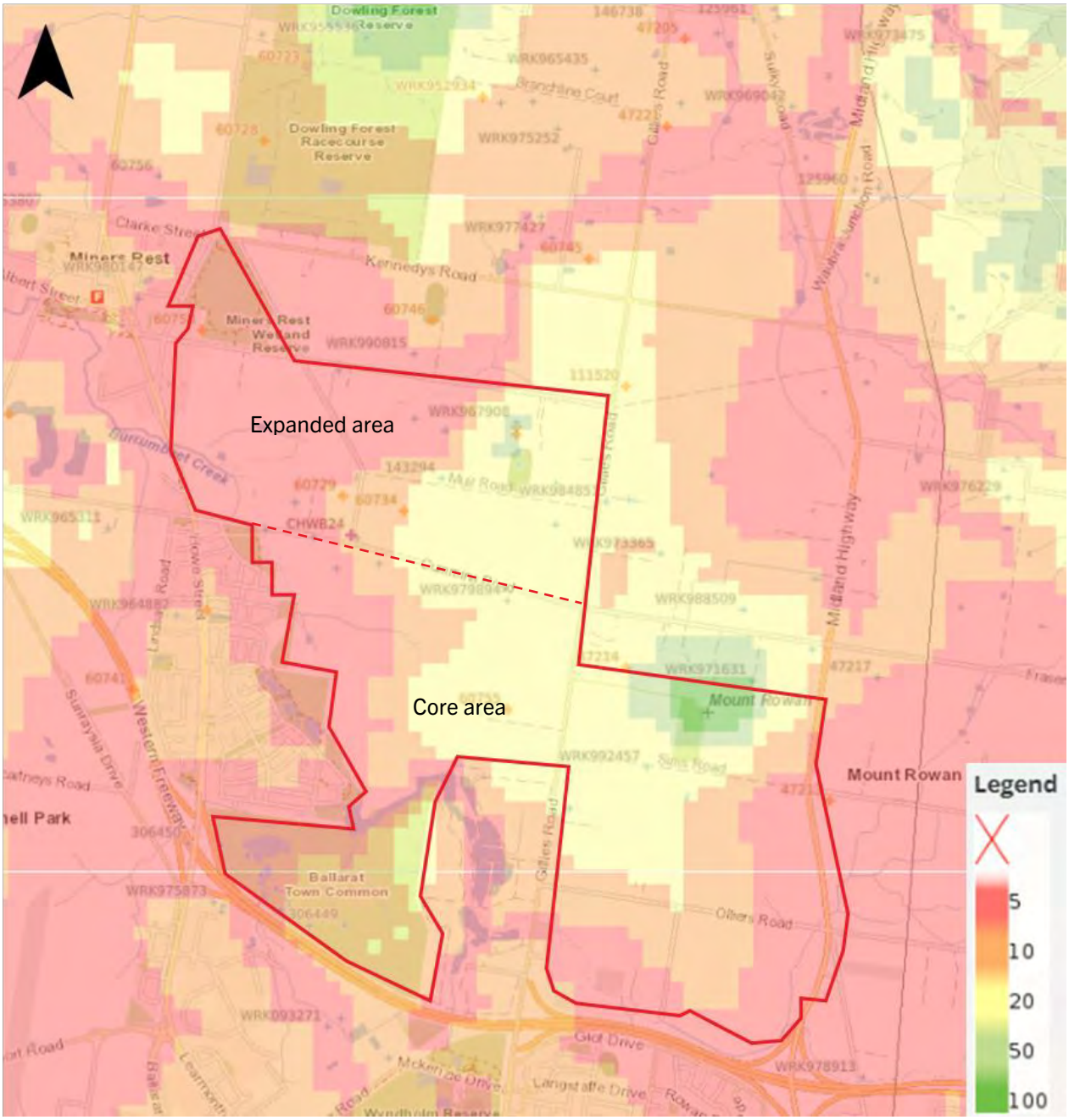


Figure 3-10 Depth to water table (Visualising Victoria's Groundwater)

3.1.7 Geology and Soils

Figure 3-11 represents the Land Unit for Ballarat North PSP. Based on the Land Capability Assessment by Arup, the majority of this site consists of newer volcanic material which typically consists of basaltic clay overlying basalt rock. The eastern and western edges of the site and land around Burrumbeet Creek is alluvium and colluvial. The report also states that the potential of land instability over significant areas of the site boundary is generally considered to be very low. Areas of localised instability may occur, adjacent to the existing Creek and waterways.

The VPA is currently undertaking an updated Land Capability Assessment specific to the Ballarat North PSP.

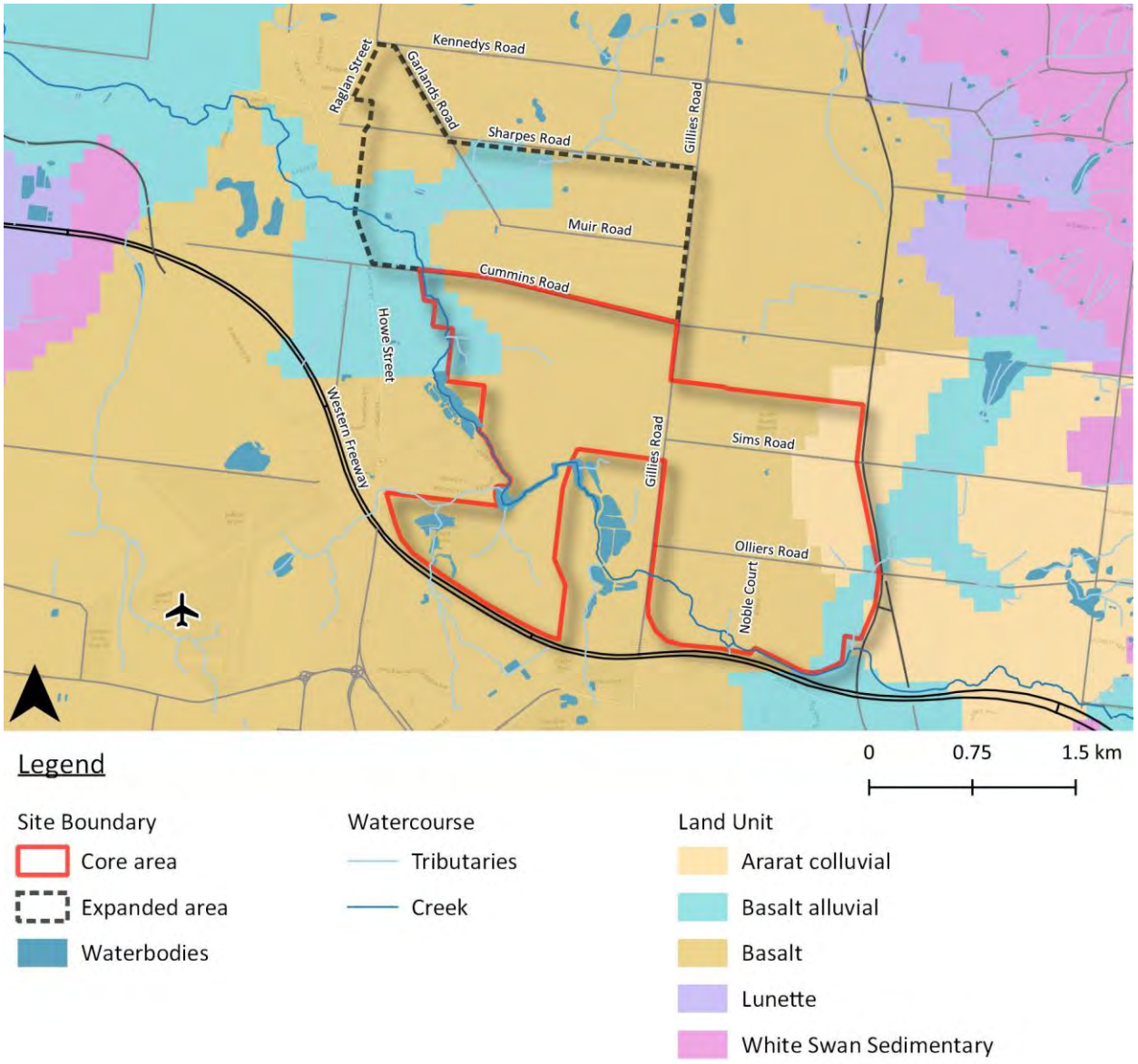


Figure 3-11 Geotechnical context within and surrounding the Ballarat North PSP

3.2 Underground Infrastructure Networks

3.2.1 Existing utilities

Based on the Dial Before You Dig (DBYD) enquiry carried out by Arup in the Land Capability Assessment Report for Northern GIA, the major utility services present in the area include (Figure 3-12):

- Stormwater drainage
- Sewerage
- Recycled water
- Water supply

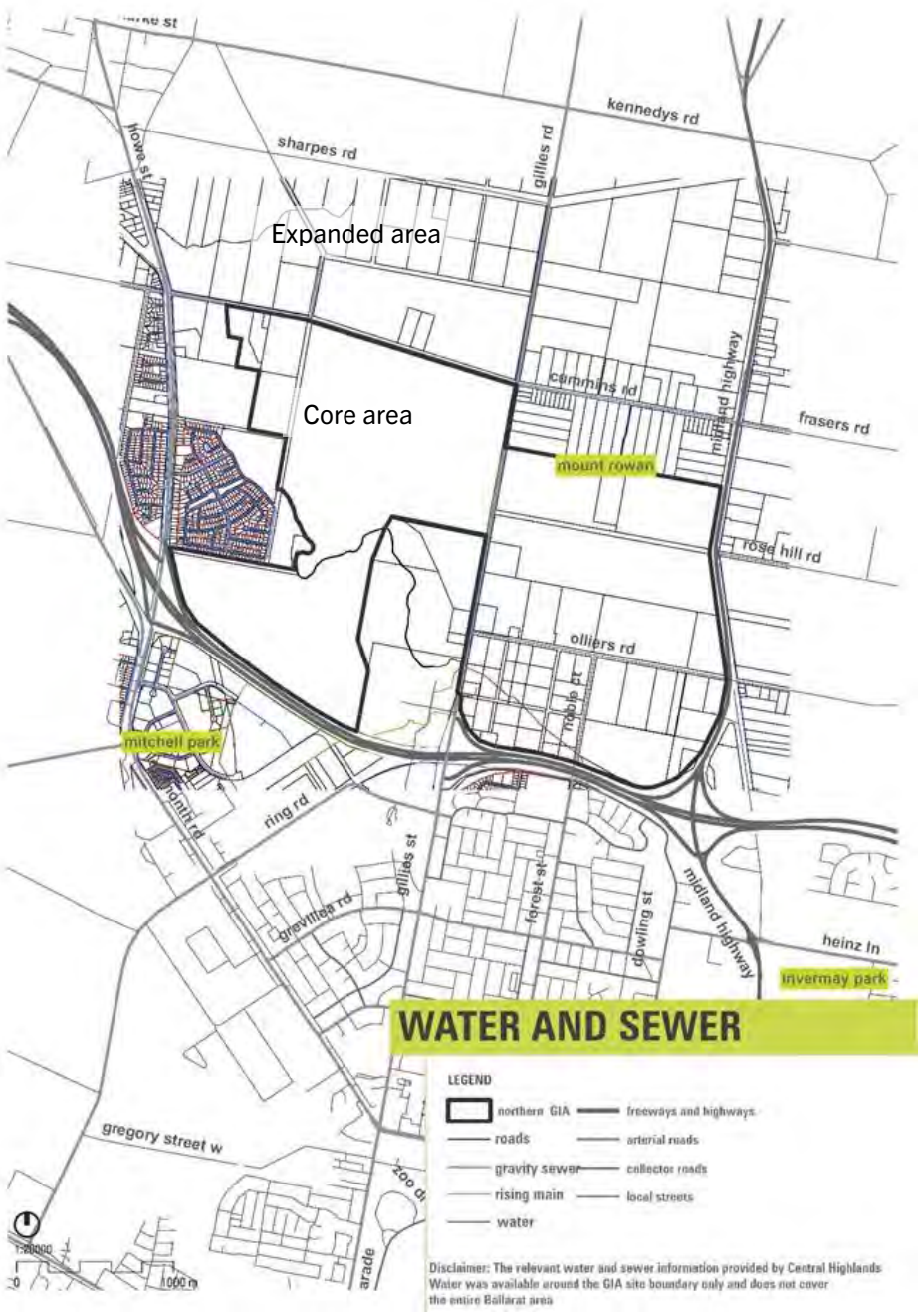


Figure 3-12 Water and Sewer infrastructure (Hansen Partnerships Pty Ltd and Arup)

3.2.2 Stormwater drainage infrastructure

The site drains towards Burrumbeet Creek on the southern and western boundaries. Based on the flood extent (as shown in Figure 3-7) there are areas in the south and west of the Core Area and the west of the Expanded Area likely to be impacted by a 1% AEP flood event and these areas would be preferable to avoid in siting stormwater management assets. Formal stormwater drainage infrastructure does not currently exist within the PSP boundary and would be delivered through the development process.

3.2.3 Sewerage infrastructure

The existing Ballarat North Wastewater Treatment Plant (WWTP) is located on the Western Highway/Gillies Road junction, along the southern boundary of the PSP area. There are several trunk outfall mains that travel within the site and around its boundary. The largest outfall main is an 825mm diameter concrete pipe that runs north-east across the site from the southern boundary at Forte Street. This gravity fed system has no spare capacity at its pump station. The other outfall main located within the study area is a 300mm diameter uPVC pipe, which is centrally located and runs north-south to the Ballarat North WWTP. The Ballarat sewerage network is shown in Figure 2-4.

The report also states that CHW does not own any sewer assets along the northern or eastern boundaries of the site and recycled water reticulation within this site does not currently exist.

3.2.4 Recycled water supply

Recycled water is an important part of the growth and development of Ballarat. Figure 3-13 below shows known recycled water schemes provided by CHW. It's understood that the capacity increase of Ballarat North WWTP is planned, however, it is yet to be decided whether recycled water from the plant is planned for Ballarat North PSP.

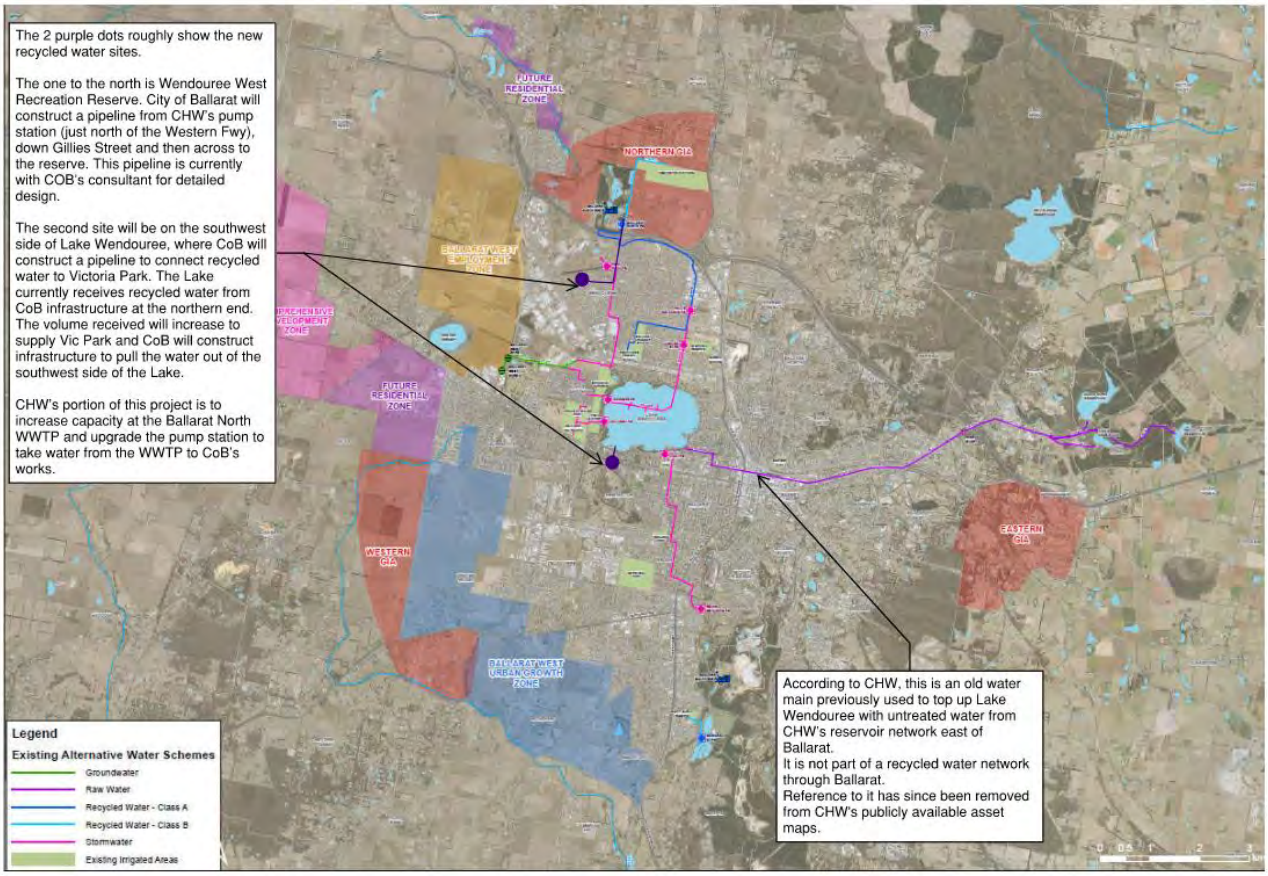


Figure 3-13 Known recycled water schemes

3.2.5 Potable water supply

CHW provides and manages the existing water supply infrastructure within Ballarat and the outlying areas. The Ballarat water supply is shown in Figure 2-3. The only water assets within the Ballarat North core PSP area are the 150mm diameter pipes that run north-south down Gillies Road and east along Olliers Road. Supply of potable water along Olliers Road extends approximately 260m east from the Gillies Road/Olliers Road intersection.

3.3 Precinct scale Green-Blue Infrastructure

3.3.1 Miners Rest Wetland

Miners Rest Wetland is located within the expanded area of Ballarat North PSP, it is bound by Garlands Road to the north-east, Sharpes Road to the south, Ranglan Street to the northwest and Clarke Street/Kennedys Road to the north. The Miners Rest Wetland is a significant local recreational and environmental asset, and features a shallow freshwater marsh, providing habitat for significant plant and animal species. The catchment area of the wetland is located directly to the north and north-east of the wetland with Burrumbeet Creek flowing south of the wetland. Based on a vegetation management plan on Miners Rest Wetland by Practical Ecology (2014), the wetland has a restricted catchment area with concerns of the wetland receiving far less as a result of increasingly dry weather periods. The assessment also states

that due to the reduced water flows, the threatened flora and fauna species could face a further decline without any ecological or vegetation interventions.

Figure 3-14 shows the current state of Miners Rest Wetland taken by the Arup team during their site visit on 18th September 2023.

Figure 3-14 Miners Rest Wetland (image captured on 18th September 2023)

3.3.2 North Common Wetland

North Common Wetland is located within the Ballarat Town Common which lies in the southwest corner of the PSP boundary. The wetland is Crown Land and on that basis does not constitute land for potential development. However, there is potential use of existing landscape features to create linear open space along Burrumbeet Creek, including links with North Common Wetland Reserve.

3.3.3 Macarthur Park Wetland

The Macarthur Park Wetland lies to the west of the PSP area on the western bank of Burrumbeet Creek. It was developed as a stormwater treatment wetland to service the adjacent development area. The wetland is well established and is making a positive contribution to the biodiversity and environmental health of the creek. Placement of wetland assets within the PSP provide an opportunity to create a network of green infrastructure assets that provide connectivity and amenity in the area.

Figure 3-15 shows a photo of Macarthur Park Wetland, taken by the Arup team during their site visit on 18th September 2023.

Figure 3-15 Macarthur Park Wetland (image captured on 18th September 2023)

Figure 3-16 below shows the location of Miners Rest, Macarthur Park and North Common Wetlands, in relation the PSP.

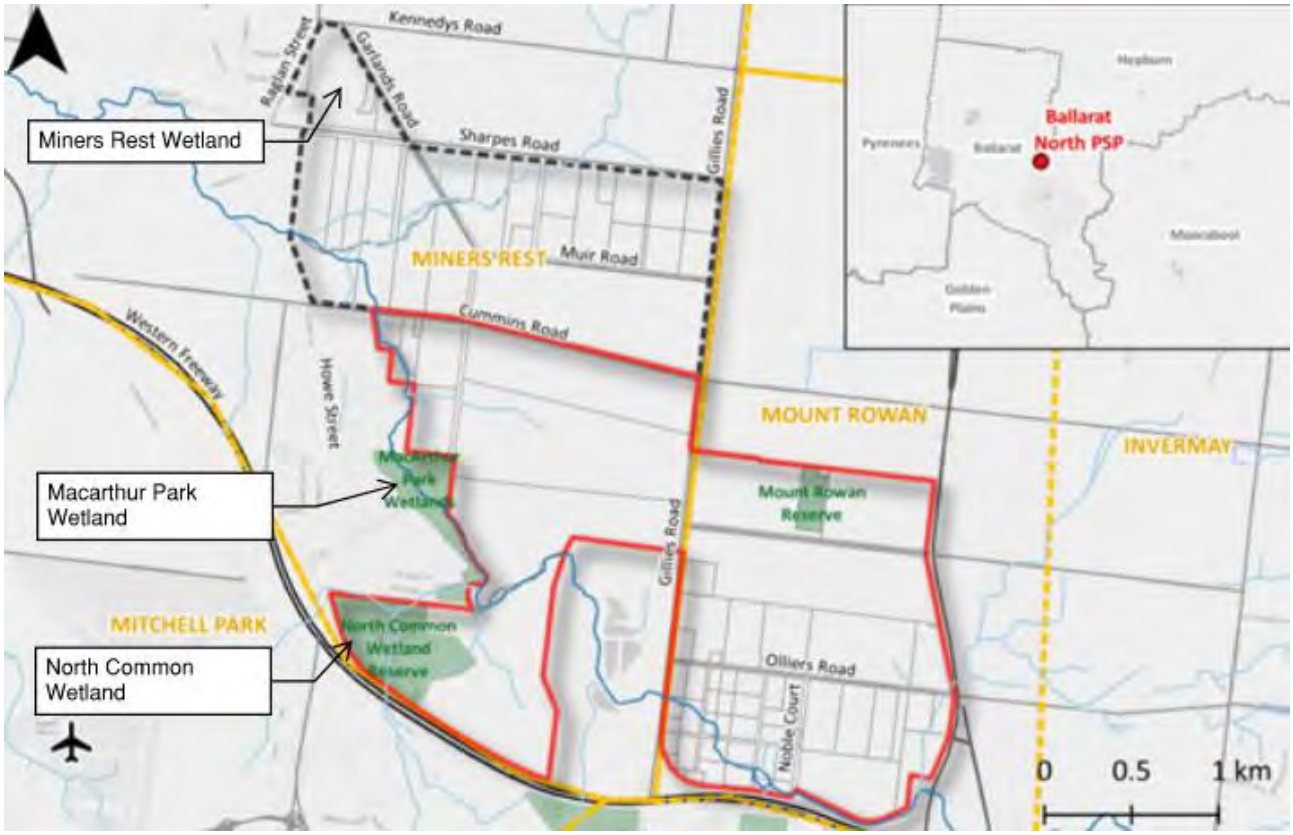


Figure 3-16 Existing wetlands around the PSP

3.3.4 Precinct Scale Stormwater Management Assets

Stormwater management assets to service development will be incorporated into land use planning for the PSP. Refer to Section 6 for the initial assessment of the location and size of precinct scale assets.

3.4 Lot and Street scale water-sensitive development

Water sensitive initiatives within development will be determined through the IWM approach for the site and depends on the nature of development. The water balance in Section 5 details the expected land uses and their anticipated water demands along with the wastewater and stormwater generated by development. Based on CHW's supplementary guide on Ballarat Potable Water Demand Target, CHW requires new developments to incorporate the principles of WSUD and IWM for any relevant PSPs or endorsed IWM plan to achieve the associated potable water reduction/substitution targets. CHW also suggests the incorporation of a 2kL or greater rainwater tank within every household as a minimum base case for residential developments within PSP areas/greenfield investigation areas in support of Ballarat City Integrated Water Management Plan and to reduce the reliance on potable water.

At a lot and street scale, a range of initiatives can be delivered that will enhance liveability and greening, while also driving alternative water use. As highlighted in Section 2, the VPA guidelines set objectives for support of street trees with alternative water sources, and contribution to the objectives of the Catchment Scale IWM Plans. Various development scale initiatives will be considered through the IWM plan development.

3.5 People, Place, Information, Economy

3.5.1 Community Infrastructure

IWM provides an opportunity to support liveability and community well-being through the management of water. This could include the provision of alternative water supplies to support greening and park irrigation, or other community facilities. It could also include opportunities to support community education and connections with water.

Figure 3-17 represents existing community facilities within close proximity to the core Ballarat North PSP area (also known as Northern GIA). A 400m and 800m radius has been shown from the closest schools, kindergartens, childcare centres and commercial precincts. New community facilities and open spaces will be integrated into the PSP, including local parks, town centres, schools and educational facilities.

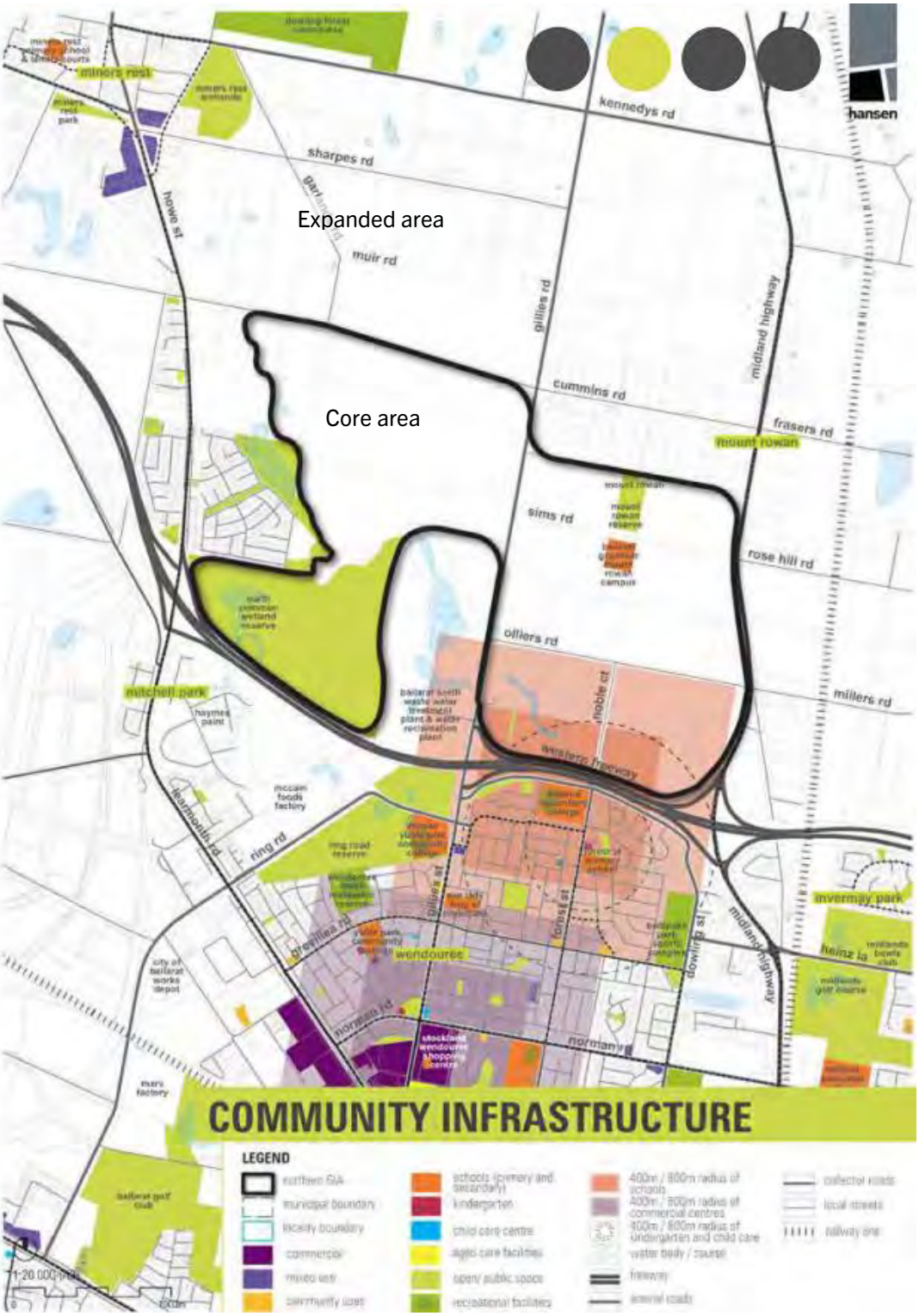


Figure 3-17 Community infrastructure (Hansen Partnerships Pty Ltd and Arup)

3.5.2 Cultural Heritage

As shown in Figure 3-18, there are areas of Aboriginal cultural sensitivity along the Burrumbeet Creek with a 200m buffer on either side of the creek. The IWM statement provided by WTOAC and included in Appendix F discusses the cultural significance of the water cycle as a whole.

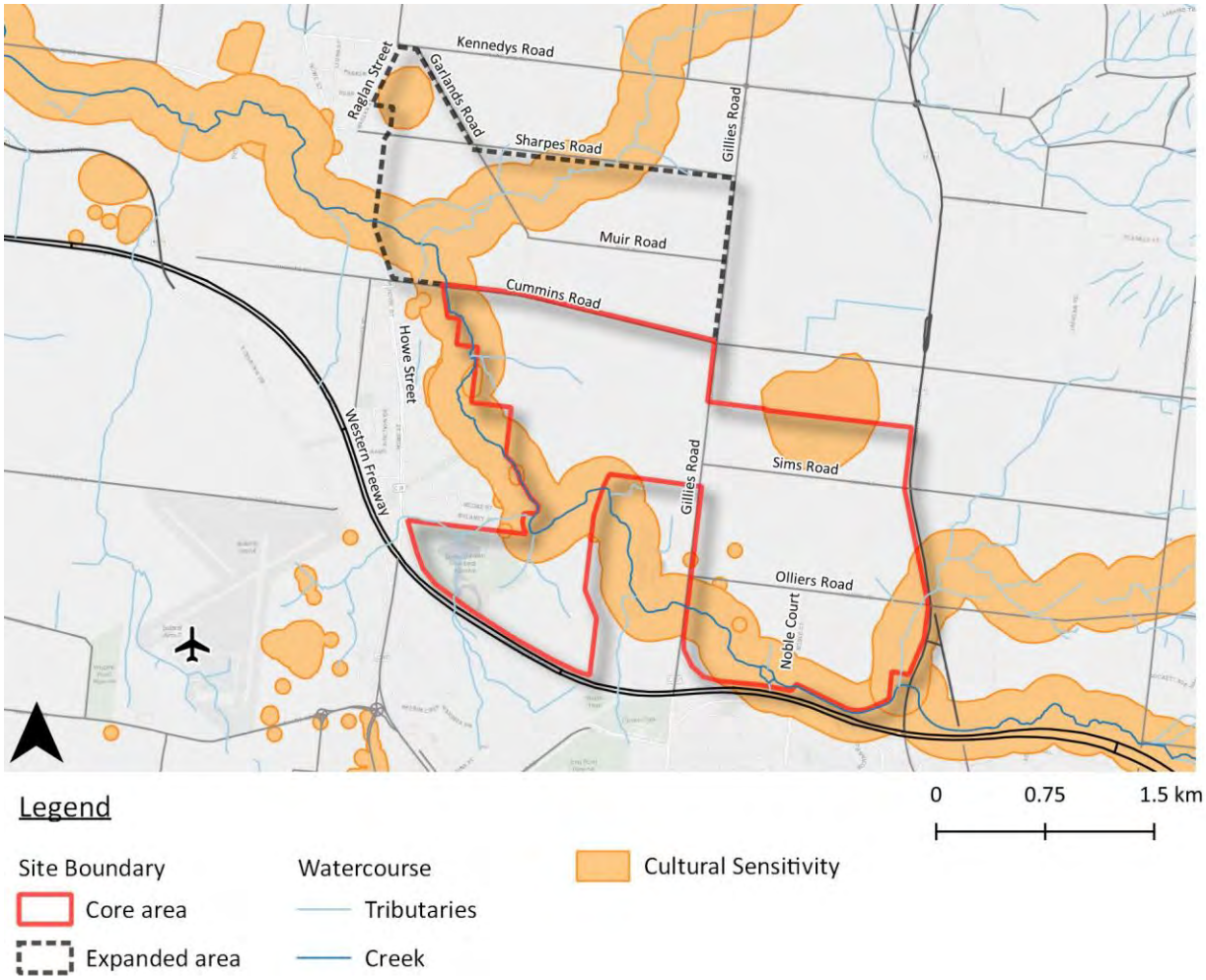


Figure 3-18 Cultural Sensitivity within and surrounding the Ballarat North PSP

Ballarat North PSP lies within the lands of the Wadawurrung People who are the traditional owners. Areas of cultural sensitivity have been designated where Aboriginal cultural places and objects are known or are likely to exist. The presence of these areas indicates the need for a Cultural Heritage Management Plan (CHMP) under the Aboriginal Heritage Act 2006. A CHMP focuses on tangible cultural places and objects. Whilst not mandated in the Aboriginal Heritage Act, a Cultural Values Assessment will be undertaken by the WTOAC to assess intangible heritage within the core area. The WTOAC Healthy Country Plan sets out the shared vision of the Wadawurrung people, which is summarised in Figure 3-19.

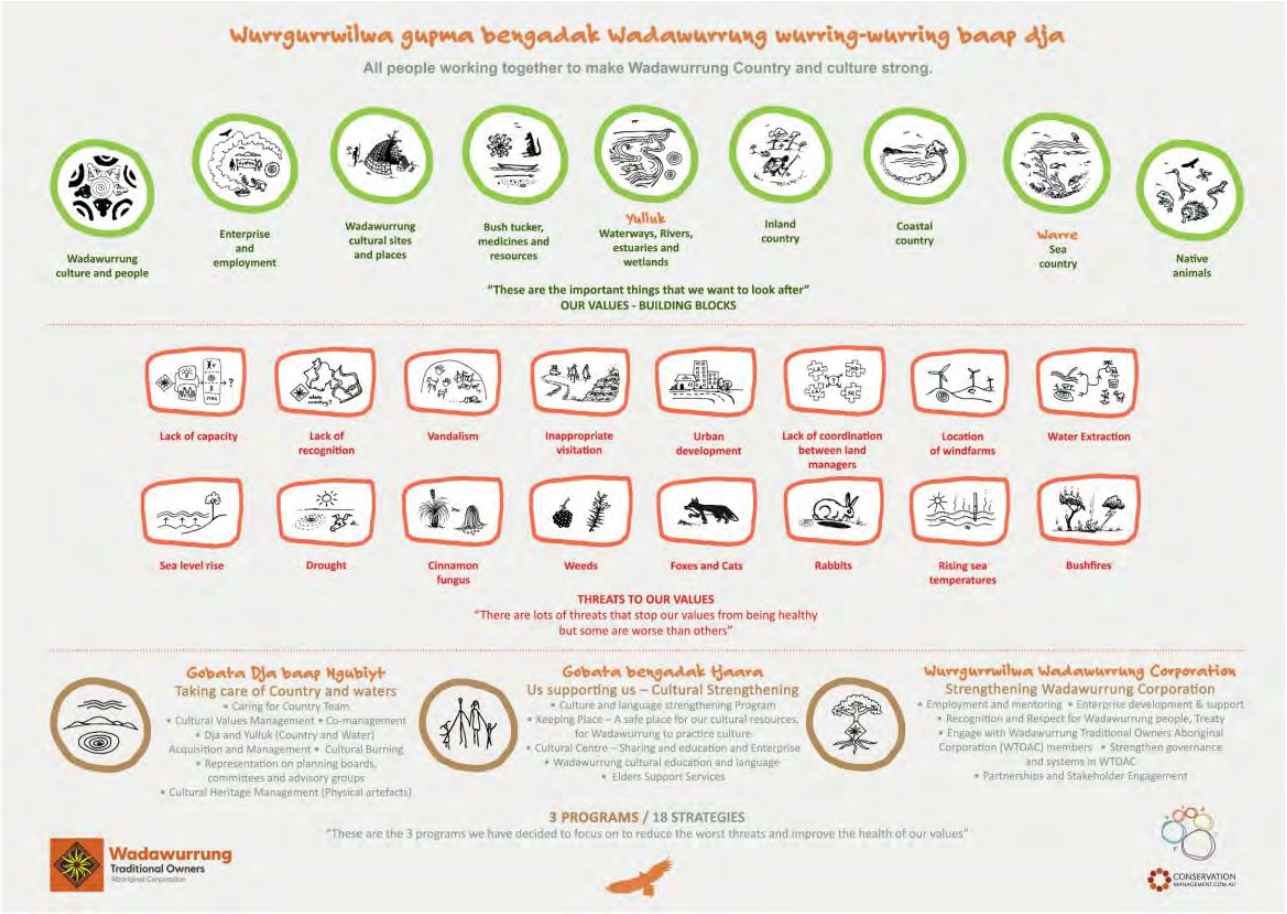


Figure 3-19 Shared values of the Wadawurrung people

Of note, the Healthy Country Plan acknowledges the importance of looking after waterways and reinstating cultural flows to maintain habitats for eel, perch, blackfish and yabbies. Furthermore, there are 2030 targets set out for cultural flows and water quality.

As part of this study, a statement from the WTOAC was shared with Arup via the VPA. The core principles and outcomes expressed in this statement, with respect to IWM are as follows:

- While treated storm water can be used to support environmental flows and systems, treated storm water must not to be used as Cultural Water - it should be used as the re-allocation source for systems in place, freeing up licenses and reducing extraction from natural systems, allowing passing flow management and future water entitlements to be handed back to Traditional Owners
- From Wadawurrung's perspective, rather than continually extract and license water from natural flowing systems, new sources of water like storm water and recycled water, through IWM projects can be used as the asset for sale, on selling it to users like irrigators, golf courses and other major industry
- The need to increase the confidence of users for alternative water sources so that waterways can begin to heal, and our Mobs can regain agency over what has always been theirs.
- People must understand that water that exists on Wadawurrung Country, must stay on Country as it is part of the holistic wellbeing of that landscape. It supports all aspects of life, from the deep water and the life within, to the banks with the river red gums, to the grass lands and bushland surrounding, the canopies and the birds that live above right through to the sky country that feeds the water back into the landscape.

4. Site Mapping and Constraints Analysis

The key constraints for Ballarat North PSP are shown in Figure 4-1. The data sources for the constraints map are listed in Table 4-1.

Table 4-1 Data sources for Ballarat North PSP Constraints Map

Dataset	Source	Dataset Custodian
Planning Overlays	Vicmap Planning- Planning Scheme Overlay (Extracted from Datashare in August 2023)	Department of Energy, Environment and Climate Action
Cultural Sensitivity	Areas of cultural heritage sensitivity (Extracted from Datashare in August 2023)	Department of Premier and Cabinet
Existing Utility Network	Georeferenced from Hansen Partnerships Pty Ltd and Arup (2018)	N/A
Former Landfill Site	Georeferenced from Hansen Partnerships Pty Ltd and Arup (2018)	N/A

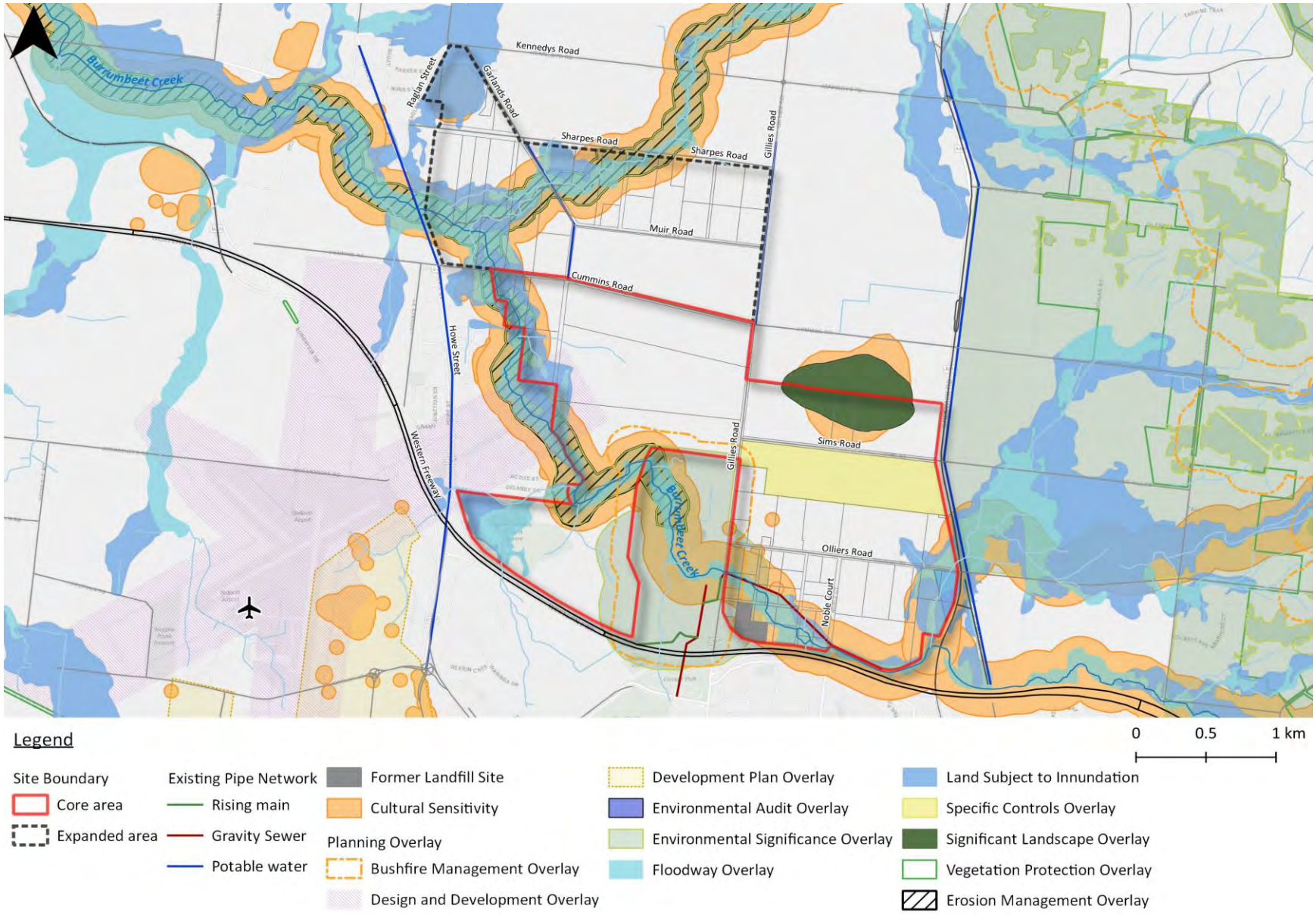


Figure 4-1 Ballarat North PSP Constraints Map

5. Defining the base case: Water and pollutant balance

A ‘base case’ was developed which characterises the water and pollutant balance for the development area; understanding water demands, wastewater generation and stormwater generation.

The base case was completed using a high-level land use budget provided by the VPA to Arup on 26/09/2023. This land use budget is indicative in nature and will vary as the PSP planning progresses. The land use breakdown and areas were used to calculate water demands for the proposed development, as well as flow, and pollutant loads generated as a result of the site. These can then be used as a base for comparison for future IWM solutions.

5.1 Development scenarios

This report investigates the base case for two scenarios:

- Scenario A: Core Area only
- Scenario B: Core Area and Expanded Area

Figure 5-1 shows the draft land use budget for Ballarat North PSP based on two scenarios; one being only the Core Area is developed, and the other being the Core and Expanded area are developed. The average residential density assumed for residential areas is 20 dwellings/ha.

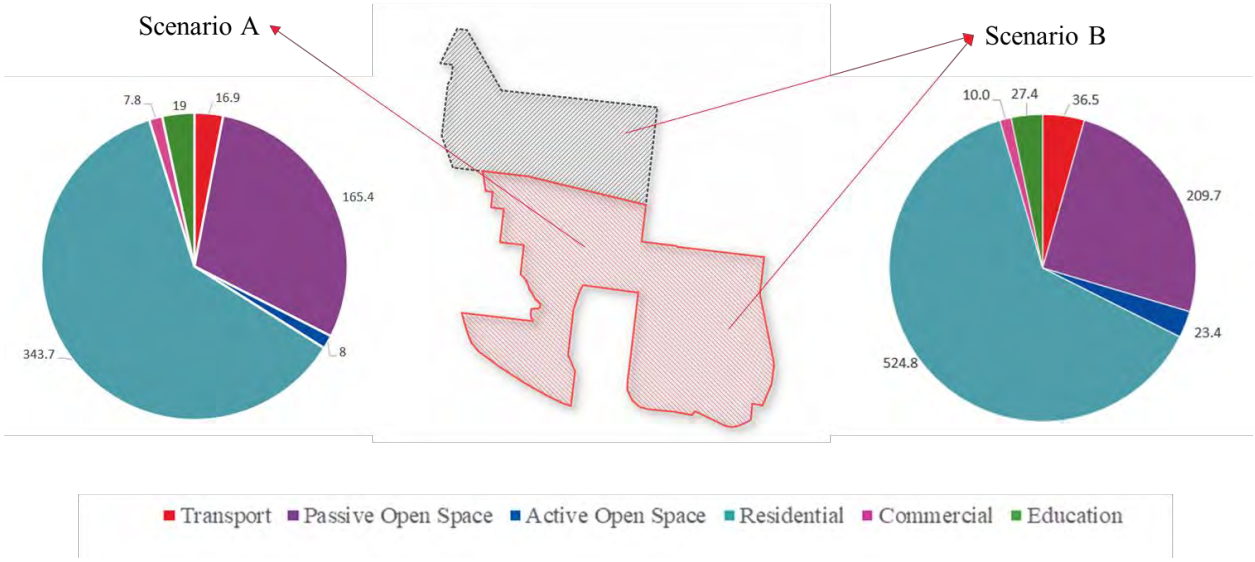


Figure 5-1 Proposed land use budget for Scenario A and B (values are in ha)

5.2 Water demands

To calculate the anticipated water demands, and wastewater generation volumes for the PSP, the assumptions shown in Table 5-1 were adopted.

Table 5-1 Water demand assumptions

Type	Water Demand	Unit	Assumption source
Residential potable water demand	126.9	kL/hh/year	Ballarat Potable Water Demand Target (CHW, 2018)
Residential non-potable water demand (includes toilet flushing, outdoor use and laundry)	43.3	kL/hh/year	Ballarat Potable Water Demand Target (CHW, 2018)

Type	Water Demand	Unit	Assumption source
Commercial	730	kL/ha/year	Previous Arup projects
Passive Open Space	2000	kL/ha/year	Previous Arup projects
Active Open Space	5000	kL/ha/year	Previous Arup projects

The assumptions outlined in Table 5-1 were applied to the land use budget received from VPA. Figure 5-2 represents estimated demands for Scenario A and B. Here buildings represent residential and commercial.

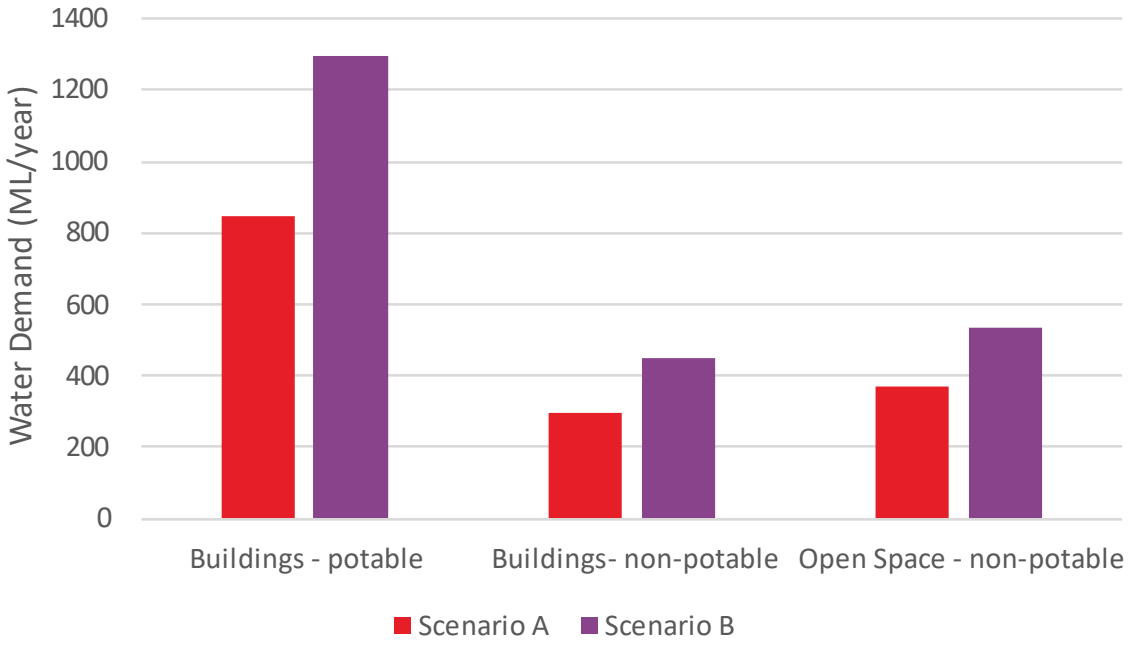


Figure 5-2 Demand Estimation for Scenario A and B

Ballarat Potable Water Demand Target Supplementary Guidelines state a compulsory potable water target of 124 L/p/d within the PSP and has recommended the utilisation of WSUD to meet this target. Based on these guidelines, 36% of the non-potable water demand is met using a 2kL rainwater tank with approximately 60% reliability. This approach has been adopted the base case analysis in Section 5.4.

5.3 Wastewater generation

Assuming a typical conversion of 80% of water use within buildings is transferred to the wastewater system, 911 ML/year or 1387 ML/year of wastewater is expected to be generated by scenario A and scenario B respectively. Wastewater from the site will be drained to the adjacent Ballart North WWTP.

5.4 Stormwater volume and pollutant generation

The volume of stormwater generated by the developed area and the pollutants within stormwater have been modelled. MUSICX modelling was undertaken using meteorological data (Station 89002 Ballarat Aerodrome) from Bureau of Meteorology over a 10-year period (2010-2020) to determine flows and pollutant loads for predevelopment and post development.

Stormwater generation within the development area will depend on the relative imperviousness of development, and the degree to which source control management measures are included within development. Central Highlands Water currently applies development guidelines, which encourage developers to include a rainwater tank as part of the provisions to reduce water demand. Harvesting rainwater at a lot scale will also reduce stormwater runoff and associated pollutants reaching Burrumbeet

Creek. However, the success and longevity of CHW's guidelines is unknown (in terms of compliance and ongoing maintenance and effectiveness).

In both cases, it is assumed that precinct-scale stormwater treatment wetlands would be constructed to achieve BPEM standards for stormwater pollutants. However, if rainwater tanks are included (and effective) the size of the precinct scale wetlands could be significantly reduced.

Accordingly, within the base case, two options have been assessed for Scenario A and B;

- **Option 1: Development without rainwater tanks:** Post development scenario using the areas provided in the land use budget. This option assumed the presence of wetland/s before discharge into the Burrumbeet Creek, which have an indicative total surface area of 8 – 12 ha. This wetland was included to meet Best Practice Environmental Management (BPEM) as set out in the Victorian Planning Provisions as listed in Section 2.2.
- **Option 2**: **Development with rainwater tanks:** Post development scenario using the areas provided in the land use budget accounting for *Ballarat City Integrated Water Management Plan*'s compulsory potable water use target for residential developments within PSP areas. This option assumes a minimum of 2 kL rainwater tank to be used for toilet, laundry, and outdoor areas in every household. This option also assumes the presence of wetlands before discharge into Burrumbeet Creek to meet BPEM targets as listed in Section 2.2. In this case the minimum wetland area required to meet best practice standards for pollutant removal would have an indicative total surface area of 2.2 – 3 ha.

Table 5-2 shows the assumed impervious fraction for the land use budget and key model inputs based on Melbourne Water MUSIC Guidelines (2018) and design assumptions are as follows:

- Source Nodes
  - Soil Storage Capacity: 120 mm
  - Field Capacity: 50 mm
- Wetland
  - Extended Detention Depth for wetland: 350 mm
  - Evaporative Loss as % of PET: 125 %
  - Detention Time: 72 hours
  - Permanent Pool Volume: 40% of wetland surface area
  - Inlet Pond Volume: 10% of wetland surface area

Table 5-2 Land use budget assumed imperviousness.

Land Use Type/ Source Nodes	Assumed Imperviousness	Scenario A - Core Area (ha)	Scenario B – Core + Expanded Area (ha)
Transport	70%	16.9	36
Passive Open Space	10%	165.4	210
Active Open Space	10%	8	23
Residential (assuming high density)	85%	343.7	525
Commercial	70%	7.8	10
Education	70%	19	27
TOTAL (ha)		**560.8**	**832**

Appendix B shows the MUSICX models for Option A and B. Table 5-3 summarises the stormwater treatment results for Option 1 using a wetland sized 80,000 m^2 and 120,000 m^2 for Scenario A and Scenario B respectively.

Table 5-3 Option 1: MUSICX results for Scenario A and B

	Scenario A - Core			Scenario B – Core + Expanded		
	Source	Post-treatment	% Reduction	Source	Post-treatment	% Reduction
Flow (ML/yr)	2,036.2	1908.7	**6.3%**	3,078	2,887	**6.21%**
Total Suspended Solids (kg/yr)	366,629	49,961	**86.4%**	573,511	82,797	**85.6%**
Total Phosphorus (kg/yr)	812	232	**71.4%**	1,174	331	**71.8%**
Total Nitrogen (kg/yr)	5,516	3,054	**45%**	8,522	4,633	**45.6%**
Gross Pollutants (kg/yr)	68,032	0	**100%**	104,292	0	**100%**

Table 5-4 summarises the stormwater treatment results for Option 2 using a wetland sized 22,000 m^2 and 30,000 m^2 for Scenario A and Scenario B respectively and assuming a 2kL rainwater tank for each household meeting 66% of non-potable demand.

Table 5-4 Option 2: MUSICX results for Scenario A and B

	Scenario A - Core			Scenario B - Core + Expanded		
	Source	Post-treatment	% Reduction	Source	Post-treatment	% Reduction
Flow (ML/yr)	2,036.2	1,447.5	**28.9%**	3,078.1	2,186.9	**28.9%**
Total Suspended Solids (kg/yr)	369,559	74,775.4	**80%**	541,950.8	100,978.6	**81.3%**
Total Phosphorus (kg/yr)	807.2	278.8	**65.4%**	1,326.4	454.3	**65.7%**
Total Nitrogen (kg/yr)	5,563.9	3,011.8	**45.8%**	8,433.9	4,623.6	**45.1%**
Gross Pollutants (kg/yr)	68,032.7	0	**100%**	104,292.9	0	**100%**

Based on the stormwater pollutant results (Table 5-3 and Table 5-4), the target reductions for TSS, TP and TN are achieved (80%, 45%, 45% respectively). However, the more recent stormwater harvesting and infiltration targets (29% and 7% respectively) set out in the Urban Stormwater Management Guidance (see Section 2.2) are not achieved in Option 1 due to the presence of wetland only, however, Option 2 meets the harvesting target due to the presence of a 2kL rainwater tank for every household. Achieving the infiltration target would require further interventions, such as increased permeable surfaces or infiltration areas.

Opportunities to meet both the harvesting and infiltration targets set out in the Urban Stormwater Management Guidance will be explored through the analysis of possible IWM opportunities.

5.5 Summary water and pollutant balance

Figure 5-3 provides a summary for base case for Ballarat North PSP Scenario A with core area only and Figure 5-4 provides a summary for base case for Ballarat North PSP Scenario B with core and expanded area.

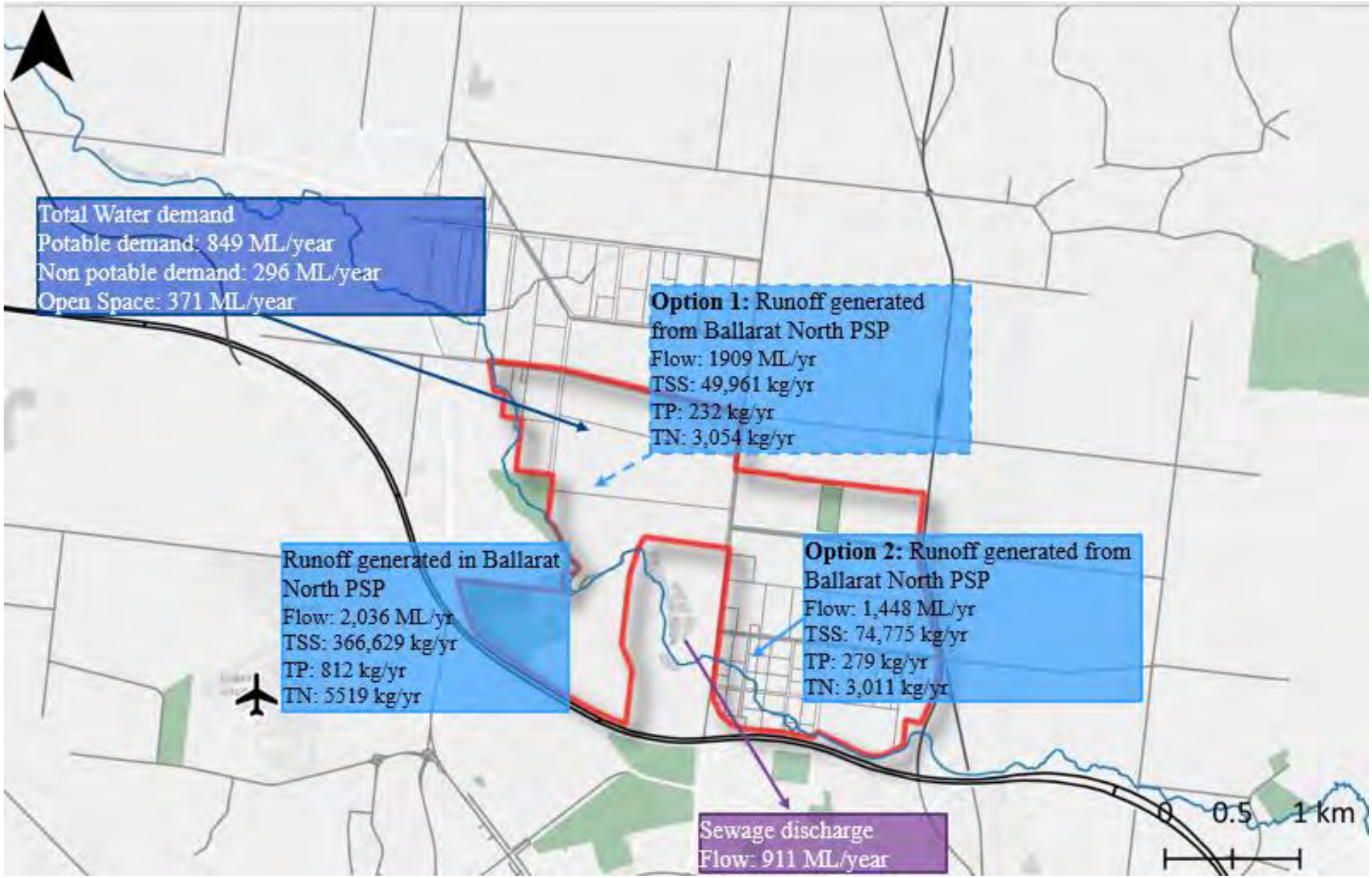


Figure 5-3 Water and Pollutant Balance Base Case Summary for Scenario A (Core area only)

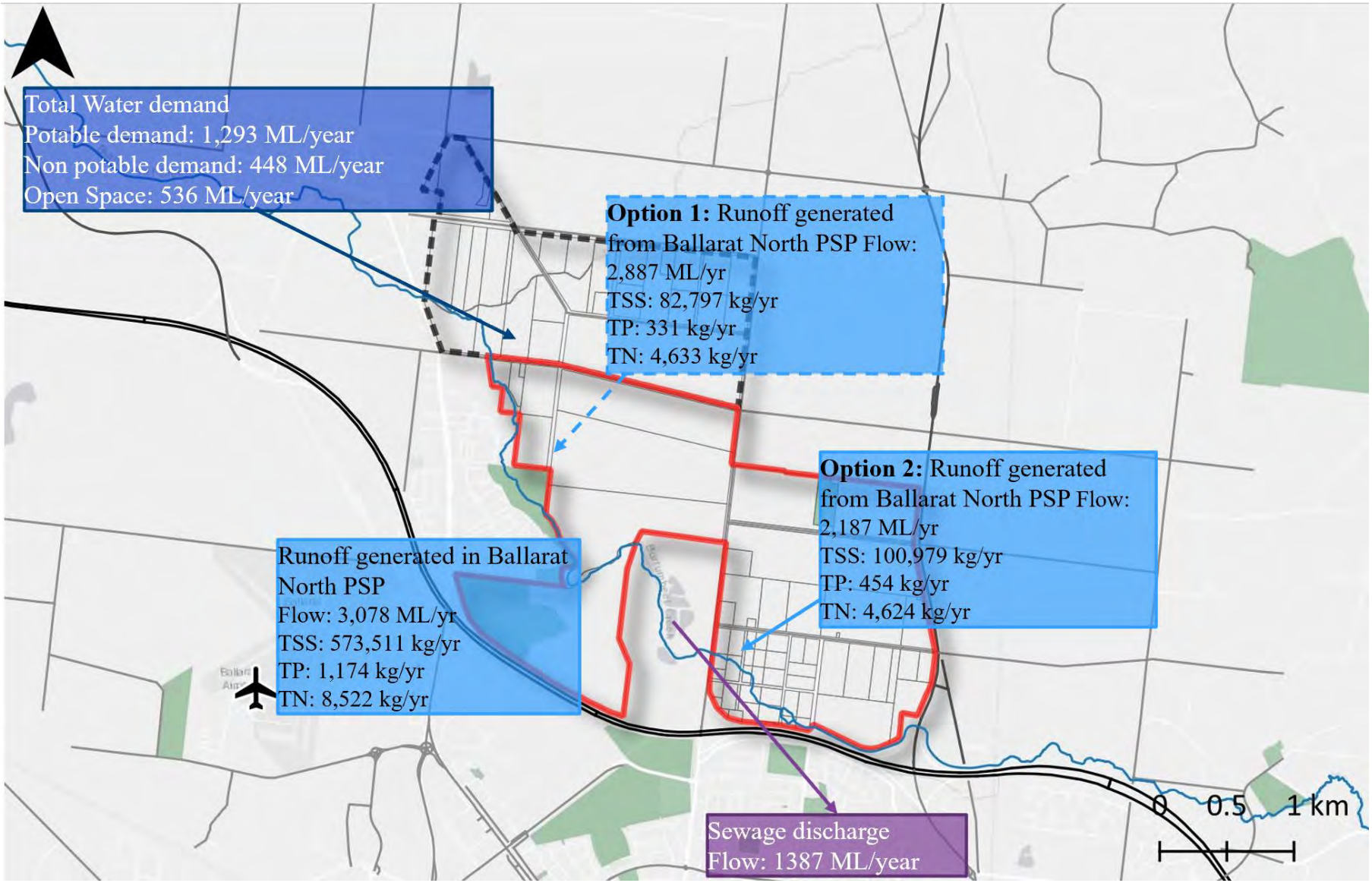


Figure 5-4 Water and Pollutant Balance Base Case Summary for Scenario B (Core and expanded area)

6. Defining the base case: Drainage and Flood Management

Hydrological modelling using RORBwin Version 6.45 was undertaken to determine stormwater flows within the PSP area for the pre-developed and post developed scenarios. Results from an existing hydraulic (TUFLOW) model were used to determine flood extents within the PSP area for the 1% AEP plus climate change event.

6.1 Previous studies

A flood investigation of the Burrumbeet catchment was completed by Water Technology in 2013 for the Glenelg Hopkins Catchment Management Authority (GHCMA). RORB and TUFLOW models of the Burrumbeet catchment were provided by the GHCMA for use in this assessment.

6.2 Hydrological modelling

The GHCMA RORB model of the Burrumbeet catchment was used to determine pre and post developed flows for the PSP area.

The following modifications were made to the RORB model within the PSP area:

Catchment Layout

- Sub-areas, reaches and nodes area were modified as shown in Figure 6-1.
- Reach Type 1 (Natural) was used for pre-developed reaches.
- Reach Type 2 (Excavated but unlined) was used for post-developed reaches (as recommended for flow down a road in AM 6200 - Melbourne Water Guide to Flood Mapping Project Specifications).

Fraction Impervious (FI)

- Pre-developed FI was determined based on current aerial imagery.
- FI values for the post-developed subareas were based on the 'DRAFT Ballarat North Concept Land Use 2023-09-26'. The assumed FI value for each land use type can be found in Table 6-1.

Pre and post developed FI values for each of the subareas within the PSP boundary can be seen in Table 6-2.

Parameters

- A Kc (RORB routing parameter) value of 7.53 has been adopted within the PSP area for both the pre and post developed model
- Continuing loss (i.e. the loss applied throughout the storm duration) values within the PSP area were modified for the post-developed model to represent the increase in impervious area. A CL value of 2mm/hour was used. This is within the range of CL values recommended for areas indirectly connected to the drainage network in AM 6200 - Melbourne Water Guide to Flood Mapping Project Specifications.

Table 6-2 contains a summary of modelled inputs of the subareas included in the PSP area. Note that minimal development was assumed for subareas **DI, CW** and **CM** as most of the area is inundated in the 1% AEP plus climate change event, and therefore they have been assigned Reach Type 1 (Natural) (discussed further in Section 6.4.5).

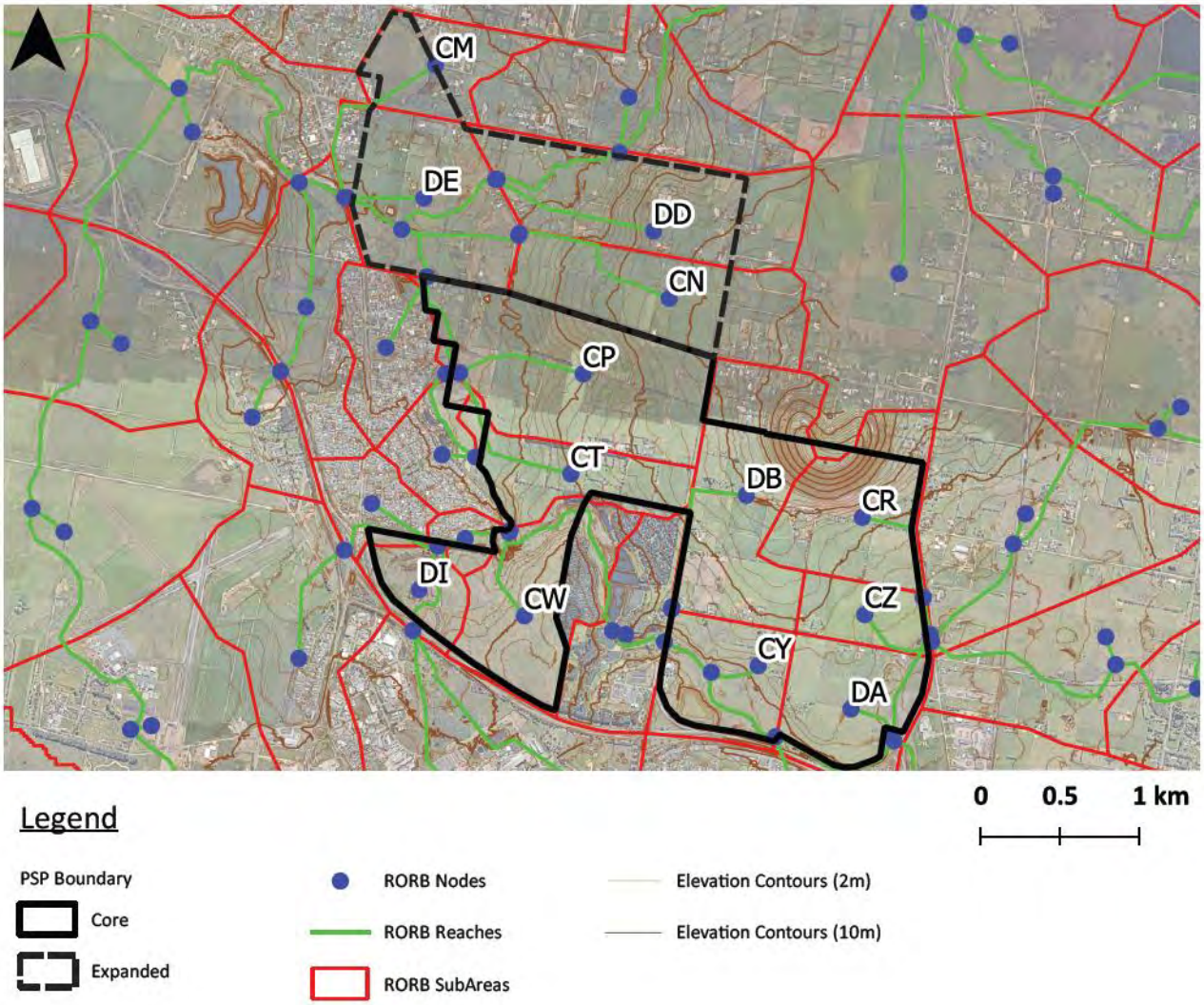


Figure 6-1 RORB Model Catchment Layout (note labels refer to subarea names)

Table 6-1 Adopted FI Values

Land Use	Adopted FI
Community Facilities	0.7
Drainage (Floodway)	0.05
Education	0.7
Local Open Space	0.1
Municipal	0.7
Non-Arterial Road	0.7
Other	0.7
Residential	0.85
Town Centre	0.7

Table 6-2 RORB Model Summary

Subarea	Area (km^2)	FI		Reach Length (km)	Reach Slope (%)	Reach Type	
		Pre-Dev	Post-Dev			Pre-Dev	Post-Dev
CR	0.817	0.100	0.690	0.76	1.2	1 Natural	2 Excavated but unlined
CZ	0.323	0.100	0.830	0.57	3.5	1 Natural	2 Excavated but unlined
DA	0.705	0.155	0.640	0.33	1.1	1 Natural	2 Excavated but unlined
CY	0.614	0.155	0.500	0.32	1.9	1 Natural	2 Excavated but unlined
DB	1.082	0.120	0.620	1.1	1.6	1 Natural	2 Excavated but unlined
CW	0.910	0.100	0.100	0.59	1.8	1 Natural	1 Natural
DI	0.309	0.105	0.105	1.07	1.4	1 Natural	1 Natural
CP	1.348	0.100	0.790	0.8	1.7	1 Natural	2 Excavated but unlined
CT	0.547	0.100	0.750	1.1	1.4	1 Natural	2 Excavated but unlined
DD	1.194	0.125	0.590	1.1	2.9	1 Natural	2 Excavated but unlined
CN	0.963	0.100	0.510	1.1	2.4	1 Natural	2 Excavated but unlined
DE	1.018	0.175	0.650	0.48	0.8	1 Natural	2 Excavated but unlined
CM	0.496	0.135	0.260	1.26	0.7	1 Natural	1 Natural

6.3 Hydraulic Modelling

1% AEP plus climate change results from a TUFLOW model of the Burrumbeet catchment were provided by the GHCMA for use in this assessment. These results were used to determine and comment on flood extents across the PSP area.

The climate change scenario considered a 20% increase in rainfall. Based on the Australian Rainfall and Runoff (ARRO) climate change factors for this area this increase is larger than what is expected for the 2100 projection.

6.4 Results of hydrology and hydraulic assessment

6.4.1 Site Context

A conceptual stormwater strategy for the PSP site has been developed including:

- Detention basin sizing to not exceed pre-developed flows in the 1% AEP event
- Minor (20% AEP) and major (1% AEP) flow conveyance
- Indication of any potential flood risks from the Burrumbeet Creek catchment (with consideration of climate change)

Appendix C contains a catchment layout and drainage schematic that has been developed for the PSP area. This includes basin locations, flow paths and the 1% AEP plus climate change flood extent.

Sizing of detention basins, pipes and channels is outlined below.

6.4.2 Pre and Post Developed Flows

Table 6-3 contains 20% AEP and 1% AEP pre and post developed flows for each of the subareas in the PSP area.

Table 6-3 Pre and Post Developed Flows

Subarea	Pre-developed maximum flow (m^3/s)		Post-developed maximum flow (m^3/s)	
	20% AEP	1% AEP	20% AEP	1% AEP
CR	1.86	4.41	5.30	11.23
CZ	0.82	1.91	1.96	4.14
DA	3.19	7.07	6.76	13.92
CY	2.78	6.16	6.07	12.86
DB	1.86	4.49	5.91	13.13
CW	2.65	6.14	2.65	6.14
DI	0.14	0.48	0.14	0.48
CP	3.15	7.46	9.51	19.51
CT	0.83	2.02	2.83	6.22
DD	2.17	5.20	7.50	16.01
CN	1.53	3.71	5.30	11.63
DE	3.64	8.24	4.13	9.43
CM	0.63	1.60	0.72	1.80

6.4.3 Detention Basins

Basins have been sized in RORB to detain post-developed 1% AEP flows to pre-developed levels. Basin locations can be seen in Appendix C and sizes are summarised in Table 6-4.

Basins have been sized for Option 1: Development without rainwater tanks.

The following assumptions apply to the sizing of the detention basins:

- 1 in 8 side slope
- Maximum depth of 1.2m
- 300mm freeboard
- Sized for Option 1: development without rainwater tanks

Table 6-4 Detention Basin Sizing

Asset Name	Subareas Captured	Maximum Outflow (m^3/s)	Outflow Pipe Size (mm)	Volume (m^3)	Area (m^2)	Note
Basin 1	DD	5.2	2 x 750	20,160	17,300	
Basin 2	CN, DE	3.7	2 x 600	28,080	40,000	Outflow sized for subarea CN with additional volume included for subarea DW
Basin 3	CP, CT	9.5	3 x 675	42,240	35,900	
Basin 4	CY, DB	4.5	2 x 675	68,640	57,600	Outflow sized for subarea DB with additional volume included for subarea CY
Basin 5	DA	4.5	2 x 825	10,800	9,400	
Basin 6	CR, CZ	5.2	2 x 750	23,520	20,100	

Note that basins 1 and 2 are within the expanded area and will not be required if this area is not developed.

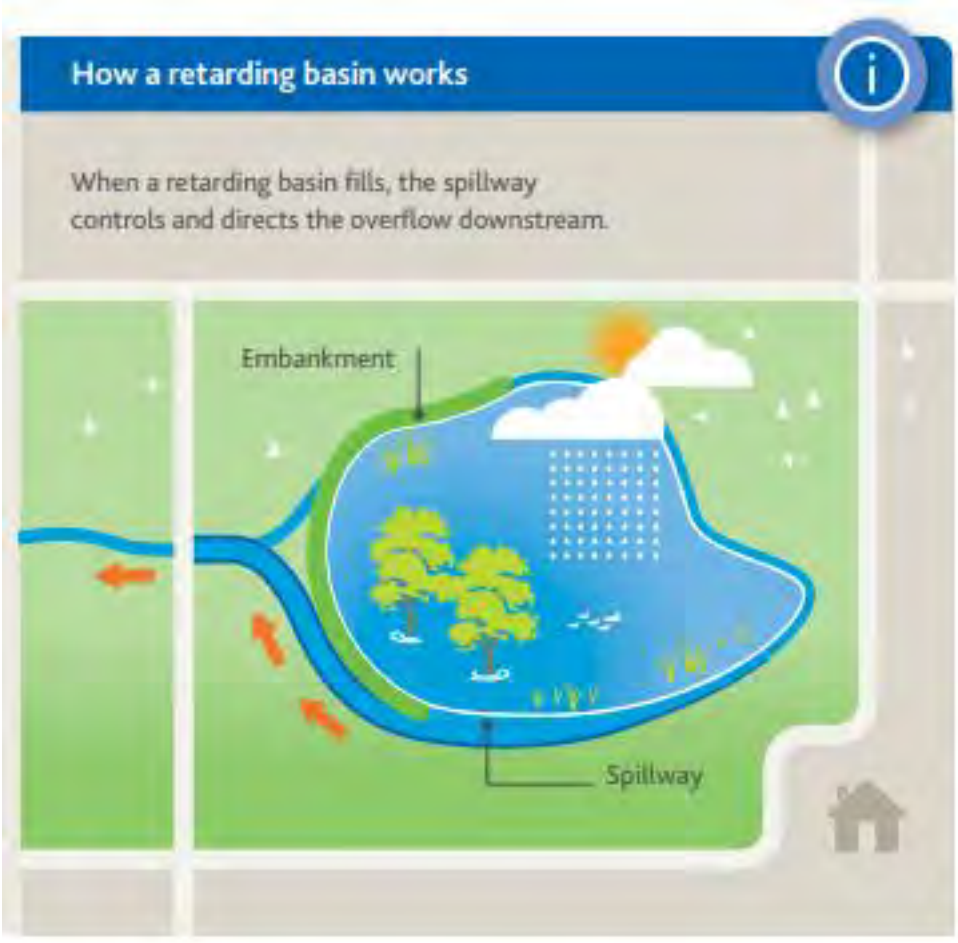


Figure 6-2 - Retarding Basin Schematic (Source: Melbourne Water, Upgrade of Hawthorn East)

6.4.4 Drainage Network

Minor Flows

Pipes have been sized to convey minor (20% AEP) flows in an underground drainage network. Table 6-5 contains the sizes of pipes shown in the drainage schematic (Appendix C).

Table 6-5 Minor Flows and Pipe Sizing

Asset Name	Flow (m^3/s)	Grade (%)	Size (mm)
Pipe 1	7.50	1	1200
Pipe 2	5.30	1	1200
Pipe 3a	9.51	1	1500
Pipe 3b	2.83	1	900
Pipe 4	5.91	1	1200
Pipe 5	6.76	1	1350
Pipe 6	5.04	1	1050

Major Flows

Gap flows greater than the 20% AEP and up to the 1% AEP will be conveyed overland via the road network. The overland flow associated with each of the pipes are summarised in Table 6-6 below.

A cross check was completed using Manning's Equation for a standard road cross section with the following parameters:

- Width: 11.7m
- Manning's: 0.2
- Slope : 3%

It is assumed that the road can convey up to $10m^3/s$ at a depth of 250mm.

Table 6-6 Major Flows

Flow Path	Gap Flow (1% AEP - 20% AEP Flow) m^3/s
Overland Flow 1 – Road	8.5
Overland Flow 2 – Road	6.3
Overland Flow 3a – Road	10
Overland Flow 3b – Road	3.4
Overland Flow 4 – Road	7.2
Overland Flow 5 – Road	7.1
Overland Flow 6 – Road	6.2

Optional Drainage Channel in North Ballarat Common

A conceptual broad overland flow path has been sized to estimate corridor requirements to manage flows from subarea CW (North Ballarat Common). It has been advised by VPA that this area will not be developed therefore the proposed channel is an optional feature that could be considered for a multi-use stormwater management feature in the future, should the Council wish to undertake this.

Table 6-7 outlines the 1% AEP flow rate and overland flow path sizing. The sizing is based on the assumption of co-located activities (e.g. public use). The overland flow path has been sized for the pre-developed (i.e. existing) flow rate.

A 50-metre buffer has been used at the channel to allow for the flow path width plus any additional waterway corridor features (see Figure 6-4 for an example cross section).

Table 6-7 Channel Sizing

Flow Path	1% AEP Pre Developed Flow (m^3/s)	1% AEP Post Developed Flow (m^3/s)	Channel Slope (m/m)	Bed Width (m)	Side Slope	Manning's	Depth (m)	Velocity (m/s)
Overland Flow 7 - Channel	6.14	6.53	0.02	20	1 in 3	0.05	0.26	1.13

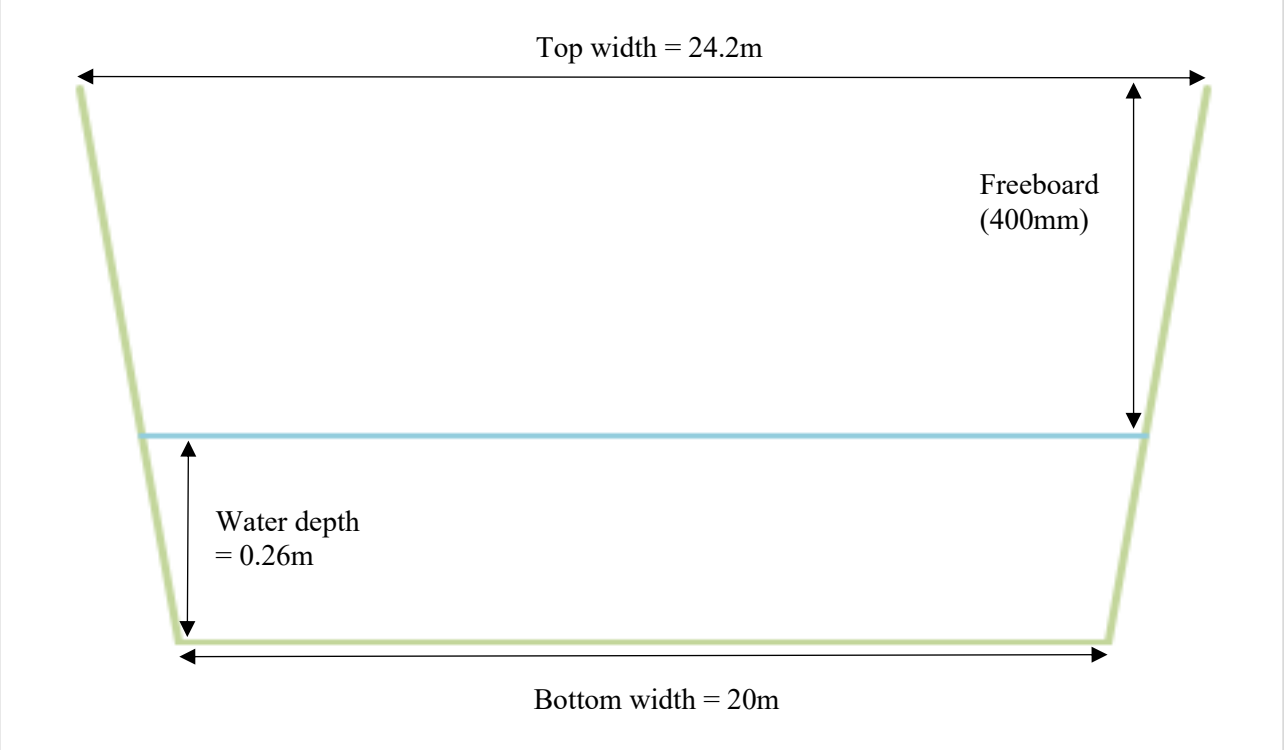


Figure 6-3 Channel Schematic

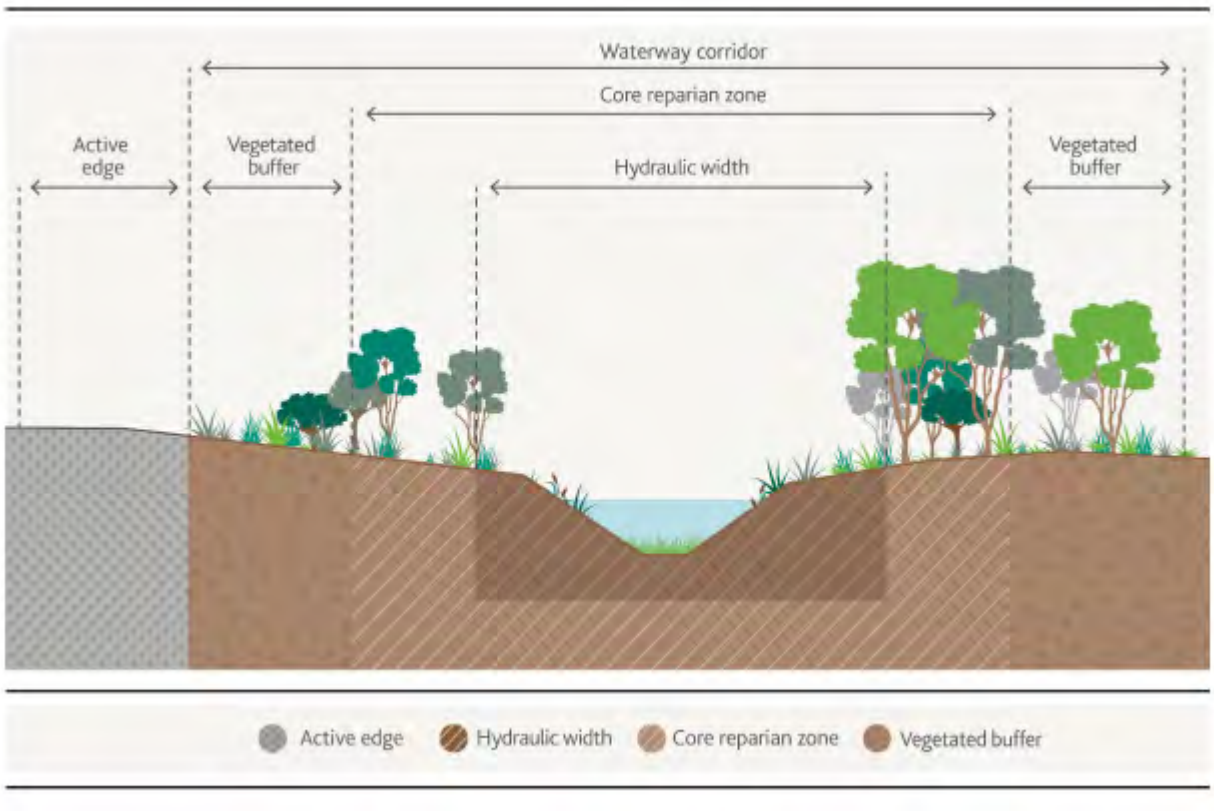


Figure 6-4 Example water corridor section for a constructed waterway (Source: Waterway Corridor Guidelines, Melbourne Water, 2013)

6.4.5 Flood Risk

Parts of the PSP area is inundated in the 1% AEP plus climate change event as seen in Figure 6-5. The following is recommended to mitigate flood risks during development of the area:

- All development should be located outside of the 1% AEP plus climate change event.
- Detention basins to control post-developed flows should be located out of the 1% AEP plus climate change event (basin locations relative to the flood extent can be seen in Appendix C).

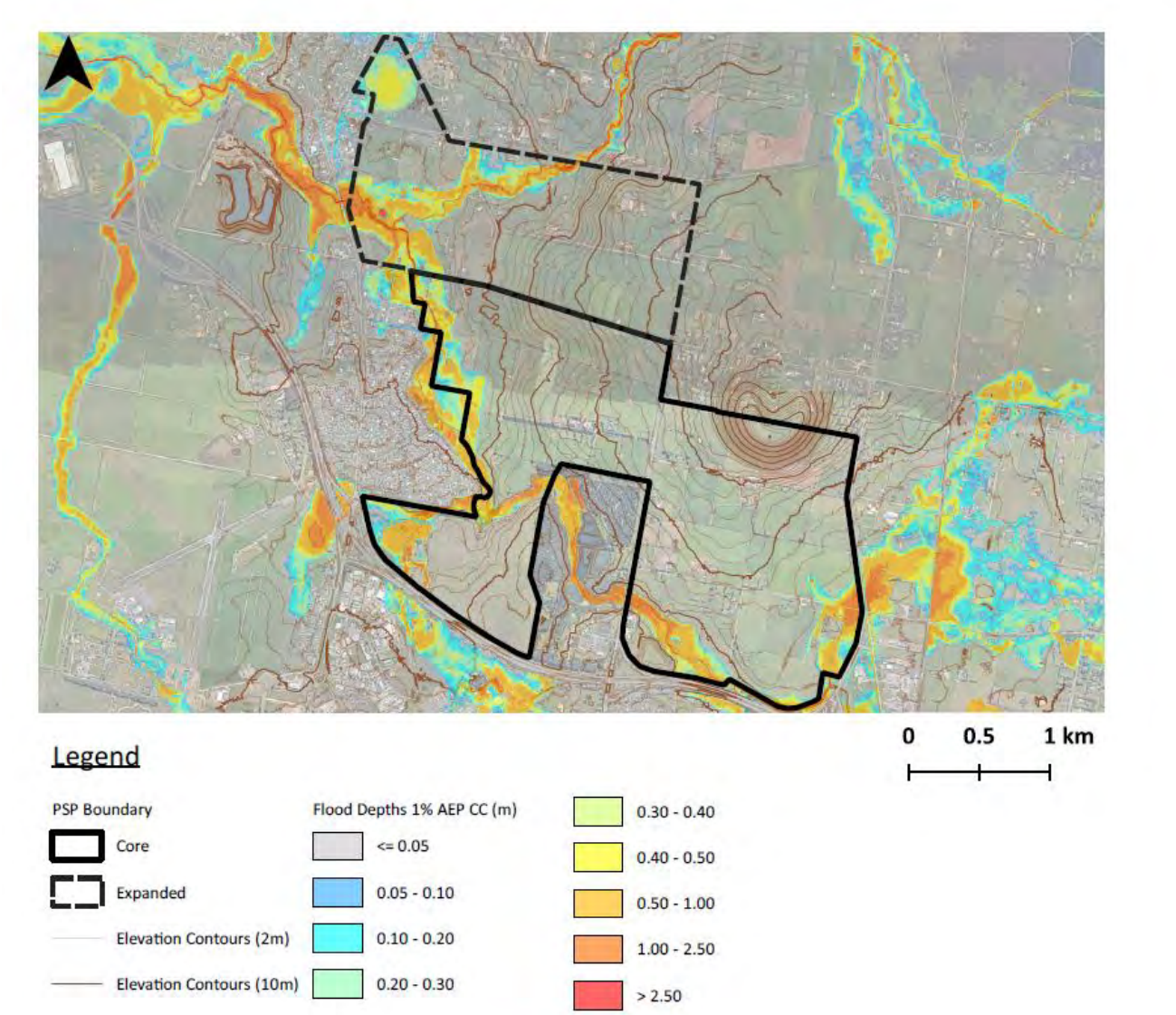


Figure 6-5 1% AEP Plus Climate Change Flood Extent (Source: GHCMA Burrumbeet Creek TUFLOW Model)

Part B: IWM Option Assessment and Recommendations

7. IWM Shared Vision

Following the Contextual Analysis and Base Case phase of this study, an IWM Shared Vision workshop took place on 30th November 2023. The list of attendees is shown below.

Table 7-1 List of attendees at Ballarat North PSP IWM Shared Vision Workshop

Organisation	Name	Role
Victorian Planning Authority (VPA)	Patricia OCampo	Senior Strategic Planner
	Noor Syuhada Shamsul	Strategic Planning Manager
	Lucy McGovan	Planner
	April Chan	Infrastructure Engineer
	Pete Murrell	Senior Sustainability Advisor
Arup	Celeste Morgan	Project Director and IWM Lead
	Ayisha Paw	Project Manager and Senior Engineer
	Polly Wright	Flooding and Hydrology Engineer
	Meredith Yates	IWM Undergraduate Engineer
City of Ballarat (CoB)	Fiona Koutisvos	Sustainable Growth Principal Planner
	Justin Hinch	Coordinator Development Engineering
	Mario De La Pena	Growth areas infrastructure engineer
Central Highlands Water (CHW)	Stephen Carter	Manager Growth & Development
	John Frdelja	Strategic Asset Management and Planning Manager and IWM Forum member
Department of Energy, Environment and Climate Action (DEECA)	Molly M Kinghorn	Natural Environment Programs Native vegetation and Biodiversity
	Felicity G Christian	Natural Environment Program
	Carly J Kuczer	Planning and Approvals Officer
	Natalie Cursio	Natural Environment Programs
Glenelg Hopkins Catchment Management Authority (GHCMA)	Peter Robertson	Waterway Planning Manger

The objective of the workshop was to present findings from the Contextual Analysis and Base Case report, which was circulated to attendees prior to the workshop, as well as to determine desired goals, directions, and outcomes for the PSP to guide the development of the IWM Plan and drainage strategy.

Attendees were asked to develop desired outcomes and place them under the relevant category. For example, minimising flood risk downstream of the development, or making Ballarat an attractive and sustainable place to live. The desired outcomes were then themes based on lot, street and precinct scale.

The main areas of interest and concern from each stakeholder groups were:

- CoB: Adoption, maintenance and staffing requirements for IWM solutions
- CHW: The requirements to provide recycled water to the PSP from Ballarat North WWTP
- DEECA: The reintroduction of aquatic species into Burrumbeet Creek
- CHCMA: Concerns raised over the use of the potentially out-dated 2013 Flood Investigation for Burrumbeet Creek. The CMA raised concerns that too much development in the catchment has progressed outside of the recommendations outlined in the 2013 study. They are encouraging for a new flood study/extent, and there are currently ongoing discussions between CoB and the CMA that are happening to agree a way forward.

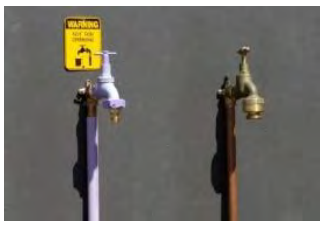
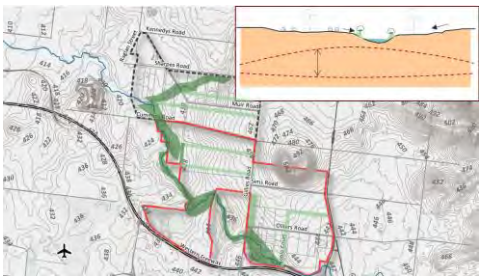
The output of the Shared IWM Vision workshop is included in Appendix E, and the long list of IWM options that emerged from this workshop is discussed in the next section.

7.1 Long List Identification

From the opportunities identified by participants in the Shared Vision Workshop, a long list of IWM opportunities were identified. Table 7-2 provides a description for each of these IWM opportunities across lot, street and precinct scale. Those options in italics are included in the base case scenario are likely to be driven by existing Victorian Planning Provisions.

Table 7-2 Long list of IWM options

Scale	Ref	Option	Description	Reference Image
Precinct	1	*To improve the water quality of Burrumbeet Creek, stormwater runoff is treated by wetlands*	This base case opportunity utilises wetlands to capture and treat stormwater runoff to meet Best Practice Environmental Management (BPEM) guidelines for excess pollutant and nutrient reduction.	
	2	*Allow for adequate land for floodwater storage (retarding basins) to control 1% AEP post developed flows to pre-developed levels.*	This base case opportunity utilises retarding basins in low-lying areas to collect stormwater during heavy rainfall events to reduce flood risk.	
	3	*Stabilisation of Burrumbeet Creek to accept urbanised flows*	This base case opportunity meets the minimum requirements of containing and conveying runoff by stabilising the physical form of the creek and defining a buffer area along the creek corridor.	
	4	Using recycled water from Ballarat North WWTP for public open spaces	This opportunity utilises recycled water from Ballarat North WWTP to irrigate public open spaces. This opportunity is beneficial by decreasing potable water use and also may assist CHW in meeting discharge conditions for the plant. Further details on demands and assumptions can be found in Section 8.2.	

Scale	Ref	Option	Description	Reference Image
	5	Using recycled water for Ballarat North WWTP for residential use	This opportunity utilises recycled water from Ballarat North WWTP to residential homes via a non-potable water supply network. This opportunity is beneficial by decreasing potable water use and also may assist CHW in meeting discharge conditions for the plant. Further details on demands and assumptions can be found in Section 8.2.	
	6	Stormwater harvesting and reuse for public open spaces from wetland	Stormwater runoff is collected, treated, stored and used for irrigation purpose. Stormwater harvesting differs from rainwater harvesting as runoff is collected from drains rather than roofs and is of lower quality. Further details on demand and assumptions can be found in Section 8.2.	
	7	Stormwater harvesting and reuse for residential (laundry, flush and outdoor irrigation) from wetland	Stormwater runoff is collected, treated, stored and used for non-potable residential use via a non-potable water supply network. A precinct-scale stormwater harvesting scheme would require land for a treated water storage to balance seasonal supply with demand. Further details on demand and assumptions can be found in Section 8.2.	
	8	Blue-green corridors	Blue-green corridors maximise the use of natural topography and drainage lines. This intervention would require corridors to be incorporated within urban design and integrated with street and movement layouts. The corridors will be along natural drainage lines, WSUD assets and strategically placed along social infrastructure. In a rainfall event, stormwater could be conveyed overland into the corridor which would provide pollutant removal as well as flow reduction benefits. Keeping stormwater on the surface can be a useful strategy for draining flat sites as it can also reduce the required depth of downstream retarding basins and wetlands. 	
	9	Provide ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek	This regenerative opportunity explores the options of creating a resilient ecological refuge within Ballarat North PSP. This can be achieved by increasing the width for riparian habitat and creating buffers around the creek to prevent waterway and habitat degradation. This opportunity aims to support the native flora and fauna residing within Burrumbeet Creek and return the Creek back to its natural state. It represents creek enhancements beyond the minimum standard practice represented by Option 3.	 

Scale	Ref	Option	Description	Reference Image
Street	10	Bioretention systems to treat road runoff	Bioretention systems in this option, receive stormwater runoff from roads. Their primary function is to remove excess pollutants and nutrients from road runoff but they can also provide amenity and be integrated with car parking and traffic calming bump outs. Further details on assumptions can be found in Section 8.2.	
	11	Passive street tree irrigation	This option includes a system to redirect, collect, filter and transfer road runoff into underdrains to water street trees. Passively irrigating trees can increase growth rates, support larger canopies and provide drought resilience. Ideally, passive street tree irrigation is located along key pedestrian routes that will be cool routes where targeted fast tree growth is preferred. Further details on assumptions can be found in Section 8.2.	
Lot	12	*Rainwater harvesting in all households*	Rainwater can be conveyed from roofs to tanks, which can then be used in homes to serve non-potable demands such as laundry, toilet flushing and outdoor irrigation. Based on the Supplementary Guide (CHW, 2018), new residential developments require to install a minimum 2kL rainwater tank to reduce reliance on potable water. Further details on assumptions and demands can be found in Section 8.2.	
	13	Permeable pavement in all households' driveways	Permeable paving is made of porous material or blocks with spaces which allow water to pass through the pavers and into the soil or underground storage to reduce and treat stormwater flow. This option explores the potential of permeable pavements in residential lots, however would require infiltration testing to confirm viability, and maintenance by residents. Further details on assumptions can be found in Section 8.2.	
	14	Green roofs in non-residential buildings	Installing green roofs across non-residential buildings can act as a bioretention basin and capture rainwater to enhance biodiversity and decrease urban heat island effects. Green roofs have been used throughout Australia. It is expected these will be maintained by the plot or building owner.	
	15	Household driveways and roofs connected to raingardens	Raingardens are a common stormwater treatment element. Within a lot-scale, stormwater runoff from driveways and rainwater from roofs are collected, naturally filtered to remove pollutants and reduce stormwater volumes from entering Burrumbeet Creek. City of Ballarat have required raingarden installation in some townhouse developments in the past.	

Additional solutions that were proposed at the Shared Vision workshop which haven't been included for assessment in the IWM analysis. These suggestions are broader strategies to support good urban design and ecological options, which are complimentary to IWM but not directly enabled by water management.

- "Appropriate buffers between waterways and development" – "*The retention of drainage corridors with vegetation buffer areas along waterways*" is stipulated in the Local Floodplain Development Plan 2015, which was Incorporated within clause 81 of the Ballarat Planning Scheme. Therefore, council will be able to reject any applications that hinder the natural drainage function or habitat corridor.
- "Open space allocation that supports greater permeability" – The allocation of open spaces will be defined by the VPA when the PSP is fixed, however this study will help influence the PSP.

- "Good linked canopy coverage" – Canopy coverage is typically dependent on the landscape strategy and should aim to meet the VPA PSP guidelines of 30%. The IWM assessment will, however, quantify benefits of passively irrigating street trees, contributing to target T14 of the PSP guidelines.
- "Planting of diverse native vegetation along waterway appropriate to Ecological Vegetation Classes (EVCs)" – This will be part of a landscape strategy for the site and not the IWM assessment. This recommendation should be noted by the VPA, as it noted in Feature F12 in the PSP guidelines.
- "Linear reserves and revegetation along waterways" – same as above.

8. Assessment of Options

8.1 Assessment Criteria

The assessment criteria to assess the short-list of opportunities was developed using the Preliminary Assessment Method (PAM) for IWM options. It integrates the outcomes discussed in the workshop with the strategic outcomes from the Strategic Direction Statement for Central Highlands catchment.

Table 8-1 shows the assessment criteria for the IWM options proposed.

Table 8-1 Assessment criteria

Strategic Outcome	Place-based IWM objective for Ballarat North	Measure	Unit
Strategic Outcome 1 – Safe, secure and affordable supplies in an uncertain future 	Reduce potable water demand to reduce pressure on Ballarat's supplies and provide adaptability during drought.	Alternative water sources that substitute potable mains water supply	ML/year
Strategic Outcome 2 – Effective and affordable wastewater systems 	Utilise future wastewater flows to Ballarat North WWTP for beneficial local outcomes.	Volume of recycled water delivered to residents	ML/year
Strategic Outcome 3 – Existing and future flood risks are managed to maximise outcomes for the community. 	Manage flood flows from the development are to prevent any increase in flood risk downstream.	Impact on downstream fluvial flood mitigation	High/ Medium / Low
Strategic Outcome 4 – Healthy and valued waterways and marine environments 	Protect and improve ecological value and habitat potential of Burrumbeet Creek. Reduce stormwater runoff and improve stormwater quality flowing to Burrumbeet creek to support waterway health	Reduction in mean annual runoff volume	ML/year
		Total Nitrogen (TN) prevented from discharging to receiving waters	kg/year
Strategic Outcome 5 – Healthy and valued urban and rural landscapes. 	Create greener neighbourhoods, supporting trees and enhancing open space. Create additional landscapes, permeable areas and green infrastructure through water management.	Alternative water supporting urban greening	High/ Medium / Low
		New green infrastructure or permeable space created	Ha
Strategic Outcome 6 – Community values are reflected in place-based planning.	Create green-blue corridors within the development and support connections and community access to and awareness of nature.	Wadawurrung statement criteria: 1. Minimises wastewater discharging to the creek. 2. Minimises stormwater discharging to the creek.	Number of criterions met

Strategic Outcome	Place-based IWM objective for Ballarat North	Measure	Unit
	Embed Traditional Owner values and care for country.	3. Creek restoration	
		Opportunity to enhance community awareness and engagement	High/ Medium / Low
		Opportunity to create linked corridors to support connections	High/ Medium / Low
Strategic Outcome 7 – Jobs, economic benefits, and innovation 	N/A	This strategic outcome is not applicable to Ballarat North as it is primarily a residential precinct	N/A
Additional delivery criteria: Ease of delivery 	Adopt a fair and equitable approach to IWM, ensuring all stakeholders contribute to the place based IWM objectives.	Ease of implementation	High/ Medium / Low
		Ease of operation and maintenance	High/ Medium / Low

8.2 Assumptions

Assumptions were made to model each scenario. These were based on the most appropriate data or project experience. A summary of assumptions used for each opportunity are describes in Table 8-2 below.

Table 8-2 Summary of Assumptions

Option	Option Description	Assumptions	Reference and notes
1	To improve the water quality of Burrumbeet Creek, stormwater runoff is treated by wetlands	• Base case wetland size 8-12 ha treats stormwater runoff to meet Best Practice Environment Management (BPEM)	Based on Ballarat North contextual analysis report.
2	Allow for adequate land for floodwater storage (retarding basins) to control 1% AEP post developed flows to pre-developed levels.	• Base case retarding basin size 2-6 ha to control 1% AEP post-developed flows to pre-developed levels.	Based on Ballarat North contextual analysis report.
3	Stabilisation of Burrumbeet Creek to accept urbanised flows	• This opportunity only meets minimum requirements of containing runoff.	Based on Ballarat North contextual analysis report.
4	Using recycled water from Ballarat North WWTP for public open spaces	• 100% of the public open space demand can be met. • Assuming TN removed is 10kg/ML/year.	Based on previous projects.
5	Using recycled water for Ballarat North WWTP for residential use	• 100% of the residential demand can be met. • Assuming TN removed is 10kg/ML/year.	Based on previous projects.
6	Stormwater harvesting and reuse for public open spaces from wetland	• Harvested stormwater will be collected in a wetland. • Active open space includes sports reserves and has an irrigation demand of 5 ML/ha/year.	Irrigation rate based on clearwater methodology 2012.

Option	Option Description	Assumptions	Reference and notes
		• Passive open space includes areas of non-active recreation and local parks. It has an irrigation demand of 3 ML/ha/year.	
7	Stormwater harvesting and reuse for residential (laundry, flush and outdoor irrigation) from wetland	• Harvested stormwater will be connected in a wetland. • Approximately 60% of non-potable residential demands can be met with stormwater harvesting from wetland. • Approximately 3000-4000 kg/year of TN is removed from stormwater harvesting	Based on previous projects.
8	Blue-green corridors	• 3% of the PSP area is dedicated to overland blue-green corridors with 10% imperviousness. • Waterway corridor length of 3-4 km	Based on previous projects.
9	Provide ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek	• Ecological refuge can be achieved by creating blue-green corridors with an additional creek width of 20m riparian habitat and buffers around the creek to prevent further waterway and habitat degradation.	Based on previous projects.
10	Bioretention systems to treat road runoff	• Assuming bioretention system is 1% of no. of lots x 20m frontage x 6m half road width.	Based on previous projects
11	Passive street tree irrigation	• Assuming one tree per lot. • Stormwater reduction for passive street tree irrigation is 5 kL/year/tree • Total Nitrogen reduction for passive street tree irrigation is 0.0105 kg/year/tree	Based on previous projects
12	Rainwater harvesting in all households	• 2kL rainwater tanks (for laundry, toilet flushing and outdoor irrigation) in every household to meet approx. 60% non-potable demand	Based on Ballarat Potable Water Demand Target: Supplementary Guide (CHW, 2018)
13	Permeable pavement in all households' driveways	• Assuming 50% of residential area is non-roof area and 50% of this area would be permeable pavement. • An average driveway size is estimated to be 38 m² • In the absence of infiltration data, we have assumed they are lined with an exfiltration rate of 5 mm/hr.	Driveway size estimation is based on an average of residential lots located near Ballarat North PSP
14	Green roofs in non-residential buildings	• Assuming 50% of non-residential buildings are roof areas and 50% of this roof area would be converted into green roof.	Based on previous projects.
15	Household driveways and roofs connected to raingardens	• Assuming 50% of non-roof and 50% of roof area of a residential lot is connected to a lot-size raingarden of 2 m² area.	Based on previous projects.

8.3 Score Ratings

A three-score rating system was adopted to preliminary assess the comparative impact of opportunities towards each criterion. As such, the ratings were created to rank opportunities against one another. Zeros were given when the criteria were not relevant to the opportunity. Table 8-3 below describes the rating adopted for each criterion.

Table 8-3 Description of each score rating adopted for each criterion.

Criteria	1	2	3
Alternative water sources that substitute potable mains water supply (ML/year)	0-49	51-199	201+
Volume of recycled water delivered to residents (ML/year)	0-50	51-200	201+
Impact on downstream fluvial flood mitigation (H/M/L)	Low impact: Option can reduce stormwater runoff, but has minimal impact under high rainfall events	Medium impact: Option can be designed to provide some attenuation storage, minimising flooding impacts downstream	High impact: Option can withhold large volumes during rainfall events, minimising flooding impacts downstream
Reduction in Mean annual runoff volume (ML/year)	0-100	101-200	201+
Total Suspended Solids (TSS) prevented from discharging to receiving waters (tonnes/year)	0-100	101-200	201+
Total Nitrogen (TN) prevented from discharging to receiving waters (kg/year)	0-1000	1001-2000	2001+
New total number of passively irrigated trees	0-4000	4001-8000	8001+
Area of open and/or recreational space supported by an alternative water source (ha)	0-50	51-100	101+
New green infrastructure or permeable space created (ha)	0-2	2-5	5+
Wadawurrung statement states the three following objectives to restore Burrumbeet Creek to its natural state: • Reducing stormwater runoff • Reducing wastewater from entering the creek • Working towards the restoration of the creek	Meets one objective	Meets two objectives	Meets three objectives
Opportunity to enhance community awareness and engagement (H/M/L)	Minimal opportunity for community awareness and engagement to influence delivery of solution	Some opportunity for community awareness and engagement to influence delivery of solution	Significant opportunity for community awareness and engagement to influence delivery of solution
Opportunity to create linked corridors to support connections (H/M/L)	Minimal opportunities to create linked corridors, only through passive tree irrigation	Some opportunity to create linked corridors through water restoration	Significant opportunity to create linked blue-green corridor.
Ease of implementation (H/M/L)	Opportunity is complex, requires the involvement of multiple stakeholders and might take a long time to implement.	Opportunity has been implemented in other contexts, requires some stakeholder involvement but still involves a complex process to build	Opportunity requires a standard and easy process to build and will likely not require a long time to implement

Criteria	1	2	3
Ease of operation and maintenance (H/M/L)	Relatively higher operation and maintenance requirement	Relatively medium operation and maintenance requirement	Relatively lower operation and maintenance requirement

8.4 Results of Assessment

Options were assessed for both Scenario A (core area only) and Scenario B (core and expanded area) for the Ballarat North PSP. Figures 8-1 to 8-3 show the results of the assessment, for some of the key criteria. A summary of all the scores is included in Table 8-4.

Figure 8-1 shows the substitution of potable water supply by option. Options targeting residential use have greater impact than open space. Recycled water options are higher overall due to increased reliability.

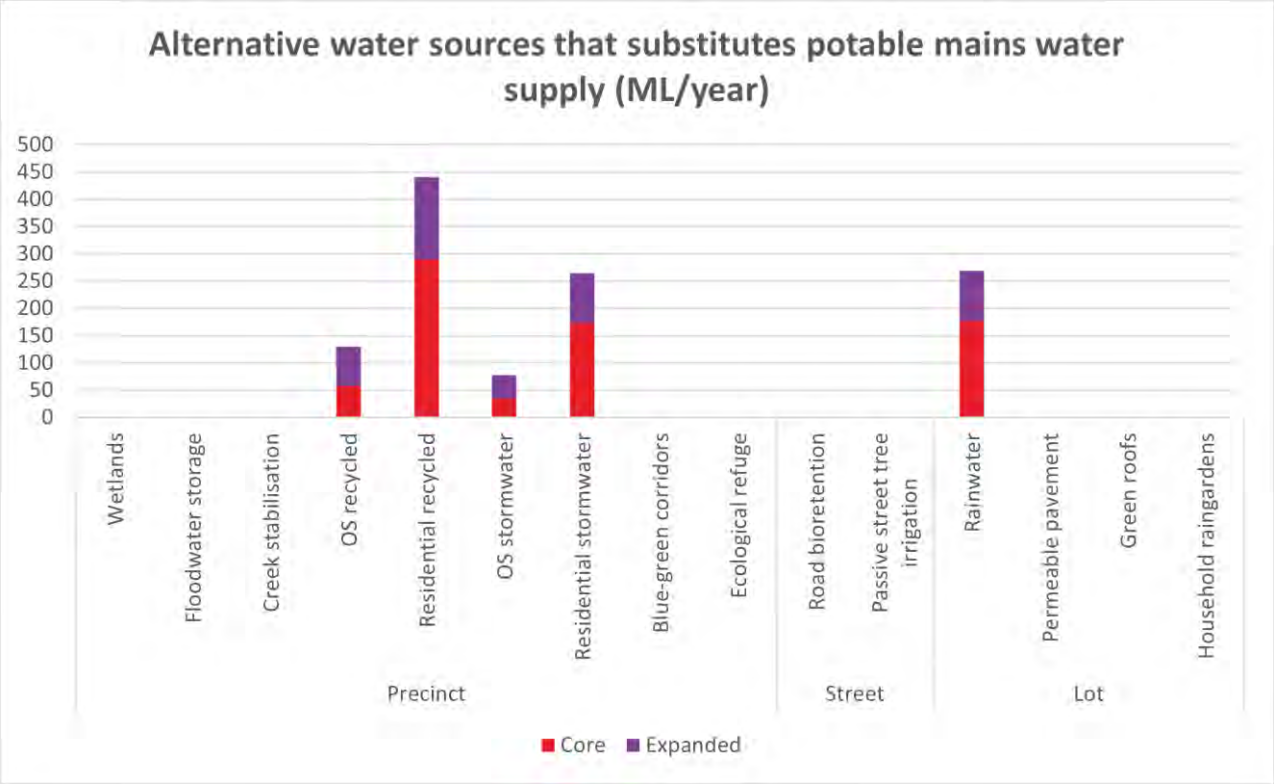


Figure 8-1 Total substitution of potable water by alternative sources

Figure 8-2 compares the reduction in stormwater with the Healthy Waterways Strategy targets. Rainwater tanks are the only option which meets the targets, if installed alone with no other solutions. However, combinations of other options may also meet the targets, particularly with residential stormwater harvesting.

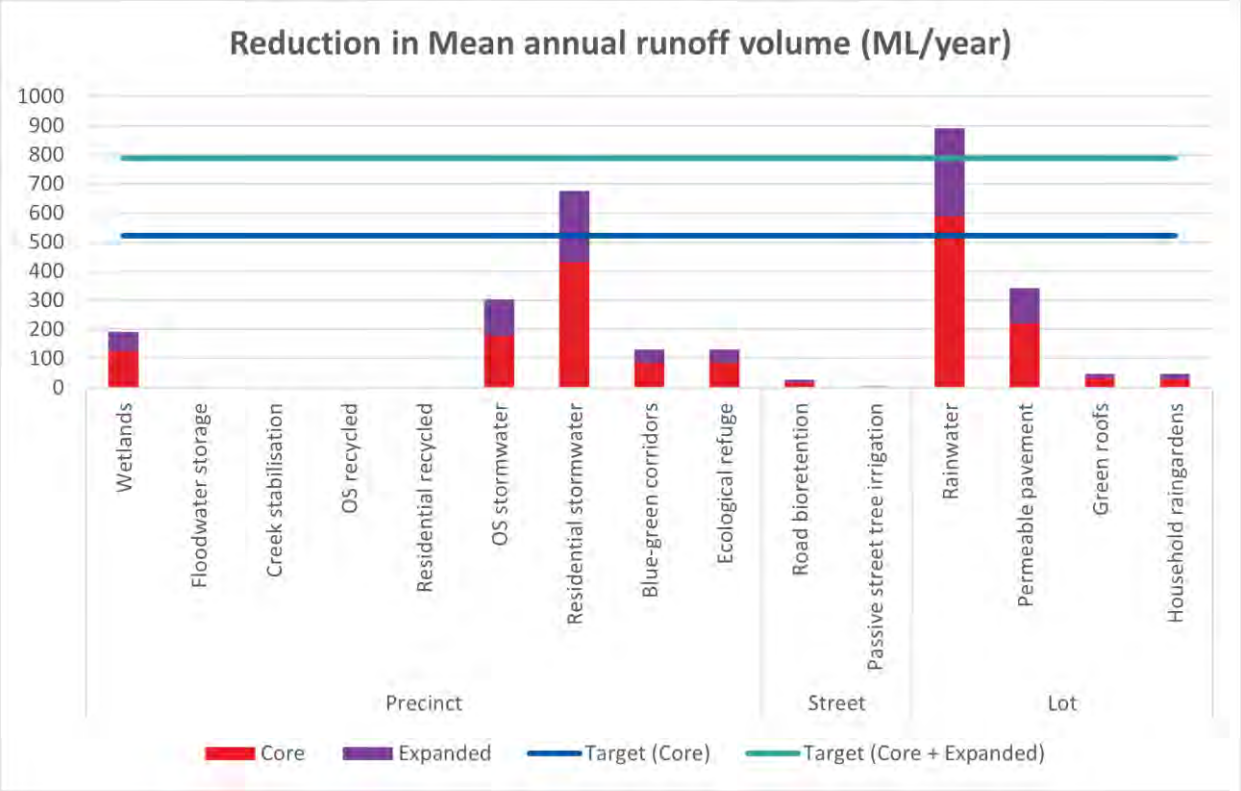


Figure 8-2 Reduction in stormwater compared with reduction targets

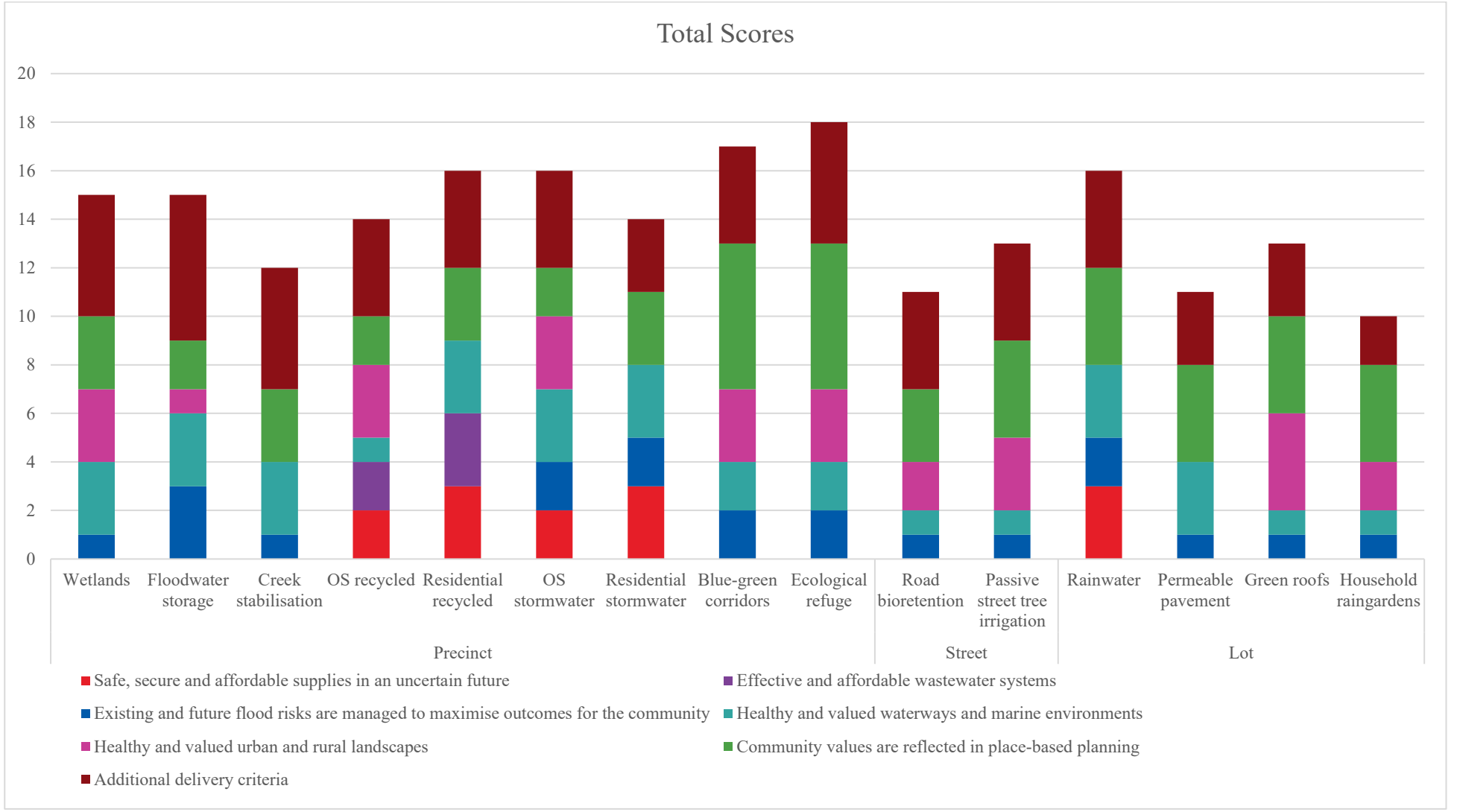


Figure 8-3 Average score of each option by strategic outcome

The final scores for core area only (Scenario A) and core plus expanded (Scenario B) can be found in Table 8-4 below. Appendix D provides a breakdown of scores for each opportunity against each criterion for Ballarat North PSP. Although some opportunities score poorly, they are not discarded from the assessment as they can be combined and complement other opportunities.

For score breakdown on scenario A and B assessment, refer to Appendix D.

Table 8-4 Total scores for Scenario A (core area only) and Scenario B (core and expanded area) options.

Option	Option Description	Total Score	
		A	B
1	To improve the water quality of Burrumbeet Creek, stormwater runoff is treated by wetlands	15	15
2	Allow for adequate land for floodwater storage (retarding basins) to control 1% AEP post developed flows to pre-developed levels.	15	15
3	Stabilisation of Burrumbeet Creek to accept urbanised flows	11	12
4	Using recycled water from Ballarat North WWTP for public open spaces	14	14
5	Using recycled water for Ballarat North WWTP for residential use	16	16
6	Stormwater harvesting and reuse for public open spaces from wetland	14	16
7	Stormwater harvesting and reuse for residential (laundry, flush and outdoor irrigation) from wetland	13	14
8	Blue-green corridors	16	17
9	Provide ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek	17	18
10	Bioretention systems to treat road runoff	11	11
11	Passive street tree irrigation	13	13
12	Rainwater harvesting in all households	15	16
13	Permeable pavement in all households' driveways	11	11
14	Green roofs in non-residential buildings	13	13
15	Household driveways and roofs connected to raingardens	10	10

9. Potential IWM Portfolios for Ballarat

9.1 Selection of Portfolios

Using the preliminary assessment, IWM options were strategically bundled and placed in portfolios. Portfolios combine complimentary IWM options to provide a holistic solution. Each portfolio builds on the base case (i.e. what would happen at Ballarat North PSP with minimal IWM interventions). Portfolios have been created based on a sliding scale of ecological gain, as depicted in Figure 9-1.

Figure 9-1 Approach to creating portfolios

- **Portfolio 1 Base Case** – Includes retarding basins to control the 1% AEP post development flows, with combined wetlands to meet pollutant reduction targets. This also includes a 2kL rainwater tank in all households (as mentioned in Table 2-1), and stabilisation of Burrumbeet Creek to accept urbanised flows from all of Ballarat North PSP
- **Portfolio 2 Sustainable industry best practice** – This portfolio includes commonly delivered initiatives, regarded as best practice in the industry. In addition to the base case (except the 2kL rainwater tanks) this portfolio includes recycled water from Ballarat North WWTP being supplied to homes and open spaces, and tree pits on streets being passively irrigated.
- **Portfolio 3 Meeting aspirational targets**- In addition to the base case, this portfolio aims to meet and exceed the 29% harvesting and 7% infiltration targets as set out in Table 2-1 to increase green infrastructure and protect Burrumbeet Creek from urban runoff. This portfolio includes precinct scale stormwater harvesting to irrigate open spaces, household driveways and roofs connected to raingardens and bioretention systems to treat road runoff.
- **Portfolio 4 Burrumbeet revitalisation**– In addition to the base case (except the 2kL rainwater tanks) this portfolio includes recycled water from Ballarat North WWTP being supplied to homes, precinct scale stormwater harvesting to irrigate open spaces, blue-green linear corridors within the PSP and the provision of ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek.

9.1.1 Portfolio 1: Base case

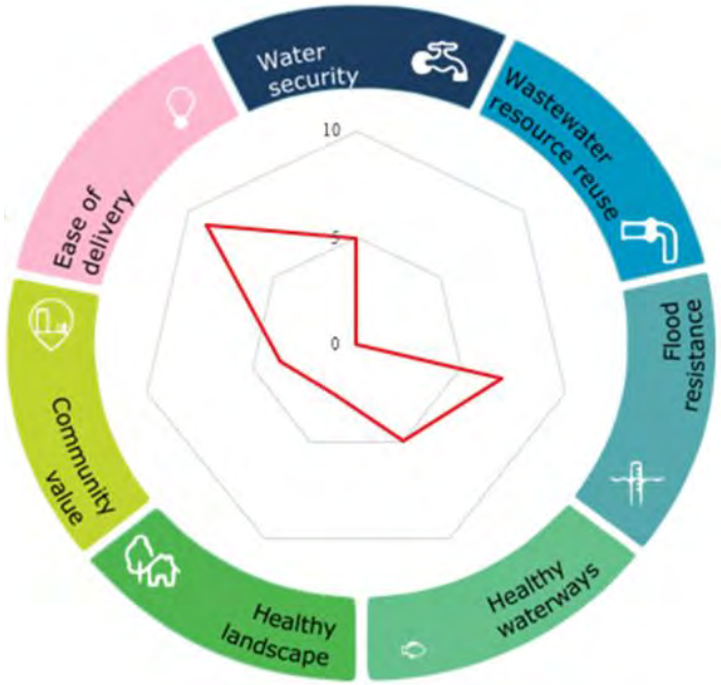
Portfolio 1 brings in all the base case opportunities together for Ballarat North PSP. This portfolio aims to meet the minimum requirements at a precinct level with a reliance on CoB council and residents for asset management. It provides a deliverable solution, which contributes to water quality and flood resilience outcomes, as driven through the Victorian Planning Provisions, but contributions to water resource management and support of liveability and landscape value is limited.

This portfolio includes:

- *Wetland to treat runoff and reduce excess pollutant and nutrients from entering Burrumbeet creek (Option 1).*
- *Reducing flood risk by using retarding basins and stabilising Burrumbeet creek to accept post-development flows from the precinct (Option 2 and Option 3).*
- *Decreasing reliance on potable water by using rainwater tanks to substitute non-potable residential water demand (Option 12).*

Table 9-1 Description of Portfolio 1 in relation to strategic outcomes

	• Moderate water security for residential areas as rainwater tanks are utilised to substitute non-potable water demand for each household. • Approximately 60% residential potable water reduction with rainwater tanks
	• No wastewater reuse as recycled water not utilised
	• High flood resilience achieved through retarding basins, rainwater tanks and creek stabilisation. • Rainwater harvesting at lot scale also created additional storage capacity to store water during heavy rainfall events.
	• Moderate flow reduction as retarding basins and wetlands treat and reduce runoff volumes from entering Burrumbeet creek. • Flow reduction of 33%
	• Low value for heathy landscape as only wetland creates additional greening and increase permeability. • This portfolio does not provide alternative water to support greening.
	• This portfolio has minimal community value. Although it creates community engagement by installing rainwater tanks in each household, but the precinct as a whole does not promote connections and community access to nature. • Additionally, regarding the Wadawurrung statement, this portfolio only meets the criteria to reduce stormwater runoff from the creek.
	• Ease of delivery and implementation for this portfolio is high due to relatively lower operation and maintenance requirement.



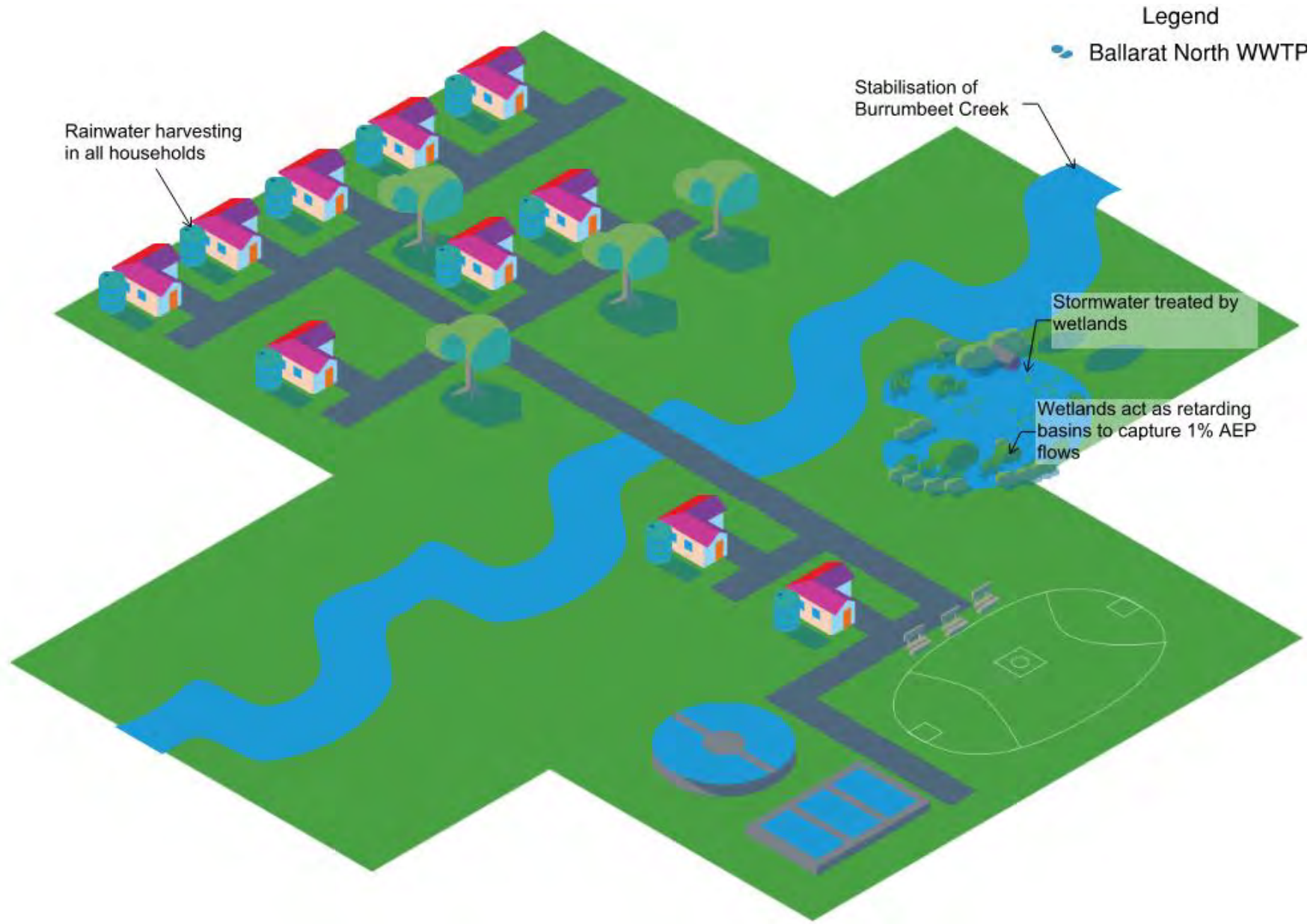


Figure 9-2 Portfolio 1: Base case

9.1.2 Portfolio 2: Sustainability industry best practice

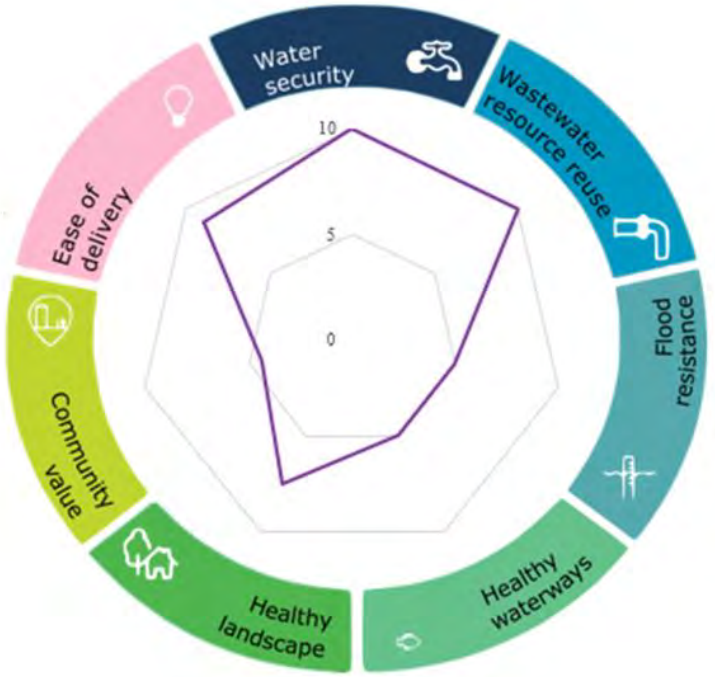
Additional to the base case options, portfolio 2 provides a best practice approach to Ballarat North PSP by providing recycled water to the precinct, reducing road runoff and supporting greening through passive street tree irrigation. It is important to note here, the introduction of recycled water networks would eliminate rainwater tanks at a residential lot scale. This portfolio would require recycled water to be mandated by CHW for the precinct and would require design guidance from VPA and CoB to support delivery of passively irrigated trees (through kerb cuts, lined swales or vegetative swales etc).

Portfolio 2 incudes (base case options in italics):

- *Wetland to treat runoff and reduce excess pollutant and nutrients from entering Burrumbeet creek (Option 1).*
- *Reducing flood risk by using retarding basins and stabilising Burrumbeet creek to accept post-development flows from the precinct (Option 2 and Option 3).*
- Alternative water supply through recycled water for residential and open space water demand (Option 4 and 5).
- Reducing road runoff through passive street tree irrigation (Option 11)

Table 9-2 Description of Portfolio 2 in relation to strategic outcomes

	• High water security as recycled water is a reliable water source that is not climate dependent. The network could easily be upgraded to accommodate future growth. • 100% of non-potable residential and open space water demand is met from alternative water source.
	• Recycled water could be used to service all non-potable and irrigation demands in the precinct.
	• Moderate flood resilience achieved through retarding basins and creek stabilisation at precinct scale.
	• Moderate flow reduction as retarding basins, passive street tree irrigation and wetlands treat and reduce runoff volumes from entering Burrumbeet creek. • Flow reduction of 9%
	• High value for heathy landscape as wetlands and passive street tree irrigation creates additional greening and decreases urban heat island effects. • Additionally, alternative water through recycled water is provided to support open spaces.
	• This portfolio has minimal community value. Since all the options within this portfolio do not require community engagement or involvement. • Additionally, regarding the Wadawurrung statement, this portfolio scores relatively low as it only keeps wastewater out of the creek and reduces minimal stormwater runoff.
	• Ease of delivery and implementation for this portfolio is high due to relatively lower operation and maintenance requirement.



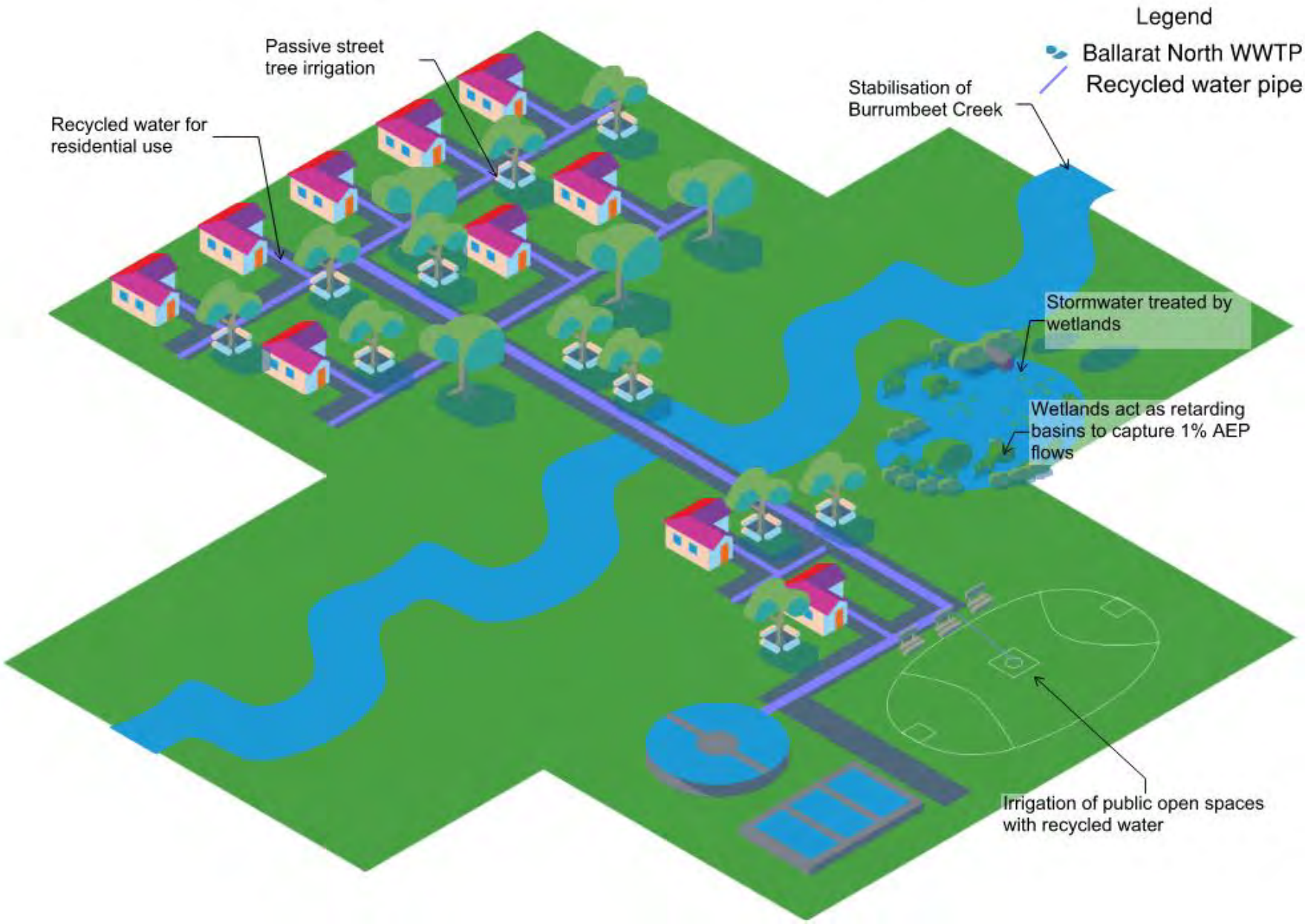


Figure 9-3 Portfolio 2

9.1.3 Portfolio 3: Meeting aspirational targets

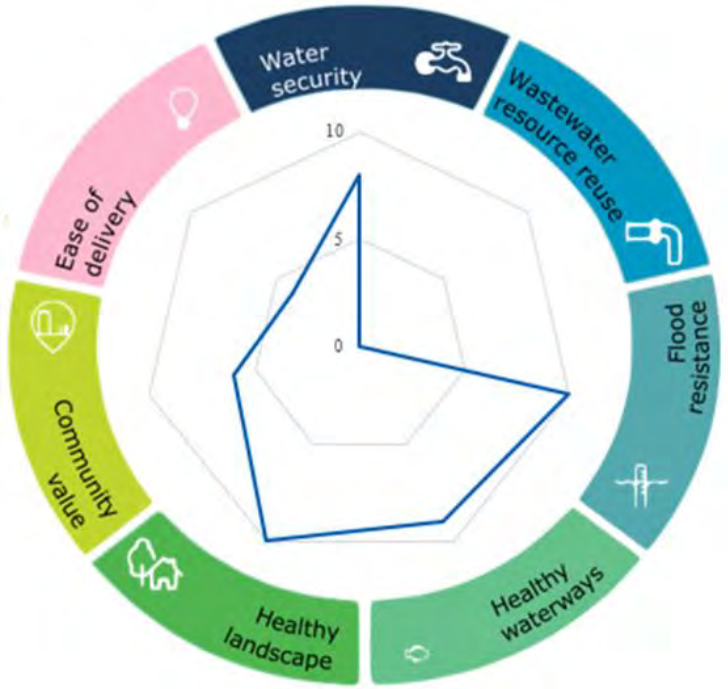
Additional to the base case options, portfolio 3 provides varying options across lot, street and precinct scale to treat and reduce stormwater flow from entering Burrumbeet Creek. The main aim of this portfolio is to meet and exceed stormwater harvesting and infiltration performance targets of 29% and 7% respectively for Ballarat North PSP, as set out by the Urban Stormwater Management Guidelines (publication 1739). Due to the varying options across different scales, there is a higher reliance on varying stakeholders, developers and householders for implementation.

Portfolio 3 incudes (base case options in italics):

- *Wetland to treat runoff and reduce excess pollutant and nutrients from entering Burrumbeet creek (Option 1).*
- *Reducing flood risk by using retarding basins and stabilising Burrumbeet creek to accept post-development flows from the precinct (Option 2 and Option 3).*
- Decreasing reliance on potable water by using *lot-scale rainwater tanks* and precinct-scale stormwater harvesting (Option 12 and Option 6).
- Reducing runoff volume through bioretention and raingarden systems in lot and streetscape (Option 15 and 10).

Table 9-3 Description of Portfolio 3 in relation to strategic outcomes

	• Rainwater tanks in each household and stormwater harvesting to irrigate open spaces will provide alternative water use for Ballarat's largest potable water users. These options would result in high water security for the precinct. • Approximately 342ML potable water reduction with rainwater tanks and open space stormwater harvesting.
	• No wastewater reuse as recycled water not utilised
	• High flood resilience achieved through retarding basins and creek stabilisation at precinct scale. • Rainwater harvesting at lot scale also created additional storage capacity to store water during heavy rainfall events.
	• High flow reduction due to the varying combination of WSUD assets across each scale treating and reducing runoff volumes from entering Burrumbeet creek. • Flow reduction of 68%
	• High value for heathy landscape as this portfolio increases permeability within the precinct through wetlands, bioretention systems and raingardens. • This portfolio also provides alternative water through precinct-scale stormwater harvesting to support greening.
	• Due to majority of options being at precinct scale, this portfolio has moderate community value. • Additionally, to support the Wadawurrung statement, this portfolio only meets the criteria to reduce stormwater runoff from the creek.
	• Ease of delivery and implementation for this portfolio is low due to the high operation and maintenance required for the WSUD assets.



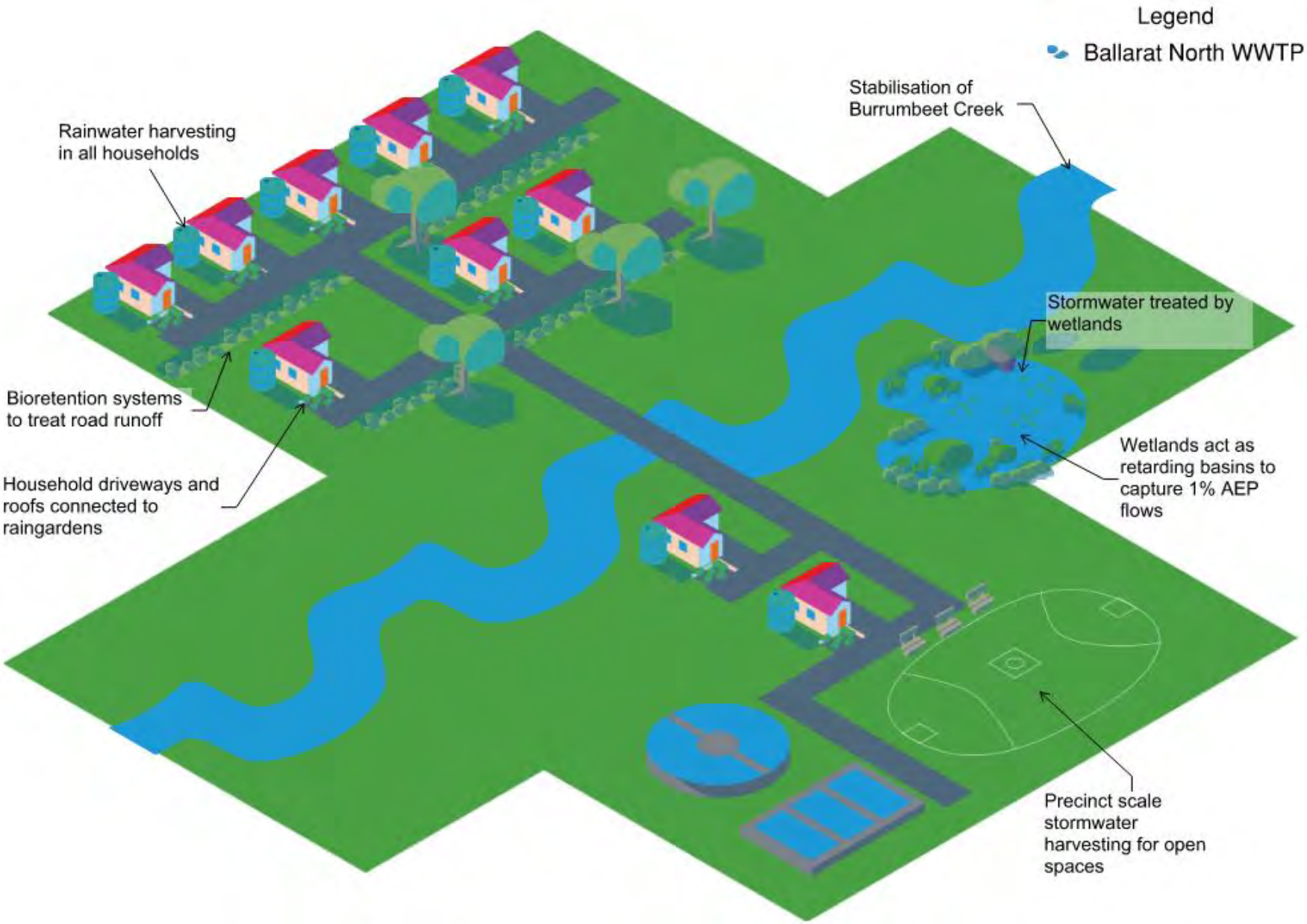


Figure 9-4 Portfolio 3

9.1.4 Portfolio 4: Burrumbeet revitalisation

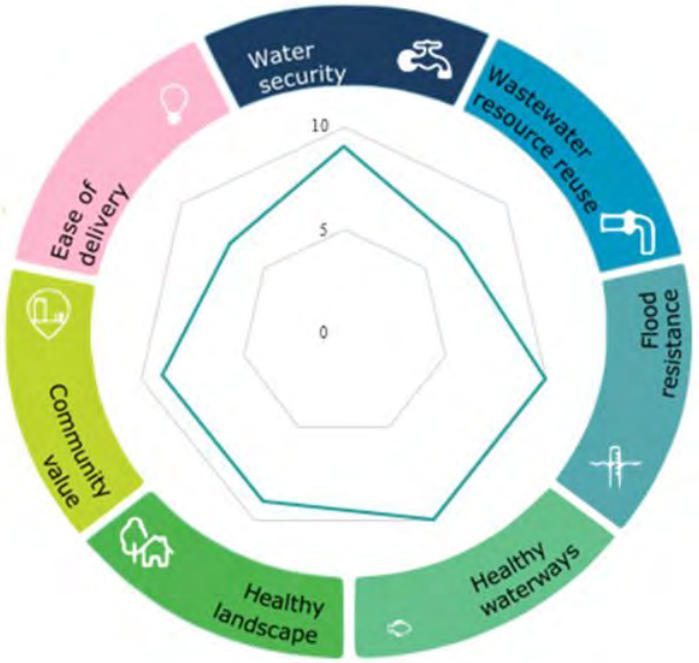
Portfolio 4 delivers a regenerative approach to Ballarat North PSP, seeking to reduce both wastewater and stormwater flows to the Creek while driving ecological restoration and embedding blue-green corridors throughout the precinct. It is closely aligned with the Wadawurrung Country Plan principles. In terms of implementation, this portfolio would require multi-stakeholder engagement to plan and carefully deliver this regenerative approach systematically.

This portfolio includes (base case options in italics):

- *Wetland to treat runoff and reduce excess pollutant and nutrients from entering Burrumbeet creek (Option 1).*
- *Reducing flood risk by using retarding basins and stabilising Burrumbeet creek to accept post-development flows from the precinct (Option 2 and Option 3).*
- Alternative water supply through recycled water and stormwater for all residents and open spaces (Option 5 and Option 6)
- Returning Burrumbeet creek back to its natural state by creating blue-green corridors and improving ecological refuge across the precinct (Option 9 and Option 8).

Table 9-4 Description of Portfolio 4 in relation to strategic outcomes

	• High water security as recycled water is a reliable water source that is not climate dependent. The network could easily be upgraded to accommodate future growth. Additionally, stormwater harvesting reuse provides alternative water to irrigate open spaces. • 100% of non-potable residential and approximately 60% of open space water demand is met from alternative water source.
	• Recycled water could be used to service residential water demands in the precinct.
	• High flood resilience achieved through water retaining assets and increase in perviousness across the precinct to reduce runoff.
	• High flow reduction through increase in perviousness to support ecological habitat along with the inclusion of wetlands to treat runoff before entering Burrumbeet creek. • Flow reduction of 30%
	• High value for healthy landscapes as this portfolio focuses on revitalising Burrumbeet creek by creating ecological refuge for native flora and fauna through blue green infrastructure increasing connectivity across the precinct.
	• This portfolio has high community value as it focuses on being a creek-centric approach and focuses on bringing the community to nature. • Additionally, to support the Wadawurrung statement, this portfolio meets all the criterion to help return Burrumbeet creek back to its natural state.
	• Ease of delivery and implementation for this portfolio is moderate since all the assets are at precinct level, therefore require careful planning and reliance on CoB and CHW.



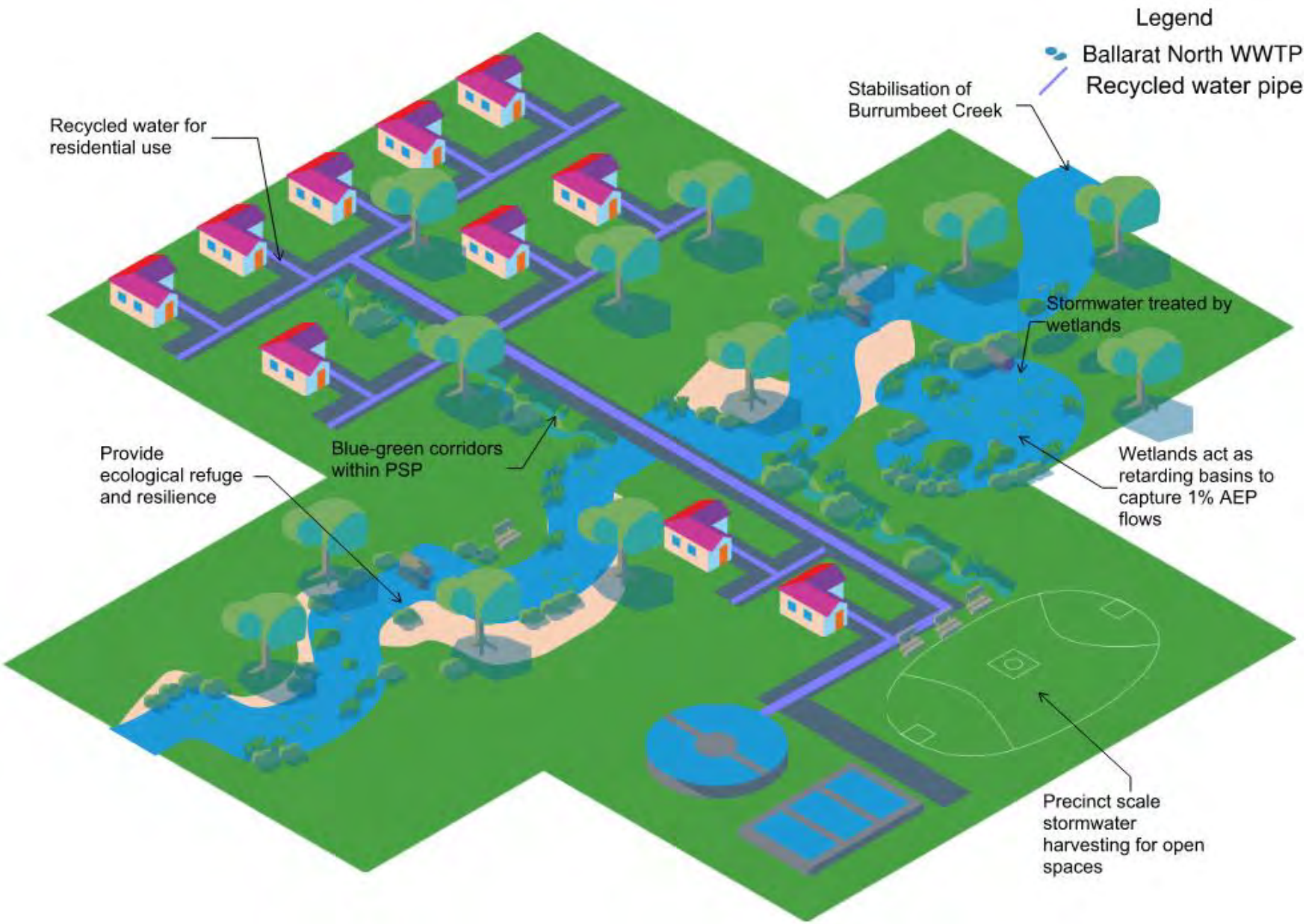


Figure 9-5 Portfolio 4

9.2 Comparison of Portfolios

The same stakeholders from the Shared Vision workshop reconvened on the 1st February 2024, where the results of the assessment and the four portfolios were discussed. It was acknowledged that each portfolio has benefits and meets the IWM SDS outcomes in different ways, but the performance generally builds from portfolio 1 to 4. For example, portfolio 3 contains many interventions aimed at reducing stormwater runoff, and therefore scores higher for healthy waterways and landscapes, compared to portfolio 2, which scores higher for water security and using wastewater as a resource. Portfolio 4 provides the most holistic mix of IWM outcomes and is the best performing portfolio overall.

Figure 9-6 below shows all four portfolios overlaid on the IWM outcomes.

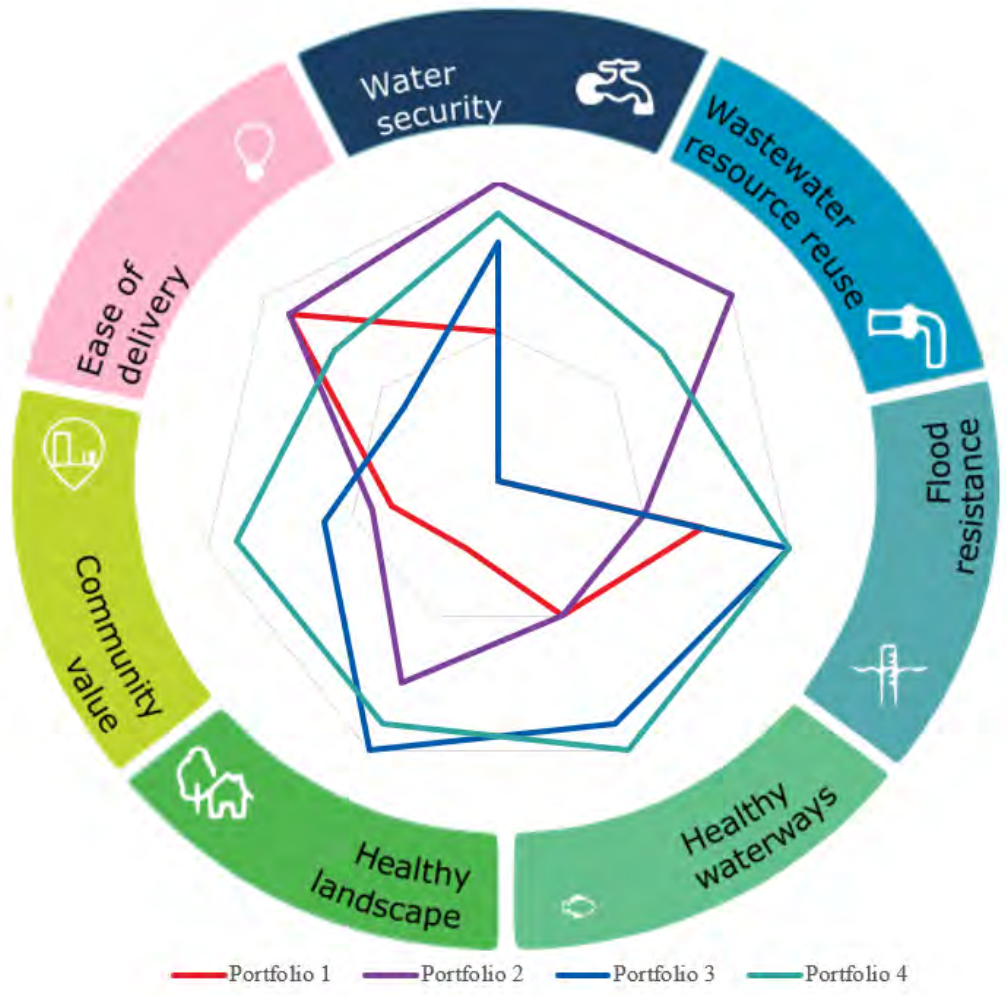


Figure 9-6 Comparison of Portfolios

This assessment aims to maintain equal weighting among the IWM outcomes, and therefore the preferred and/or recommended suite of IWM options was driven by the preference of stakeholders, and their ability to implement, adopt and /or maintain the interventions. Although the desire from stakeholders is to make Ballarat North PSP as water sensitive, water efficient and ecologically regenerative as possible, it is acknowledged that the success of the IWM interventions hinges on the capacity and acceptance, of stakeholders, particularly CHW and CoB.

10. Recommendations and way forward

10.1 Recommended Portfolio of Options

10.1.1 Recommended IWM initiatives (Portfolio 4)

The recommended portfolio for Ballarat North PSP is portfolio 4. This selection was made as this portfolio scores highly across all outcomes, is able to meet the stormwater flow reduction targets (29% harvesting and 7% infiltration), utilises recycled water for the precinct and embeds blue-green corridors and ecological restoration in precinct design.

The portfolio favours the inclusion of a recycled water scheme for the precinct supplying a more reliable than stormwater as an alternative water source and removes the need for residents to operate and maintain decentralised rainwater tanks in their homes. The opportunity for a centralised recycled water network should be referenced by the PSP, but will be subject to further investigation and development of a business case by CHW. Rainwater tanks would be the preferred alternative option for alternative water supply if recycled water cannot be provided, or for early phases of development.

It's acknowledged that post-development stormwater entering Burrumbeet Creek should be minimised as far as possible, and therefore it is recommended that precinct scale wetlands connected to local stormwater harvesting to irrigate open spaces is delivered, and that blue-green corridors are incorporated into the land use plan for the PSP following key drainage pathways. Not only do these interventions minimise runoff and pollutants from entering the creek, but blue-green corridors provide excellent amenity value, urban cooling, sense of place and can attenuate stormwater flows in high rainfall events, which can lead to reduced sizing of end-of-line retarding basins and wetlands.

Finally, it is recommended that the Burrumbeet Creek corridor is enhanced to provide ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek, or to reintroduce lost species back to the creek. There are several ways to do this, though specific interventions would require a vegetation and geomorphological assessment to be carried out. High level recommendations for providing ecological refuge and resilience for flora and fauna include:

- Following Growling Grass Frog Design Standards when designing the wetlands and retarding basins
- Minimising the quantum, and rate of urban runoff from entering the creek as far as possible (stormwater reuse for open space irrigation and blue-green corridors contribute to this)
- Understanding existing vegetation and flow regimes in the creek (by undertaking a vegetation and geomorphology assessment) which will determine the stability of the creek. This will in turn allow specific interventions that target vegetation regeneration, erosion mitigation or a combination of both.
- Implementation of native vegetation and trees along the riparian corridor of the creek
- The use of woody debris which encourages the reintroduction of invertebrate habitat by creating a diverse range of velocities and water depths in localised parts of the creek.

Enhancing the creek by via the reintroduction of lost species and reduction of post-development runoff from entering will also have knock-on benefits to the creek and connected water bodies downstream, including Macarthur Park and Miners Rest Wetlands, as well as Lake Burrumbeet further downstream.

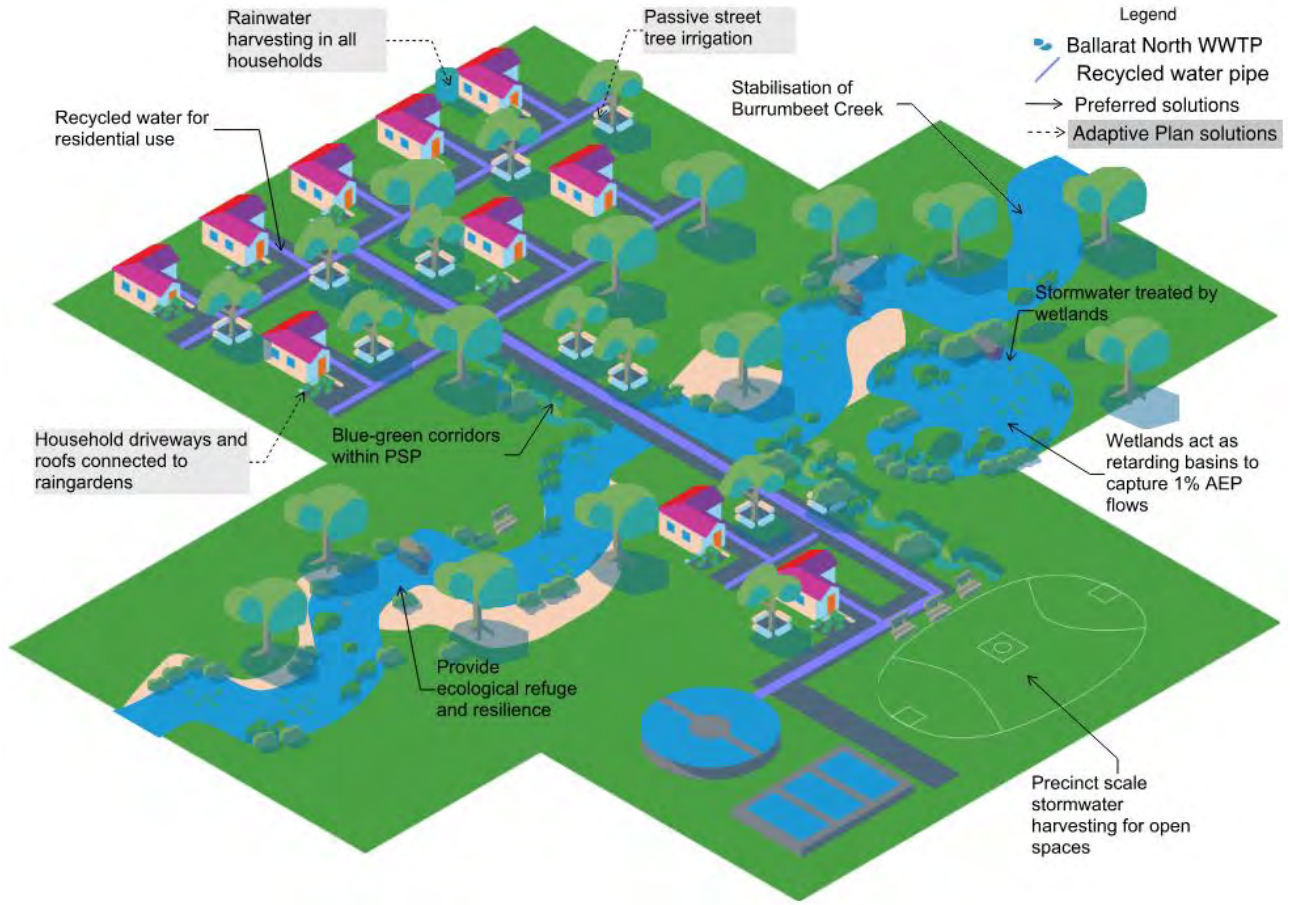


Figure 10-1 Summary of recommended portfolio, and adaptive plan solutions.

10.1.2 Adaptive plan

CHW have not yet mandated the use of recycled water for this precinct. It is understood that this study will be used as a basis by CHW to inform future investment plans for investigating a recycled water network owned and operated by CHW. In the event that CHW do not proceed with a centralised recycled water network, it is recommended that 2kL rainwater tanks are installed in homes, as recommended in the Ballarat City Integrated Water Management Plan. This solution, despite not being as reliable as a recycled water network, reduces runoff from entering the creek (and meets stormwater targets), reduces potable water demand by providing a source of non-potable water, and also encourages community awareness raiding and education about water sensitive development. Stormwater should also be collected at a precinct scale to be used to irrigate open spaces.

Furthermore, if there are spatial constraints in allowing for blue-green corridors in the PSP, then alternative localised greening and stormwater management solutions should be included in the public realm and private realm. These could include bioretention systems, swales or passively irrigated tree pits, and raingardens in private lots. These solutions provide stormwater runoff reduction and pollutant load reduction benefits by capturing stormwater at source. They also provide amenity value and greening, although to a lesser extent than blue-green corridors.

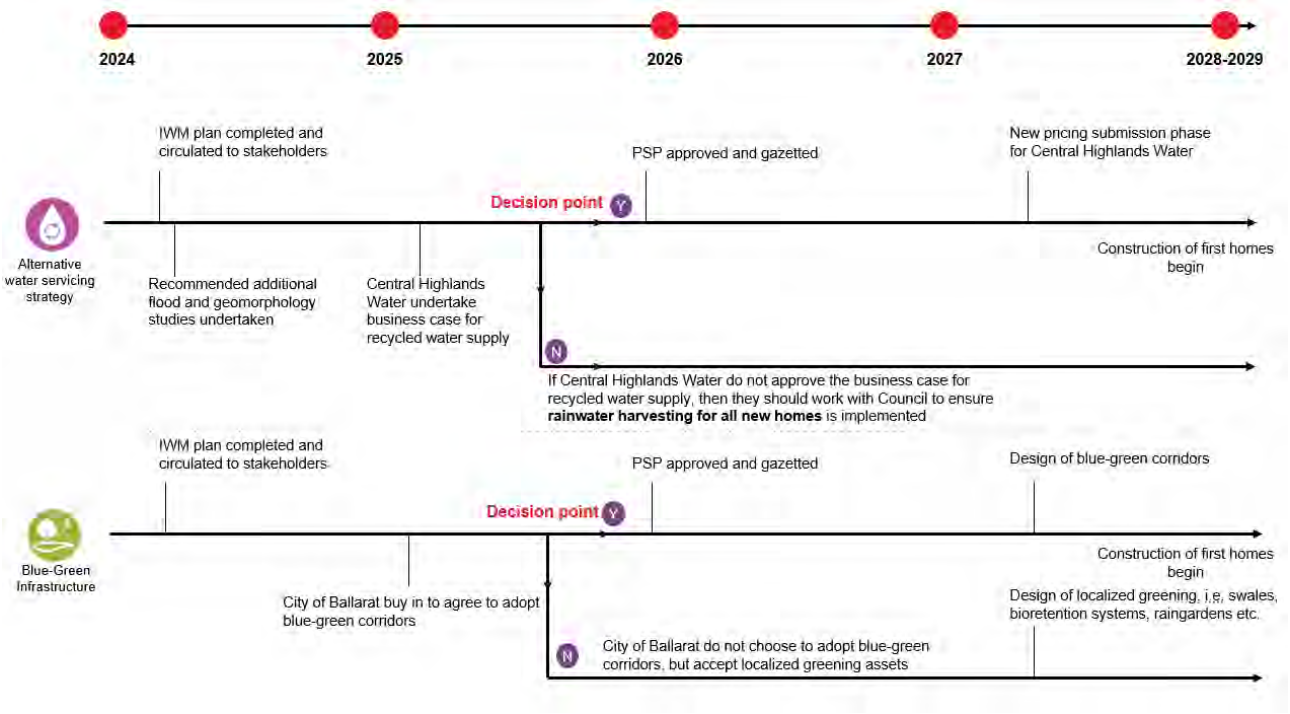


Figure 10-2 Timeline and adaptive plan (the timelines indicated are tentative)

Base case	Preferred portfolio (4)	Adaptive plan
• Combined retarding basins and wetland to meet BPEM target and to control post development 1% AEP flows • Stabilisation of Burrumbeet Creek	• Base case plus: • Recycled water to homes • Precinct scale stormwater harvesting for open space irrigation • Blue-green corridors in PSP • Provide ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek	• Base case, precinct scale stormwater harvesting for open spaces, providing ecological refuge and resilience for flora and fauna residing within Burrumbeet Creek, PLUS : • **2kL rainwater tanks in homes** • **Household raingardens** • **Bioretention systems or passively irrigated trees in the streetscape**

10.2 Way forward

A way forward and proposed action plan is set out below. Recommendations have been clustered into themes, and lead responsibilities have been assigned.

Table 10-1 Action plan

Theme	Recommendation	Lead responsibility
Flood study	It's acknowledged that GHCMA have concerns regarding the limitations of the current assumptions being made on the flood extent, based on the 2013 flood investigation study. CoB council and the CMA are considering updating this data. For this PSP, it's recommended to undertake additional analysis on flood risk within the site to ensure the flood overlay being used for planning is appropriate and that land use allocations are made accordingly.	VPA in collaboration with GHCMA
Review Water demands and undertake business case	CHW to undertake water demand assessment to feed into the business case for recycled water at the PSP. Undertake a business case to justify investment in recycled water to service Ballarat North PSP	CHW
Continued engagement with WTOAC	VPA, alongside council and Central Highlands Water, should continue to liaise with the WTOAC as the PSP progresses.	VPA, CoB, CHW in collaboration with WTOAC
Vegetation and geomorphology assessment	Undertake a vegetation and geomorphology assessment of Burrumbeet Creek to better understand vegetation and erosion conditions, which will support the preferred IWM interventions and outcomes. Recommendations from this can be used to support plans for ecological remediation which can be taken forward by developers, CoB and GHCMA.	VPA, GHCMA, CoB
Land use	If CoB are in support of blue-green corridors in the PSP, VPA to investigate integrating key green-blue corridors in land use plan and integrate with street and movement network. As this IWM Plan was developed using a high level land use budget for the PSP, it is recommended to refer to Risk and Opportunity Mapping (Water Tech & E2 Design, 2016) for conceptualising assets (such as wetlands and retarding basins) within proximity to active open spaces.	VPA, CoB
Council adoption and maintenance	Before the PSP is finalised, Council should consider their intention to adopt options proposed by this study and inform VPA if they intend to include relevant options in the PSP (blue-green corridor and any streetscape solutions).	CoB Council

10.2.1 Conclusions

The IWM options, portfolios and recommendations in this study have been pulled together using stakeholder participation, as well as the IWM Statement provided by Wadawurrung Traditional Owners Aboriginal Corporation. The portfolios in particular were included for assessment purposes in order to drive a way forward for IWM for this PSP. The VPA supports interventions that can deliver IWM objectives and community benefits, however VPA has no influence once the PSP is developed.

This assessment is conceptual in nature to provide high level direction on IWM options for Ballarat North PSP. It is up to the stakeholders to confirm the final suite of options that is suitable and feasible for the precinct. An adaptive plan is included to assist stakeholders in subsequent IWM planning in the post PSP phase.

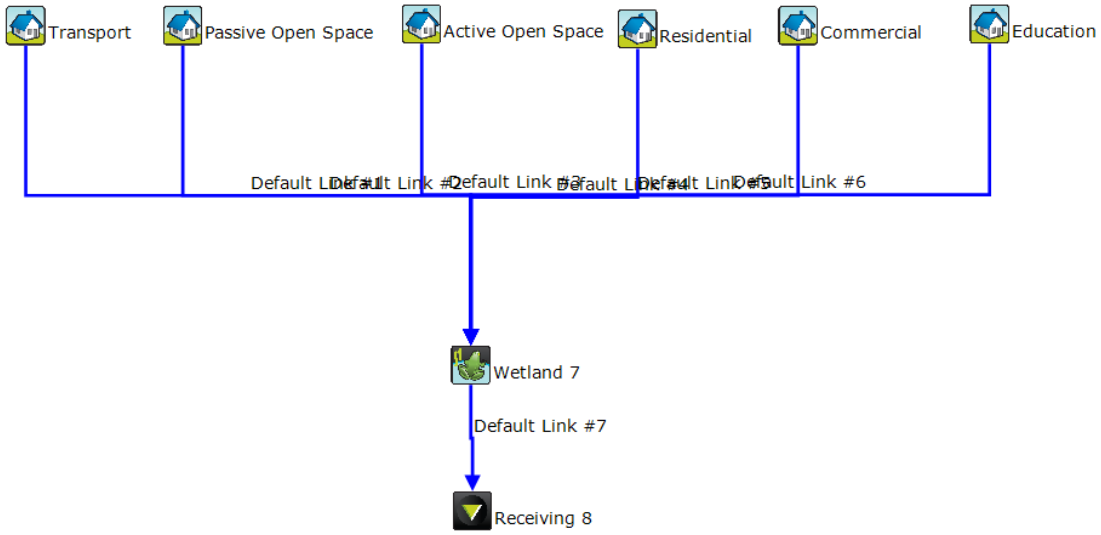
Appendix A

Summary of documents reviewed

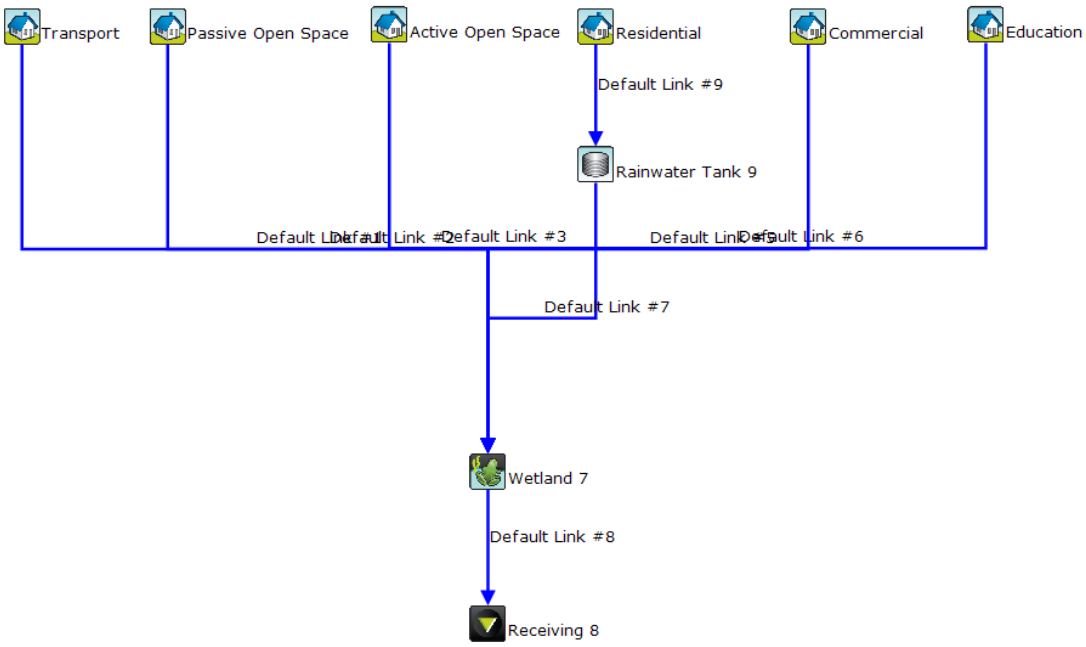
Document Name and date	Author/Organization
Ballarat Long Term Growth Options Investigation: Northern Growth Investigation Area (2018)	Hansen Partnership Pty Ltd and ARUP
Stormwater Management Strategy for Miners Rest (2020)	Beveridge Williams & Co Pty Ltd
Environmental Values of Burrumbeet Creek (2007)	Glenelg Hopkins Catchment Management Authority
Ballarat North PSP Pitching Session Report (2023)	VPA
Central Highlands Strategic Direction Statement (2022)	DEECA
Ballarat Strategy: Our Vision for 2040 (2015)	City of Ballarat
Ballarat Integrated Water Management Plan (2018)	City of Ballarat, Central Highlands Water & Corangamite CMA
Urban Water Strategy (2022)	Central Highlands Water
Regional Floodplain Management Strategy (2017)	Glenelg Hopkins Catchment Management Authority
Climate Change Strategy (2016-2023)	Glenelg Hopkins CMA
Burrumbeet Creek Catchment Local Floodplain Development Plan (2015)	City of Ballarat
Burrumbeet Flood Investigation: Summary Study Report (2013)	Water Technology
Wyndholm Park – Integrated Water Management Plan (2019)	Spiire
Miners Rest Mitigation Strategy (2021)	Water Technology
Water for Victoria (2016)	DEECA

Appendix B

MUSICX Model set up for Stormwater Pollutant Base Case



MUSICX Model for Option 1



MUSICX Model for Option 2

Appendix C

Hydrology and Hydraulic Assessment Outputs