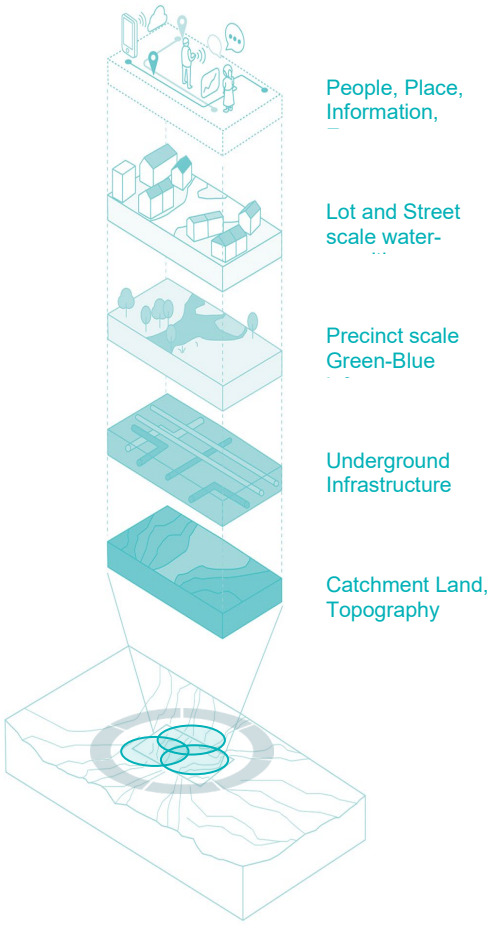
Department of Transport and Planning

Merrifield North precinct IWM Plan

Situational Analysis Report

Reference: 03

03 | 30 June 2026



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Document Verification

Project title	Merrifield North precinct IWM Plan
Document title	Situational Analysis Report
Job number	314813-00
Document ref	03
File reference	Final

Revision	**Date**				
01	20/03/2026	**Filename**	Merrifield North PSP Situational Analysis Report		
		Description	Draft report for DTP review		
			Prepared by	**Checked by**	**Approved by**
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02	30/04/2026	**Filename**	Merrifield North PSP Situational Analysis Report		
		Description	Final report		
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03	30/10/2026	**Filename**	Merrifield North PSP Situational Analysis Report		
		Description	Final Report		
			Prepared by	**Checked by**	**Approved by**
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Issue Document Verification with Document ✓

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 Wurundjeri-woi Wurrung people of the Kulin Nation who have been custodians of the Kalkallo Creek sub-catchment, Merri Creek and the Birrarung River for thousands of years.



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1. Introduction

Arup was engaged by the Department of Transport and Planning (DTP) to assess Integrated Water Management (IWM) opportunities for the Merrifield North Precinct Structure Plan (PSP). Merrifield North precinct is a greenfield area located in Melbourne's northern growth corridor, planned for primarily employment land uses in the future.

This situational analysis report summarises the site context based on a review of existing documents and establishes a base case based on a potential development scenario for the Merrifield North Precinct.

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).

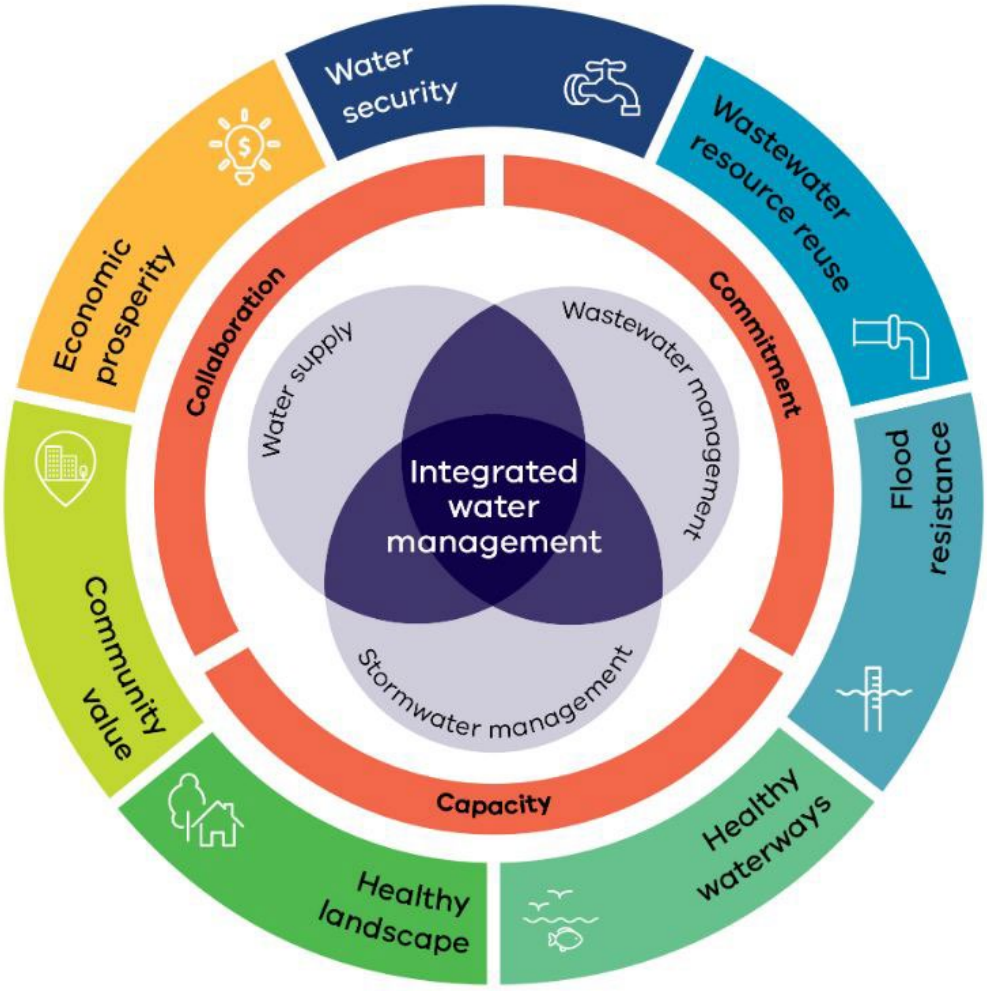


Figure 1-1 Integrated Water Management Cycle

1.2 Methodology

The situational analysis is based on information prepared for and provided by DTP and relevant stakeholders, including background studies and design workshops.

This report is the first stage in the development of an IWM Plan for inclusion in the Merrifield North PSP development. This report is the output of the first milestone.

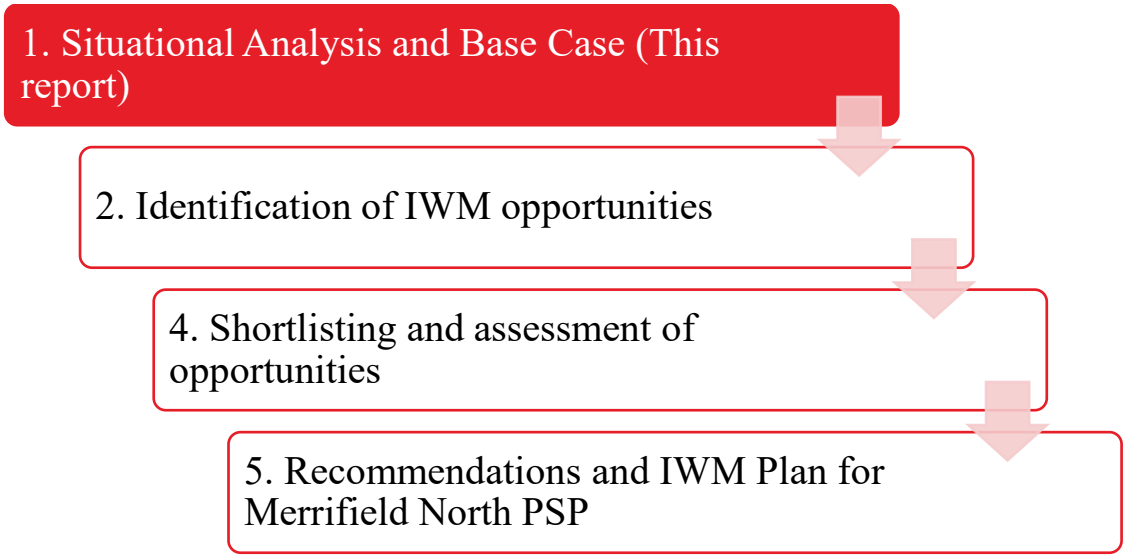


Figure 1-2 Key milestones for this study

1.3 Precinct Attributes

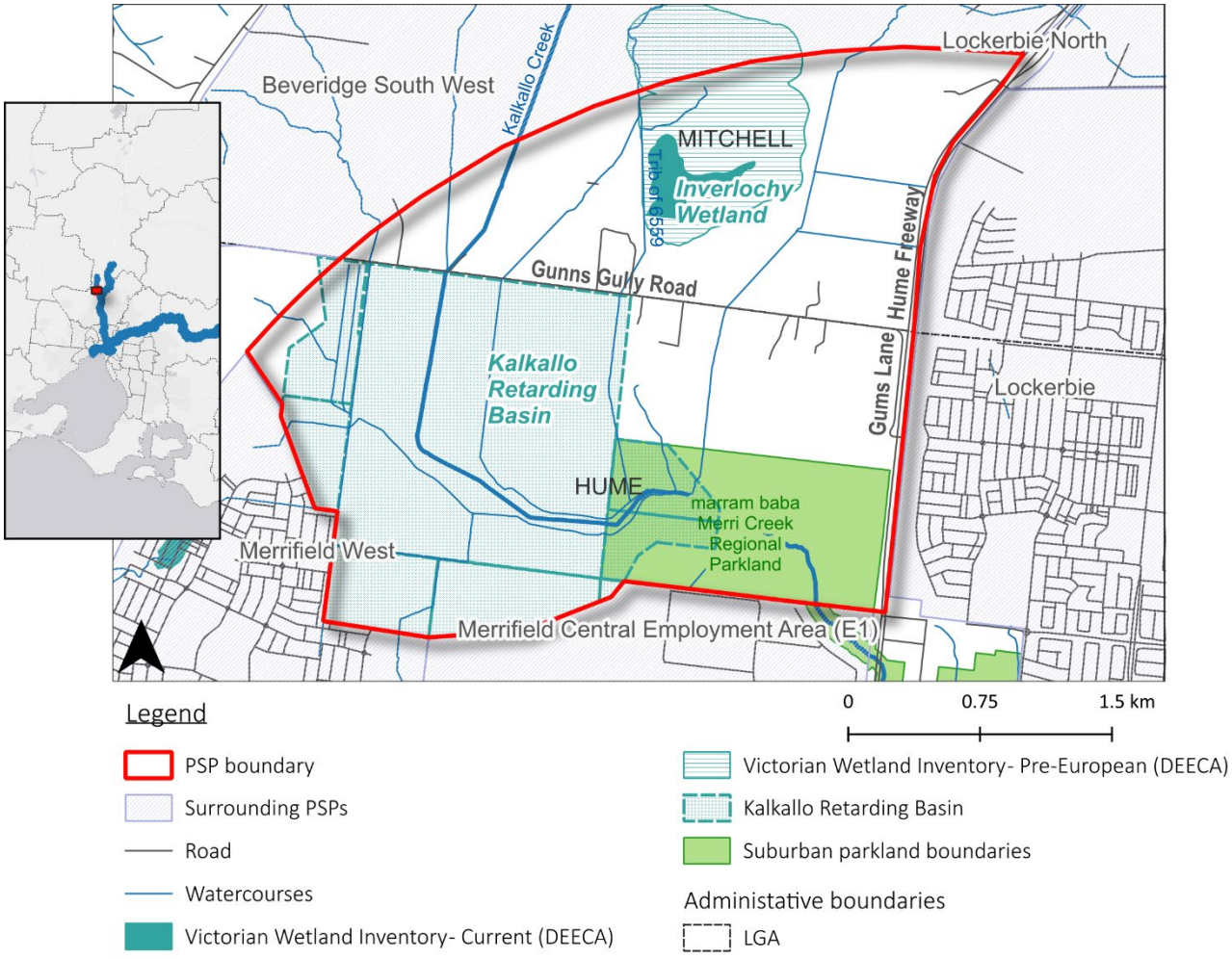
Merrifield North precinct is located within the locality of Mickleham and Beveridge as shown in Figure 1-3. The precinct area sits across both Hume City Council and Mitchell Shire Council areas. The precinct is currently predominantly surrounded by rural land, with existing residential development areas to the east (Lockerbie precinct and Kalkallo township) and the south-west (Merrifield west precinct). The Beveridge South West precinct is located to the north of the site, but planning is yet to be scheduled for that precinct.

The total site area is approximately 970.4 ha and the focus for future land use is on employment uses, most likely with an industrial and commercial focus. Through the PSP development process, DTP will develop a land use plan drawing on a suite of background studies and are currently undertaking technical assessments, engagements with landowners and relevant agencies.

The Economic Growth Statement was prepared on behalf of the Victorian State Government and sets out a vision for the state economy. The statement includes the Merrifield North precinct in the initiative "A 10-year plan to unlock industrial land to give business more certainty – and more room – to grow":

> *Bringing forward planning of the Merrifield North precinct with planning commencing this financial year and completed by the end of 2028, five years ahead of what was announced in the 10-year plan for Melbourne's greenfield. This precinct is close to the future Cloverton Metropolitan Activity Centre and comprises more than 900 hectares and with capacity for up to 4 700 jobs, with planning to commence this financial year.* (the Victorian Government, 2024)

Some of the key features with this site include Kalkallo Retarding Basin (RB), Marram Baba regional parklands and the general area believed to have been a pre-european wetland, Inverlochy wetland. Kalkallo Creek enters the site from north of the precinct, flows through the RB and ultimately flows downstream towards the southeastern part of the precinct before it confluences with Merri Creek. These features are described in more detail in Section 3.



This map reflects acknowledgement of existing publicly available information only, it does not identify Inverlochy Wetland as a Biodiversity Conservation Area under the MSA, and therefore does not imply a conservation retention requirement. The drainage footprint will be determined through the DSS (not DEECA mapping), while cultural heritage will be identified through existing information via the ACHIA and CVA, with the PSP seeking to avoid precinct infrastructure in culturally sensitive areas where possible and permit applications addressing requirements under the Aboriginal Cultural Heritage Act through any CHMPs

Figure 1-3 Merrifield North precinct overview

1.4 Key Stakeholders

The key stakeholders for IWM in Merrifield North precinct are summarised in Table 1-1. It's 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 in water management who each hold differing responsibilities. These stakeholders will be engaged at subsequent stages of this study.

Table 1-1 Key Stakeholders

Stakeholder	Responsibility	Relevance
Department of Transport and Planning (DTP) *Formerly Victorian Planning Authority (VPA)*	Responsible for development of the precinct structure plan. Undertake strategic planning and coordinated infrastructure.	The DTP will deliver a precinct structure plan for Merrifield North, of which an IWM Plan will feed into.
Wurundjeri Woi-Wurrung Cultural Heritage Aboriginal Corporation (WWCHAC)	Wurundjeri people are the traditional owners of the land where Merrifield North precinct is located.	The WWCHAC have input into the suitability of the expanded growth area, the cultural heritage within the site and parameters for development within the growth area.

Stakeholder	Responsibility	Relevance
Melbourne Water (MW)	Manage bulk water resources in the Melbourne region and distributes to suppliers including Yarra Valley Water (YVW). Responsible for major drainage assets, waterway and catchment management.	MW plan for assets (such as the Kalkallo RB) and are currently undertaking drainage modelling within this site. MW are also the responsible authority for floodplain and river health management. Kalkallo Creek flows through the precinct and the land surrounded the creek within the precinct is partially in a flood plain.
Yarra Valley Water (YVW)	Provides water supply and wastewater services to urban and commercial customers. Manages water and wastewater related infrastructure.	YVW is the responsible authority for supply of water, recycled water provisions and sewerage for the Merrifield North precinct and is a key stakeholder for this study.
Hume City 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.
Mitchell Shire 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.
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 Yarra Catchment IWM Forum to prioritise IWM initiatives in the area.
Major Road Projects Victoria	Authority responsible for planning major road assts and upgrades, before road assets are adopted by Department of Transport.	MRPV are investigating major road upgrades adjacent to the site and are responsible for delivering IWM initiatives for road infrastructure which could potentially interact with those in Merrifield North.

2. Policy drivers and requirements for IWM

This section summarises the key policies and strategies that guide the direction and implementation of integrated water management in Victoria, including:

- Key direction setting documents for IWM in Victoria and the Melbourne Region
- Legislation and Victorian Planning Policy and Provisions relating to IWM
- Key strategies and plans for IWM in the Yarra Catchment and local area

2.1 Key direction setting documents for IWM in Victoria and the Melbourne Region

Key Document	Targets, objectives and directions to embed in IWM planning
Water for Victoria, 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.
IWM Framework for Victoria, 2017	The IWM Framework supports the establishment of IWM Forums across metropolitan and regional Victoria to identify, prioritise and oversee the implementation of collaborative water opportunities. The Forums bring together key stakeholders with an interest in the water cycle, recognising that each has an important role to play in the management of our most vital resource.
Central and Gippsland Regional Sustainable Water Strategy, 2022	The Central Gippsland Regional Sustainable Water Strategy (CGRSWS) sets policy direction and outlines actions for securing the region's long-term water supplies to protect the jobs, farms, ecosystems, communities, and Traditional Owners that rely on them. The proposals which are relevant to the Yarra region include: • Proposal 5-2: It is proposed that entitlement to 1.4 gigalitres of water in the Birrarung be returned to Wurundjeri Woi-wurrung Cultural Heritage Aboriginal Corporation, and that the Victorian Government complete a formal review of the allocation decision for the remaining 0.7 gigalitres • Proposal 5-3: It is proposed that all future business cases for investment in new sources of water include a commitment to hand back a proportion of water to Traditional Owners on the completion of these substitution projects. The timeline for the completion of these projects will be included in the Sustainable Water Strategy implementation plan. The following actions and policy directions are set to address the above proposals: • Policy 4-3: Substituting river water with manufactured water in the longer term. • Policy 8-7: Return water to the Birrarung (Yarra River) • Action 2-6: Maximising water efficiency in business and industry • Action 3-18: Building community confidence in recycled water and stormwater • Action 4-2: Commitment to consider how river entitlements can be reduced via water efficiency, IWM and substitution with manufactured water sources

	• Action 8-14: Stormwater for the environment
Water is Life: Traditional Owner Access to Water Roadmap, 2022	Water is Life is a framework to create and maintain a careful and considered balance between Traditional Owner self-determination in water access and management, and the rights and entitlements of a range of stakeholders. The strategy outlines actions to deliver meaningful outcomes to Traditional Owners to enable deeper involvement with decisions around water management. The outcomes from the strategy include: • Increased role in determining how environmental water is used for the purpose of healing Country. • Increased involvement in public land management. • Recognition of Traditional Owners as waterway managers for specific locations. • Recognition of Traditional Owners as environmental water holders.
Water for Life: The Greater Melbourne Urban Water Systems Strategy, 2022	Water for Life (2022) sets out the strategy for the future of Melbourne's water supply. Importantly, the strategy recognises and prioritises IWM with the aim of diversifying water supplies for Melbourne as part of an adaptable and resilient future water supply. Integration of opportunities for recycled water supply, stormwater and rainwater harvesting in combination with other water supply resilience measures were shown to deliver the greatest benefits to the community, due to the co-benefits these alternative water supplies deliver in terms of waterway health, circular economy outcomes, landscape amenity and community well-being.
VPA Guidelines for PSPs, 2021	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

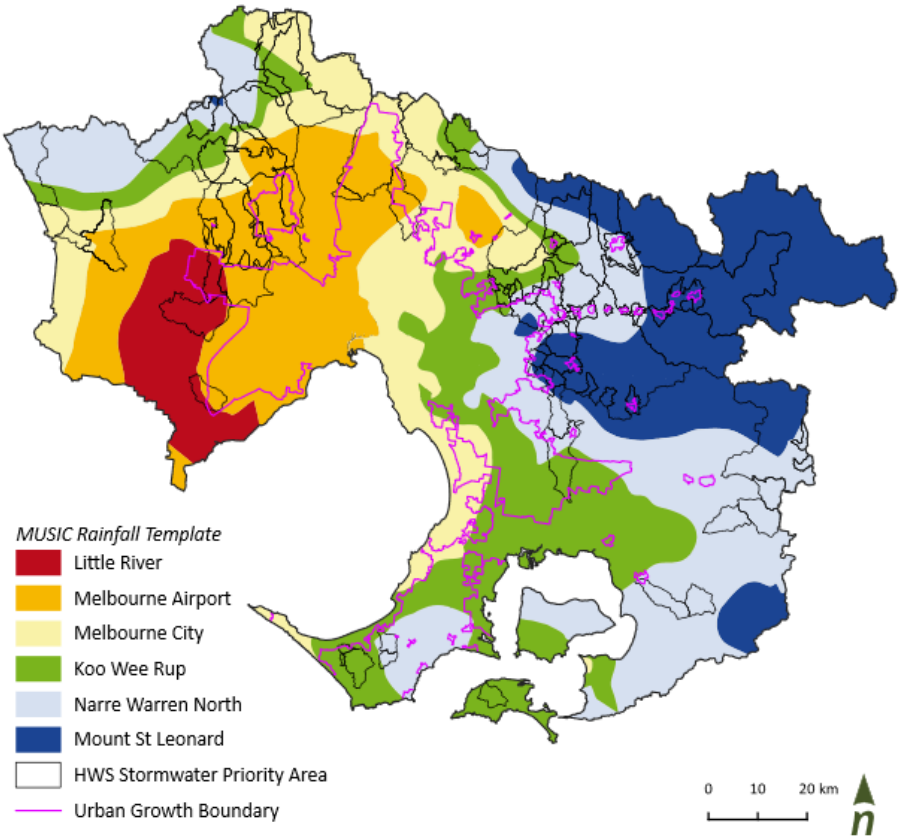
2.2 Legislation and Victorian Planning Policy and Provisions relating to IWM

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

Table 2-1 Key Policies and Legislation

Policies & Legislation	Description
General Environmental Duty under the Environment Protection Act 2017	The Environment Protection Act 2017 includes objectives that aim to protect the environment and human health. It sets out a duty to reduce the risk of harm to the environment. The General Environmental Duty applies to all Victorians, including organisations responsible for water management, land owners and developers.
Victorian Planning Provisions	Clause 19.03-3S is the primary policy relating to IWM included in all planning schemes and seeks to: "Sustainable manage water supply and demand, water resources, wastewater, drainage and stormwater through and integrated water management approach." 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 Management Guidelines (Publication 1739.1) 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.

Policies & Legislation	Description
Urban Stormwater Management Guidelines	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 the previously referenced Best Practice Environmental Management (BPEM) Guidelines: • 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. 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. For Merrifield North precinct, the 'Priority' area targets apply. Mean annual rainfall measured at Station 86282 Melbourne Airport is 500-650mm, therefore the adopted targets for this precinct will be 74% harvesting and evapotranspiration and 8% infiltration.



				Priority areas				Other Areas			
Template Name	Annual rainfall range	Model annual rainfall	Runoff	Harvesting target		Infiltration target		Harvesting target		Infiltration target	
	(mm)	(mm)	ML/year from 1 impervious ha	ML/year from 1 impervious ha (and %)							
Little River	400 - 500	472	3.7	2.9	(79 %)	0.1	(4 %)	1.2	(32 %)	0.1	(3 %)
Melbourne Airport	500 - 650	575	4.6	3.4	(74 %)	0.4	(8 %)	1.4	(29 %)	0.3	(6 %)
Melbourne City	650 - 750	708	5.8	3.9	(67 %)	0.7	(12 %)	1.6	(27 %)	0.5	(9 %)
Koo Wee Rup	750 - 850	769	6.3	4.1	(65 %)	0.8	(13 %)	1.6	(26 %)	0.7	(10 %)
Narre Warren North	850 - 1100	932	7.8	4.6	(59 %)	1.3	(16 %)	1.8	(23 %)	1.0	(13 %)
Mount St Leonard	1100 - 2100	1221	10.6	5.3	(50 %)	2.2	(21 %)	2.1	(20 %)	1.8	(17 %)

Policies & Legislation	Description
	This guidance document is referenced in the Victorian Planning Provisions as a relevant policy document and is administered under the General Environmental Duty (GED).
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.

2.3 Key strategies and plans for IWM in the Yarra Catchment and local area

The following section details some of the previous strategies and plans developed for the Yarra Catchment and area, focusing on relevant opportunities identified and relevant local objectives sought. It includes a summary of:

- Healthy Waterways Strategy: Yarra Catchment
- Yarra Catchment Strategic Directions Statement
- Yarra Catchment Integrated Water Management Plan
- Yarra Catchment Action Plan
- Upper Merri Creek Integrated Water Management Plan
- Kalkallo Creek Sub-Catchment Integrated Water Management Plan
- City of Hume IWM Plan
- Mitchell Shire Council Climate Emergency Action Plan
- Marram baba Merri Creek Regional Parklands Future Directions Plan

2.3.1 Healthy Waterways Strategy: Yarra Catchment, 2018

In 2018 Melbourne Water released the Healthy Waterways Strategy for metropolitan Melbourne. The strategy was developed in collaboration between waterway managers, scientific teams, communities, Traditional Owners, interest groups and government agencies to protect the region's waterways, enhancing the long-term health, amenity and lifestyle of the Port Phillip and Western Port region.

For each metropolitan catchment, a Co-designed Catchment Program was developed to support the Healthy Waterways Strategy. The Program provides a framework for managing waterways considering variable climatic and development conditions, and community needs.

Merrifield North precinct sits within the Merri Creek Upper sub-catchment within the Yarra catchment. Relevant performance objectives for Merri Creek Upper sub-catchment include:

- Identify and implement opportunities to reduce the key threat of flow stress on waterways by addressing causal factors such as water for domestic and stock use, climate change, diversions or urbanisation.

- For every hectare of new impervious area, harvest 4.2 ML/y.
- For every hectare of new impervious area, infiltrate 1.1 ML/y.

2.3.2 Yarra Catchment Strategic Directions Statement, 2018

The Yarra Catchment Strategic Directions Statement was developed by the Yarra IWM forum to summarise the shared vision and strategy for the catchment. It sets out the current priorities and opportunities within the catchment.

The opportunities described in the statement that are relevant to this assessment are summarised in Table 2-2.

Table 2-2 Actions from Yarra Catchment Strategic Directions Statement relevant to this assessment (Integrated Water Management Forums, 2018)

Action	Status	Agencies Involved
IWM Opportunities		
Action 11: Merri Creek Upper IWM Sub-catchment Plan Pilot The Merri Creek Upper sub-catchment will be a pilot site for the implementation of IWM Sub-catchment Plans in a predominantly greenfield development setting. The sub-catchment is undergoing significant development as part of the North Growth Corridor Plan to expand transport, housing, employment and lifestyle opportunities in Melbourne's northern growth areas. This plan represents a pilot project for the broader IWM Sub-catchment Plan strategy for Metropolitan Melbourne.	Consult and finalise	Yarra Valley Water, Melbourne Water, Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation (WWCHAC), Hume City Council, Whittlesea City Council, Mitchell Shire Council
Action 15: Kalkallo Retarding Basin Multi-Use Outcomes Melbourne Water is currently developing principles and a prioritisation tool to identify when and what type of community infrastructure is appropriate at different flood retarding basin sites. There is an opportunity to partner with local governments and other organisations to implement findings from this work, and to explore recreation, open space, water harvesting and distribution outcomes. This project will investigate opportunities for multiple and additional land uses of Melbourne Water-owned retarding basin land. Opportunities include stormwater harvesting and reuse, passive and active open space, stormwater treatment, biodiversity. The outcomes of this strategic study could facilitate on-ground works that will require collaborations with local government, retailers and community, as well as a dataset that captures a ranking and/or prioritisation of retarding basins based on multi-use benefit opportunities, and agreed principles and a tool to guide and assess multiple land use of retarding basins for Melbourne Water.	Concept and feasibility	Melbourne Water, Councils, water corporations, Wurundjeri WWCHAC, Bunurong Land Council Aboriginal Corporation (LCAC)
Additional relevant IWM Opportunities		
Action 29: Hazelwynde Water Sensitive Community	-	Yarra Valley Water, Mitchell Shire Council, Melbourne Water, Wurundjeri WWCHAC, VPA, developers, community
Action 40: Stormwater Harvesting for a Variety of Uses in the Northern Growth Corridor	-	Yarra Valley Water, Melbourne Water, Hume City Council, Mitchell Shire Council, Whittlesea City Council, Wurundjeri WWCHAC, VPA

2.3.3 Yarra Catchment Integrated Water Management Plan., 2022

The Yarra Catchment IWM Plan, created by the Yarra IWM Forum in 2022 as a result of the Victorian IWM Framework (2017), emphasises the need for a catchment-scale perspective that recognises transboundary issues and optimizes outcomes by addressing the entire water cycle and provides targets to be met.

The Yarra catchment Vision as set out in this document is:

"Working together, Yarra is a world-leading water sensitive catchment, and our communities are healthy and thriving. We honour the land and the water of the Birrarung and its tributaries as the lifeblood of the catchment."

Any IWM solutions proposed within the Kalkallo Creek sub-catchment IWM plan should contribute to the strategic IWM outcomes and associated measures and targets in the Yarra IWM Plan. The overarching strategic IWM outcomes within this plan are shown below, and the 2030 and 2050 targets are shown in Table 2-3.

This plan is closely related to the Yarra Catchment Integrated Water Management Strategic Directions Statement, discussed further in section 2.3.2, and the Yarra catchment IWM plan, discussed further in section 2.3.4.



It should be noted that both Yarra Valley Water and Melbourne Water are members of the Yarra IWM Forum, and therefore the strategic outcomes and the targets represent the aspirations of both organisations.

Table 2-3 IWM targets for the Yarra Catchment

Strategic Objective	Targets (as of 2022)
Safe, secure and affordable water supplies in an uncertain future 	• 150 litres per person per day by 2024 for the Greater Melbourne Region (as per the Central and Gippsland Region Sustainable Water Strategy) • 14 Gigalitres/year of alternative water sources that substitute potable mains supply by 2030 for the catchment • 150 Gigalitres/year of alternative water sources that substitute potable mains supply by 2050 for the Greater Melbourne Region
Effective and affordable wastewater systems 	• 85 Gigalitres/year of recycled water delivered to customers by 2030 for the Greater Melbourne Region • 230 Gigalitres/year of recycled water delivered to customers by 2050 for the Greater Melbourne Region • 94% nitrogen recovered at treatment facilities for beneficial use by 2050 for the Greater Melbourne Region • 67% carbon recovered at treatment facilities for beneficial use by 2050 for the Greater Melbourne Region
Existing and future flood risks are managed to maximise outcomes for the community 	• $10 million reduction in AAD delivered by flood management initiatives by 2030 for the catchment • $408 million reduction in AAD delivered by flood management initiatives by 2050 for the Greater Melbourne Region • 100% of projects cross-consider IWM and flood mitigation opportunities as part of their design by 2030 and maintained by 2050 for the catchment and Greater Melbourne Region
Healthy and valued waterways and marine environments 	• 21 Gigalitres/year and 70 Gigalitres/year of mean annual urban runoff volume reduction by 2030 for the catchment and the Greater Melbourne Region respectively • 71 Gigalitres/year and 197 Gigalitres/year of mean annual urban runoff volume reduction by 2050 for the catchment and the Greater Melbourne Region respectively • Remove TSS and TN to achieve the marine pollutant load objectives for the Port Phillip Bay and Western Port, as specified in the Environment Reference Standards 2021 • 28 Gigalitres/year and 53.9 Gigalitres/year of water secured for the environment to improve waterway health by 2032 for the catchment and the Greater Melbourne Region respectively (as per the Central and Gippsland Region Sustainable Water Strategy)
Healthy and valued urban and rural landscapes 	• 8% and 21% of street trees are supported with permanent irrigation from an alternative water supply by 2030 and 2050 respectively, for the catchment • 18% and 50% of active public open space (sports fields and organised recreation) is supported by an alternative water source by 2030 and 2050 respectively, for the catchment • 2% and 30% of passive public open space (parks and gardens) is supported by an alternative water source by 2030 and 2050 respectively, for the catchment
Community values are reflected in place- based planning 	• Rating of 4 out of 5 by 2030, and 5 out of 5 by 2050 for community literacy regarding the water cycle for the catchment • Rating of 4 out of 5 by 2030, and 5 out of 5 by 2050 for water as a key element in city planning and design processes for the catchment
Jobs, economic benefits and innovation 	• 2 Gigalitres/year of alternative water is supplied to agricultural production in the catchment by 2030 • 7 Gigalitres/year of alternative water is supplied to agricultural production in the catchment by 2050
Enablers 	• Rating of 4 out of 5 by 2030, and 5 out of 5 by 2050 for vision, leadership and long-term commitment through vision statement and objectives articulated in corporate documents for the catchment • Rating of 4 out of 5 by 2030, and 5 out of 5 by 2050 for knowledge, skills and organisational capacity for the catchment • Rating of 4 out of 5 by 2030, and 5 out of 5 by 2050 for cross-sector institutional arrangements and processes for the catchment

2.3.4 Yarra Catchment Action Plan, 2024

In April 2024, DEECA released an Action Plan outlining priority actions for the Yarra Catchment. The Action Plan is an extension of the Yarra Catchment IWM plan and its role it to summarise the specific **structural**, **systemic** and **place-based enabling** actions to meet the targets set out in the catchment plan and to enable the catchment vision.

The relevant structural, systemic and place-based actions that are relevant to Merrifield North are summarised below.

Table 2-4 Actions from the Yarra IWM Action Plan (relevant to Merrifield North)

Action	Status	Agencies Involved
Structural Actions		
Northern Growth Area: Dual Pipe *(Structural Action #7)* The Aurora and Wallan Recycled WTPs deliver high-quality recycled water, fostering a climate-resilient water supply and diminishing dependence on potable water sources. As development progresses from Epping North to Wallan, YVW is set to expand its investment in recycled water infrastructure, including a new treatment plant in Wollert.	Business Case	Lead: Yarra Valley Water Implementation Partners: Melbourne Water, Mitchell Shire Council, Hume City Council, Whittlesea Council
Upper Merri Creek stormwater harvesting *(Structural Action #9)* The Upper Merri Creek hosts extensive and varied remnants of native vegetation along with protected and threatened species of flora and fauna. SWH initiatives in the Upper Merri Creek catchment are designed to mitigate the environmental impacts of expected urban development and preserve the health of the creek for fish and other wildlife. By removing excess urban runoff, these efforts enhance the quality of stormwater entering Merri Creek and other local waterways. Additionally, this reduces reliance on potable water sources and aids in urban greening and cooling across the region.	Idea development	Lead: Melbourne Water Implementation Partners: Yarra Valley Water, Hume City Council, Whittlesea City Council, Mitchell Shire Council, Wurundjeri WWCHAC, Victorian Planning Authority
Kalkallo Stormwater Pilot *(Structural Action #22)* The Kalkallo stormwater harvesting scheme is designed to treat stormwater to the highest standard for reuse purposes. Supported by funding from the Australian Government, the scheme offers partners a chance to develop a controlled proof-of-concept case study for stormwater treatment. This initiative aims to inform the creation of new and more specific regulations that could broaden water sources and secure future water supplies.	Feasibility and concept	Lead: Yarra Valley Water Implementation Partners: Melbourne Water
Systemic Actions		
Secure funding and resourcing to enable Traditional Owners to make decisions and determine IWM priorities on their Country	In progress	DEECA, water corporations and local governments
Build capacity across IWM Forum partners to plan and deliver IWM	In progress	DEECA, water corporations and local governments
Develop guidance for stormwater harvesting and infiltration	In progress	Melbourne Water, EPA, local governments
Develop a framework for installation and maintenance of rainwater tanks	In progress	DEECA, water corporations
Place-based enabling Actions		
Assess open space irrigation for urban cooling opportunities	In progress	Yarra Valley Water
Explore large-scale stormwater harvesting opportunities	In progress	Melbourne Water

2.3.5 Upper Merri Creek Integrated Water Management Plan, 2023

An IWM Plan was developed for the Upper Merri Creek catchment in January 2023.

"We all respect, care for, protect and enjoy our places and nature; supporting a connected and sustainable Community." - Upper Merri Creek Community Vision

The Upper Merri Creek Plan serves as a strategic compass for the Northern Growth Area, guiding agencies in high-level planning without delving into the specifics of infrastructure planning.

Developed through extensive consultation with key Rightsholders and Stakeholders, the Upper Merri Creek IWM plan builds upon the work of the Yarra Catchment Scale IWM Plan. The document provides a framework that aligns with overarching IWM strategies and frameworks, ensuring that future capital and operational planning requirements for all involved organisations are informed by a cohesive strategic direction. This approach ensures a unified vision for IWM, where the Kalkallo IWM plan will add further granularity to the objectives presented by the Upper Merri Creek IWM plan.

The recommendations from the Upper Merri Creek IWM Plan are listed below in Table 2-5.

Table 2-5 Recommendations from the Upper Merri Creek IWM Plan

	Outcomes	Recommendations
Alternative Water	• Increase Stormwater Reuse • Increase Rainwater Reuse • Increase Sewage Reuse • Investigate Biosolid Production • Pursue 100% Beneficial Reuse of Sewage	Conduct a joint options assessment for preventing 21.89GL/y worth of stormwater from reaching waterways in Stormwater Priority Areas. Undertake a comprehensive review of potential alternative water customers. Review should identify and prioritize major users across the agricultural, industrial, residential, environmental, and cultural sectors and recommend how to manufacture and deliver alternative water to them. Conduct an options assessment to prioritize and jointly resource alternative water treatment, storage, harvesting, and reuse projects in public open spaces. Undertake a comprehensive review and prioritization of customers that are suitable for rainwater capture and reuse, including smart tank technology. Then produce a plan to facilitate, incentivize, or mandate customer access where appropriate. Trial and investigate best practice passive street tree irrigation systems to determine preferred designs which can be widely used. Conduct an options assessment for the expansion of the Wallan and Yan Yean sub-regional alternative water supply network aiming to deliver an additional 20 GL/y of alternative water to agricultural customers.
Waterway Health	• Improve Waterway Water Quality • Decrease Mean Annual Urban Runoff Volume • Identify Remnant Wetlands • Reengage Wetlands	Working within the new EPA General Environmental Duty, clarify and enforce the duty to protect waterways from stormwater runoff from development and industrial pollution incidents. Liaise with DEECA to amend standard A6 (Clause 54) and B9 (Clause 55) to increase the minimum permeable area from 20% to 30%. The location, current state, and restoration potential of wetlands in the Upper Merri Creek are identified, and where required, incorporated into formal mapping and zoning.
Blue and Green Amenity	• Increase Canopy Cover Increase Access to Blue and Green Spaces • Mitigate Land Surface Temperature Rise • Improve Connectivity of Tracks and Trails • Addition of Green and Blue Spaces	Increase the tree canopy to 27% by 2050, of which at least 30% is on private land, with all newly constructed irrigation systems using an alternative water supply. Conduct a review of pipe tracks that could be used for multiple purposes (e.g., walking tracks and WSUD) and identify any disconnected sections of linear paths along waterways. Then recommend and implement ways of connecting and activating these spaces. Identify paved waterways, explore feasibility of creek naturalisation.

	Outcomes	Recommendations
Traditional Owners	• Advance Cultural Research • Embed Caring for Country Resource Management Practices • Develop Traditional Ownership of Water Resources and Planning • Facilitate Cultural Education, Events and Visual Communication	Collaboratively support an ongoing suite of research, guided by the priorities of the Wurundjeri's Yalingang Ngarrmgatj - Research unit and Cultural Heritage unit, on the cultural values, history anthropology and genealogy of the green and blue spaces of the Upper Merri Creek. Support the significant expansion of Wurundjeri's Narrap - Natural Resource Management unit's role in natural resource management and maintenance. Develop and collaboratively support an ongoing program of work aimed at progressively bolstering the Wurundjeri Water unit's ability to contribute to civil water planning as well as the Organisation's authority over water resource management. Develop and collaboratively support an ongoing program of work aimed at progressively delivering cultural education, events and visual communications via culturally informed procurement, design, and naming, embedded across the community.
Urban Development	• Embed IWM Planning into Precinct Structure Plans • Coordinate an Improved IWM Referral Authority Framework • Support Incorporation of IWM into Development Applications • Enhance Zoning and Mapping of IWM Objectives	Investigate the viability of, and establish a process that expands the level regulatory participation which can be exercised towards IWM by partners. Provide additional guidance to the development industry, including regional IWM infrastructure strategies, officially endorsed guidelines, and enhanced opportunities to collaborate with partner agencies. Create a consistent and helpful policy framework requiring the development industry to submit IWM and Environmentally Sustainable Design assessments with development applications. Advocate for the legislation, policy settings, and the funding environment surrounding IWM to be elevated, making it commensurable with other business-as-usual management of water resources, like maintaining high-quality supplies or preserving customer satisfaction scores.
Community and Collaboration	• Improve Digital Monitoring and Reporting • Increase Community Knowledge of and Participation in Water Planning • Mitigate Impacts of Flooding on Community • Reduce Community's Potable Water Consumption • Embed Collaborative Processes	Investigate the need to develop a joint customer communications strategy. Create a resilience agreement between Local Government and Water Authorities that mitigates the consequences of water restrictions on public open spaces. Investigate for greenfield areas the installation of digital metering in the Upper Merri Creek as it becomes viable. Design and implement a program to subsidize water efficient fittings for vulnerable and inefficient sections of the community. Continue to participate in Integrated Water Management Forums.

Values identified in the Upper Merri Creek IWM Plan

The following community values and principles were identified by the local community at a workshop and included in the Upper Merri Creek IWM Plan.

Table 2-6 Community Values at the Upper Merri Catchment scale (Upper Merri Creek IWM Plan, 2023)

Community Values		
Social Values	• Ability to connect with nature • Communities that are inclusive and look after each other • Knowing your neighbours	• Opportunities to collaborate • Community safety
Cultural Values	• Indigenous land management practices • Caring for Country • Wurundjeri cultural values	• Respecting and embracing the various cultures within the community
Economic Values	• Stable economy • Local food security	• Supporting our farmers

Community Values		
	• Local water security	
Environmental Values	• Retaining and using water locally • Shared community commitment to climate change • Biodiversity • Healthy waterways and wetlands • Green corridors	• Beautiful, healthy landscapes • Trees and greenery throughout our neighbourhoods • Low carbon footprint • Recharged water table.

Community Principles identified in the Upper Merri Creek IWM Plan

- Design of neighbourhoods demonstrate our shared values of caring for Country.
- Neighbourhoods are place-based, supporting opportunities for people to be healthy, connect with one another and with nature.
- Opportunities to learn, collaborate and work together to build stronger communities are ongoing.
- Available natural resources are efficiently managed to ensure the needs of our waterways and natural landscapes are met.
- Biodiversity and ecological systems are protected and enhanced across the sub-catchment and throughout residential and commercial areas.
- Supply and use of water is fit-for-purpose and makes best use of locally captured and treated stormwater and recycled water.
- Knowledge of the natural aquatic system and achieving the required water quality is continually building and being drawn on.
- Housing options and designs are sustainable, supporting stronger communities and providing for choice and affordability.
- Local food production is planned at a variety of scales within the sub-catchment, and food growers are supported.

2.3.6 Kalkallo Creek Sub-Catchment IWM Plan

An IWM plan was developed for Kalkallo Creek sub-catchment in May 2025 by Melbourne Water and Yarra Valley Water. The report summarises catchment context, drivers for IWM and identifies and tests suitable IWM opportunities for the sub-catchment. Many of these consider the role of the Kalkallo Retarding Basin, Inverlochy wetland (referred to within the study as Inverlochy Swamp) as well as the potential for local IWM initiatives in new development areas.

Table 2-7 Recommendations from Kalkallo Creek Sub-Catchment IWM Plan

Recommendation	Lead and support agencies
Infrastructure based decisions	
Commit to design of the Kalkallo Retarding Basin Harvesting Scheme in the MW 2026 price submission	Melbourne Water, Yarra Valley Water
Kalkallo Retarding Basin Land and Configuration Clarification	Melbourne Water, Yarra Valley Water
Update the Kalkallo Drainage Scheme to include the chain of ponds harvesting proposal	Melbourne Water, Yarra Valley Water

Recommendation	Lead and support agencies
Further explore and define concepts for waterway system rejuvenation and restoration of Inverlochy Wetland	Melbourne Water, Yarra Valley Water, WWCHAC, Victorian Planning Authority, Mitchell Shire Council, Hume City Council
Embed IWM Plan and associated decisions and commitments in the Precinct Structure Plans for Beveridge North-East, Beveridge South-West and Merrifield North	Melbourne Water, Yarra Valley Water, WWCHAC, Victorian Planning Authority, Mitchell Shire Council, Hume City Council
Decision support actions	
Perform sensitivity analysis on harvesting yield and other assumptions	Yarra Valley Water, Melbourne Water, Mitchell Shire Council, Hume City Council
Consideration of delivery of rainwater harvesting in Merrifield North	Yarra Valley Water, Melbourne Water, Mitchell Shire Council, Hume City Council
Enabling processes	
Continued collaboration with Wurundjeri Woi-wurrung Cultural Heritage Aboriginal Corporation.	Melbourne Water, Yarra Valley Water, WWCHAC
Alignment with the Upper Merri IWM plan	Melbourne Water, Yarra Valley Water, WWCHAC
Project interfaces	
Align committed infrastructure for Hazelwynde with the wider Kalkallo Creek infrastructure plan, including potential combination of on-site Hazelwynde treatment plant with a downstream treatment plant at Kalkallo RB.	Yarra Valley Water
Coordinate planning with stormwater harvesting timing outside of the Kalkallo sub-catchment.	Yarra Valley Water, Melbourne Water

2.3.7 City of Hume IWM Plan

Hume city council's Integrated Water Management Plan 2020-2025 sets out the council's strategy for IWM. While the plan's effective period has passed, the plan can give insight into the council's priorities.

Targets relevant to this assessment include:

- At least 65% of water used to irrigate sporting reserves to be sourced from non-drinking water sources by 2030.
- Implement at least 61ML/yr of new stormwater harvesting schemes by 2030, at least 25ML/yr of which will be implemented by 2025. By 2030, this will remove approximately 550kg/yr of nitrogen from our waterways.
- Trial passive irrigation of street trees to determine the effectiveness on stormwater treatment, urban cooling and tree health and maintenance implications.
- Install water quality treatment assets (in addition to stormwater harvesting schemes) to remove 400kg nitrogen per year from our waterways by 2030.

2.3.8 Mitchell Shire Council Climate Emergency Action Plan

The Mitchell Shire Climate Emergency Action Plan identifies key risks the shire will face in 2050, and sets out actions to reduce emissions and improve climate resilience.

Table 2-8 Goals described in MSC Climate Emergency Action Plan

Goal	Relevance
Goal 1: Reduce the impact of extreme heat across Mitchell Shire	Increasing canopy, vegetation and public open space.
Goal 2: Improve Mitchell Shire's preparedness to climate change related emergency events	Flood mitigation and community education and engagement.
Goal 3: Protect and enhance the natural environment and support a climate resilient agricultural sector in Mitchell Shire	Protection and enhancement of biodiversity values and habitat.
Goal 4: Support Mitchell Shire residents, businesses and community groups to reduce emissions	Supporting business in adopting sustainable practices to save water.
Goal 5: Accelerate the transition to more sustainable transport solutions in Mitchell Shire	Open space amenity to enable cycling and walking.
Goal 6: Empower the Mitchell Shire community to take meaningful action in response to the Climate Emergency	Community engagement in sustainability.

Risks relevant to this assessment are summarised in Table 2-9 and result from drought, riverine flooding, or extreme heat.

Relevant actions described in the plan are as follows:

- E5: Develop and implement integrated water management plans for the Shire in partnership with water authorities, that cover stormwater, drainage, sustainable water use and re-use to reduce stormwater runoff and mitigate road flooding.
- H1: Increase tree canopy cover within shire townships on public land and enhance the diversity of tree species, prioritising the use of more climate adapted species

Table 2-9 Relevant risks from MSC Climate Emergency Action Plan

Hazard	Risk	Council Area	Risk rating (at 2050)	Risk summary
Drought	RID021 Increased frequency and severity of drought is likely to lead to greater food insecurity due to lost production, economic losses from farms and downstream businesses and lost household produce.	Public health and wellbeing	Very high	Food security impacts
	RID018 Increased frequency and severity of drought is likely to lead to greater stress on local ecosystems, potentially leading to diebacks and habitat loss.	Environment and parks	Very high	Habitat & biodiversity loss
	RID024 Increased frequency and severity of drought is likely to lead to water supply issues resulting in water restrictions.	Water	Very high	Water scarcity and supply issues
Riverine flooding	RID049 Higher intensity rainfall events could lead to more flash flooding or rapid onset flood events, which could lead to a greater loss of life as people are caught unaware or unprepared.	Public health and wellbeing	Extreme	Loss of life

Hazard	Risk	Council Area	Risk rating (at 2050)	Risk summary
	RID041 Higher intensity rainfall events could increase the frequency and severity of significant flood events leading to greater of loss and damage of public assets and infrastructure leading to greater disruption of services and repair and maintenance costs to Council.	Assets and Infrastructure	Very high	Damage and loss of assets and infrastructure
	RID042 Higher intensity rainfall events could increase the frequency and severity of significant flood events leading to greater of loss and damage of private property. More frequent flood events, even of lower-level flood events, could lead to cumulative and compounding impacts that increase long term negative impacts.	Community development	Very high	Damage and loss to private property
	RID046 Higher intensity rainfall events could increase the frequency and severity of significant flood events leading to greater loss and damage of private sector assets, including production and manufacturing equipment and tools, resulting in economic losses and flow on impacts to the community.	Economic development	Very high	Damage to private sector economic assets
Extreme Heat	RID034 An increase in hot and very hot days, warm nights (nights above 22˚C) and longer heat waves could lead to a greater number of heat related health issues, including dehydration, heat exhaustion and respiratory and cardiovascular problems. Groups with pre-existing health conditions, the elderly and lower socio-economic groups with lower quality housing are particularly vulnerable to these impact	Public health and wellbeing	Extreme	Loss of life and heat related health issues, particularly for vulnerable groups including elderly and low-socio economic group

2.3.9 marram baba Merri Creek Regional Parklands Future Directions Plan 2023

The marram baba Merri Creek parklands are part of the traditional Country of the Wurundjeri Woi-wurrung people and encompass an area of 2,778 ha, including 126 ha within Merrifield North.

The lands and water of the area known as marram baba are significant for the Wurundjeri Woi-wurrung people for its songlines, creation stories and as a place for continued cultural practice. The name 'marram baba' means 'body of mother' in the Woi-wurrung language.

The marram baba Merri Creek Regional Parklands Future Directions Plan sets out a vision, principles and strategic directions for progressive Parklands establishment, protection and management to be achieved by 2050:

"marram baba Merri Creek Regional Parklands is the preeminent natural corridor running through Melbourne's north on Wurundjeri Woi-wurrung Country, connecting and nurturing culture, nature, water, and people."

The Plan is centred around six interrelated themes shown in Figure 2-1.

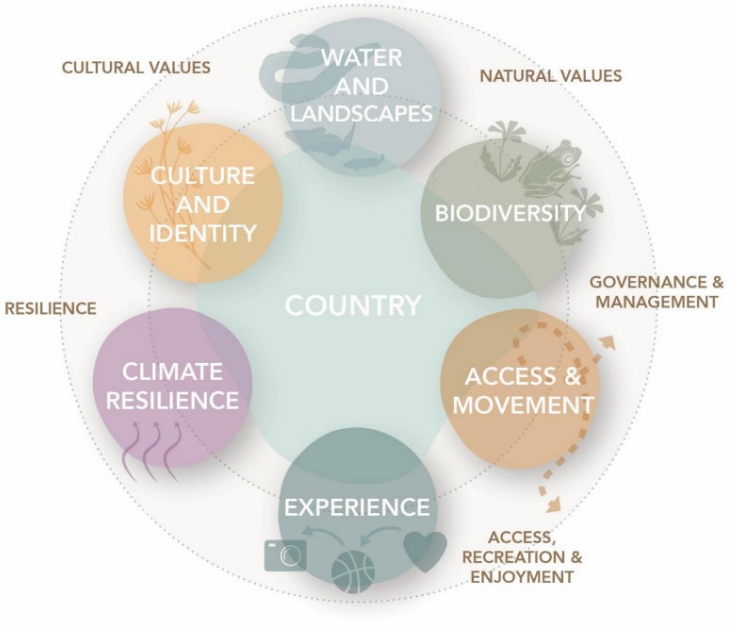


Figure 2-1 Themes from the marram baba Merri Creek Regional Parklands Future Directions Plan 2023

3. Contextual Analysis

A review of existing studies and reports relevant to the precinct and local water systems was undertaken to understand the existing context of Merrifield North. A summary of the reports reviewed is listed in Appendix A. A multi-layered approach has been used to undertake the contextual analysis of Merrifield North from an IWM perspective, as demonstrated in Figure 3-1.

Existing features are considered first, beginning with an understanding of catchment and waterways, followed by existing landscapes and land uses. Then, the future of the precinct is considered with this context, understanding future land use and how it will be supported by planned water infrastructure.

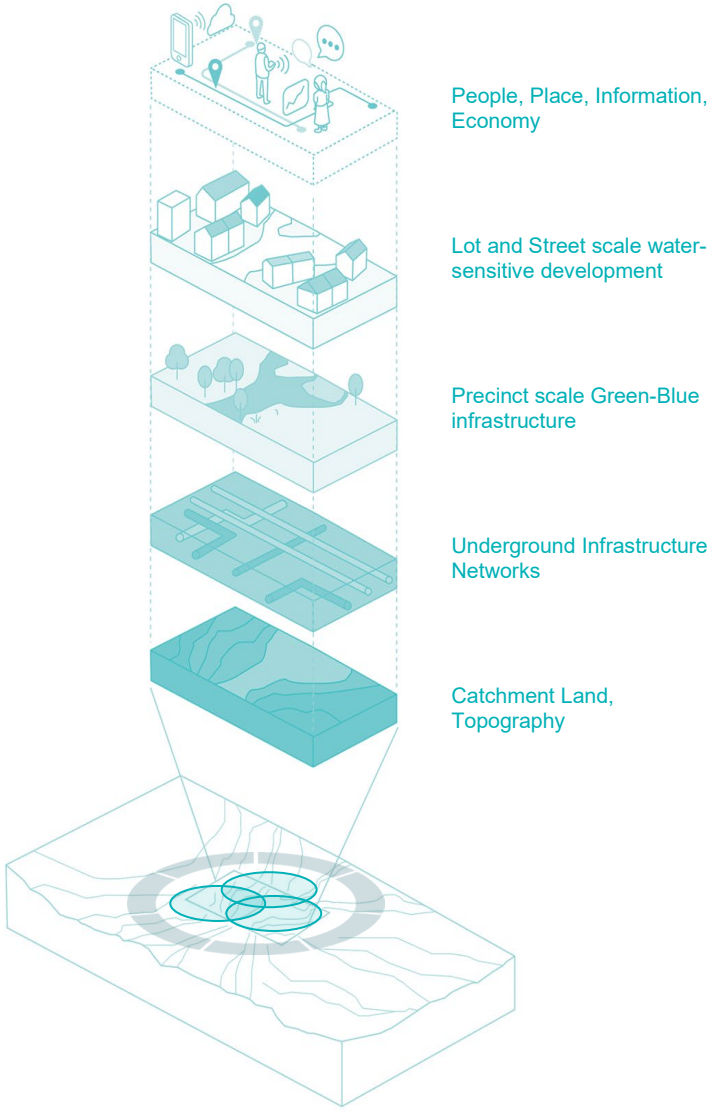


Figure 3-1 Layers of a contextual analysis

3.1 Catchment and waterways

3.1.1 Catchment and waterways context

Merrifield North sits within the upper Merri Creek sub catchment of the Yarra catchment, as shown in Figure 3-2. The entire precinct is within the catchment of Kalkallo Creek, a tributary of Merri Creek, which flows from the Beveridge North-West precinct to the north and out into the Merrifield Central precinct in the south-east corner of Merrifield North precinct. Kalkallo Creek passes through the Kalkallo retarding basin which is a large Melbourne Water land asset that occupies the south-east portion of the precinct. Kalkallo Creek then joins Merri Creek in English Street which flows on to the Yarra and ultimately flows out to Port Phillip Bay.

The Kalkallo Creek sub-catchment is designated as a stormwater priority area in Melbourne Water's Healthy Waterway Strategy, as discussed in Section 2.

Waterways within the site are discussed further in section 3.1.4.

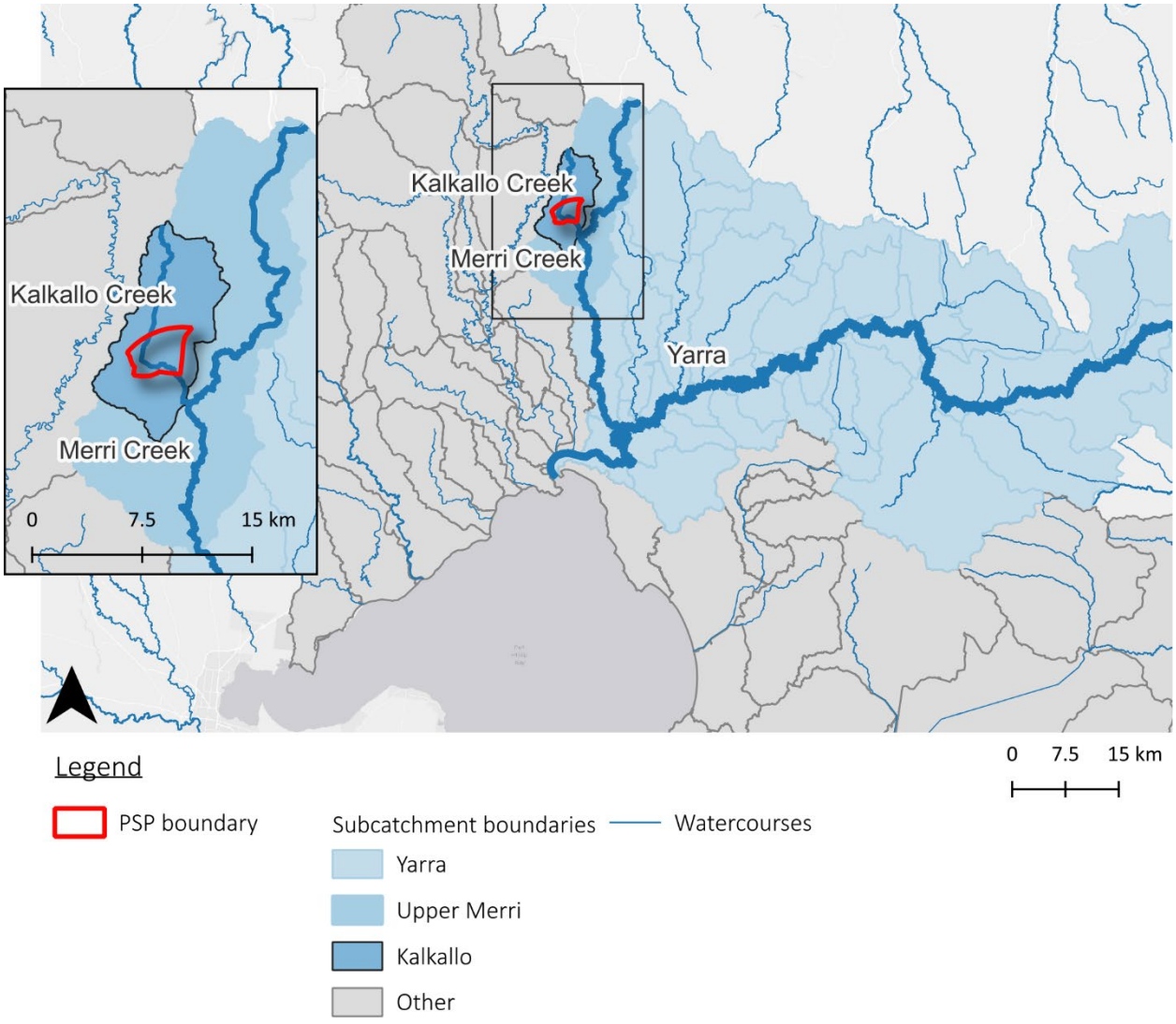


Figure 3-2 Major waterway catchments

3.1.2 Site topography

The precinct is relatively flat, ranging from approximately 220–270m Australian Height Datum (AHD) in elevation, with the majority of the precinct between 230–240 AHD (Figure 3-3).

The area of the Kalkallo RB is almost completely flat, shown in Figure 3-4. The eastern portion of the precinct is steeper, with the highest point in the north-east, around the intersection of Hume Freeway and Donovans Lane. The lowest point is in the south-east where Kalkallo Creek flows out of the precinct.

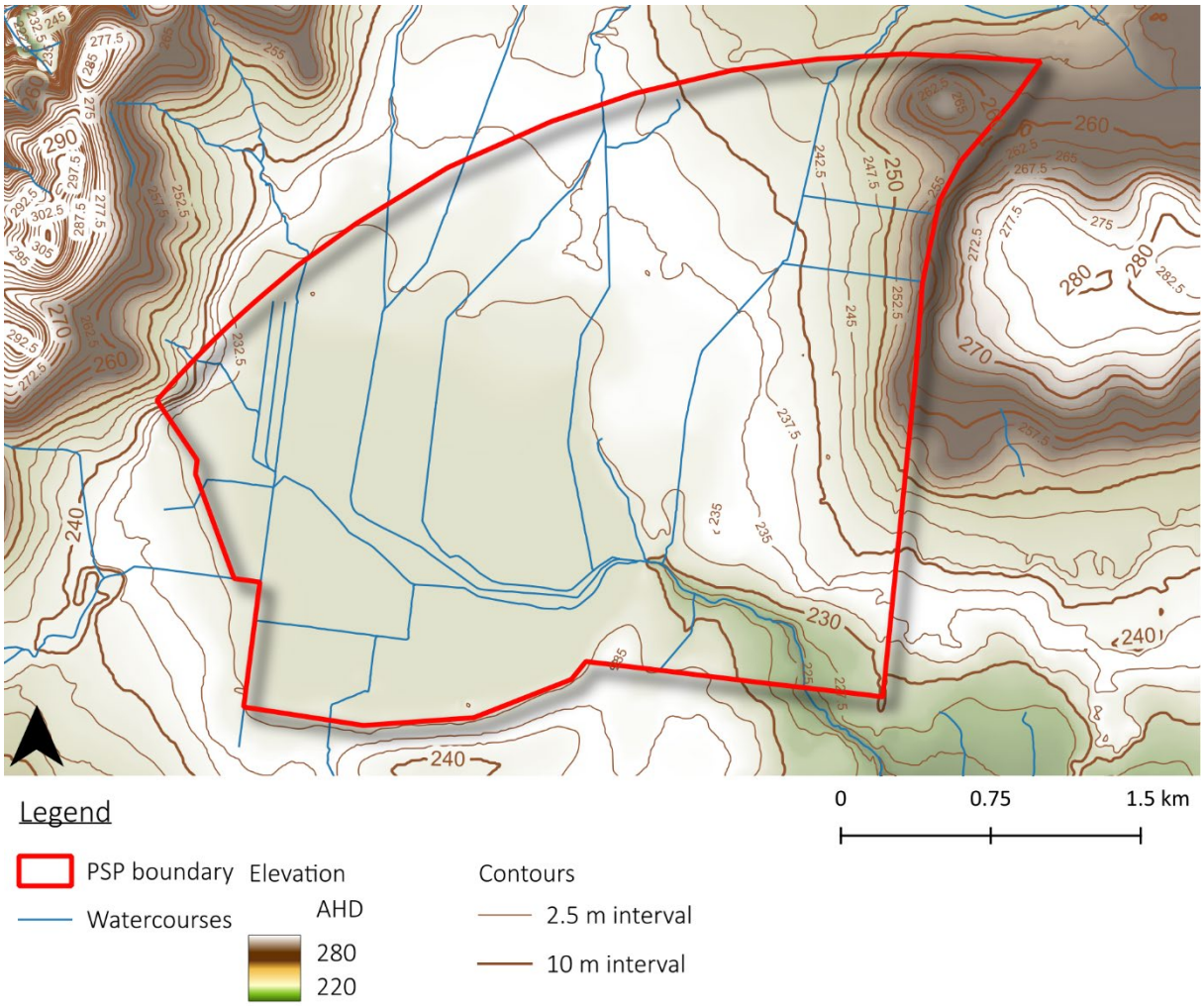


Figure 3-3 Topography of the Merrifield North precinct

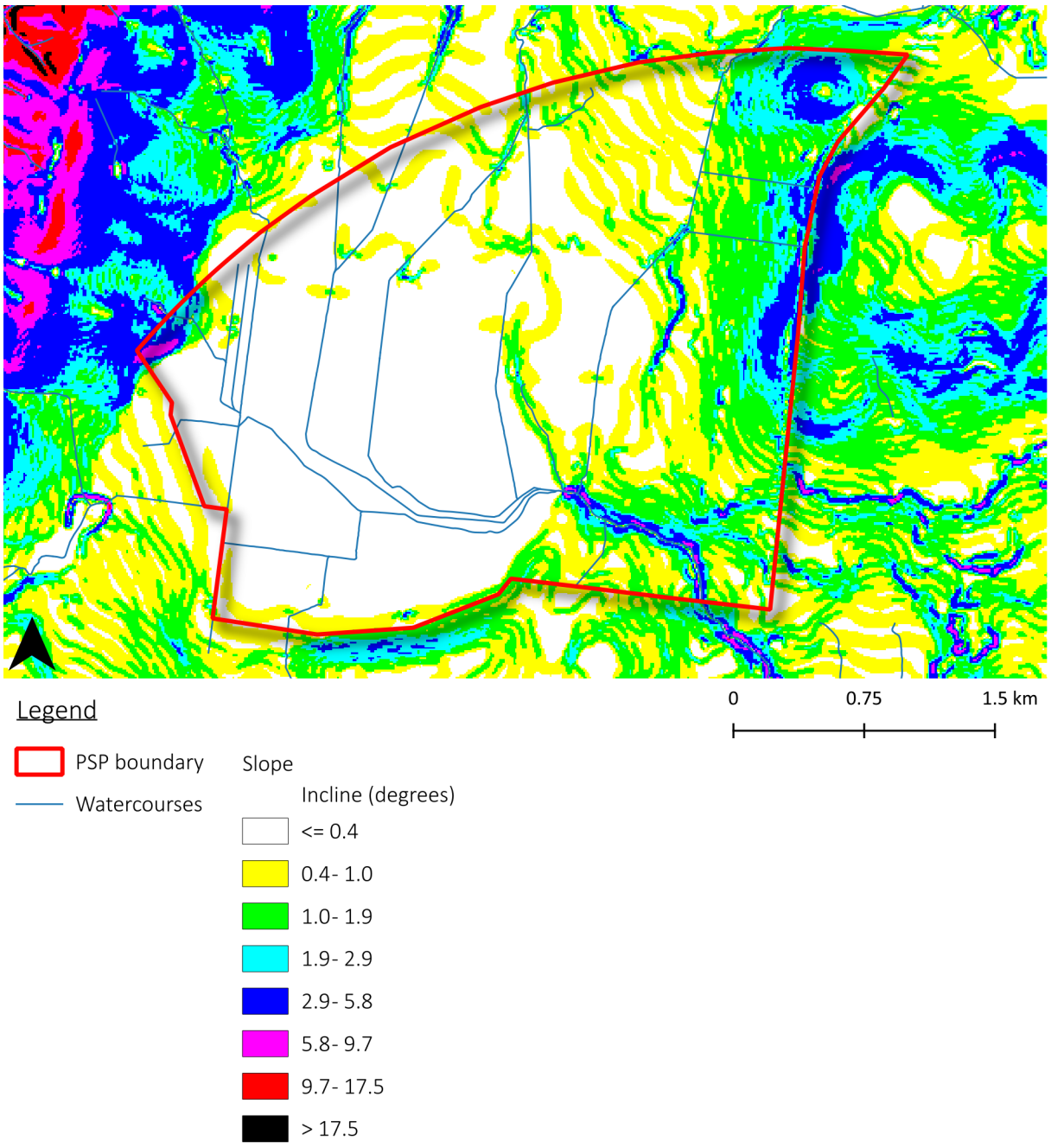


Figure 3-4 Slope within and surrounding the Merrifield North precinct

3.1.3 Geology and Soils

Merrifield North Employment Precinct – Sodic and Acid Sulfate Soil Assessment prepared by Jacobs investigated the extent and severity of sodic and acid sulfate soils within the precinct (Jacobs, 2023). In both the construction phase and future developed state, the open space and flood prone areas have been identified as having high vulnerability to soil erosion. In the construction case, this is influenced by exposure of subsoils to rainfall by construction activities. In the future developed case, the increase in impervious area will increase the runoff generated and draining into these areas, increasing vulnerability to erosion.

Figure 3-5 represents the land units for the Merrifield North precinct. The soils within the precinct are vertosols and sodosols, with vertosols surrounding Kalkallo Creek. Both vertosols and sodosols have significant implications for water. Sodosols are highly dispersive, resulting in high potential for erosion along waterways. Vertosols are reactive and will shrink and expand greatly in response to moisture levels.

While mapping indicates vertosols are not present north of Gunns Gully Road, this is likely due to variation across surveys. The potential presence of vertosols in the northern portions of the catchment, particularly surrounding Kalkallo Creek, should be considered.

Acid sulfate soils were identified across the study area, primarily within topsoils. 77.5% of topsoil samples met the acidity threshold which requires management under Acid Sulfate Soil Management Plan (ASSMP).

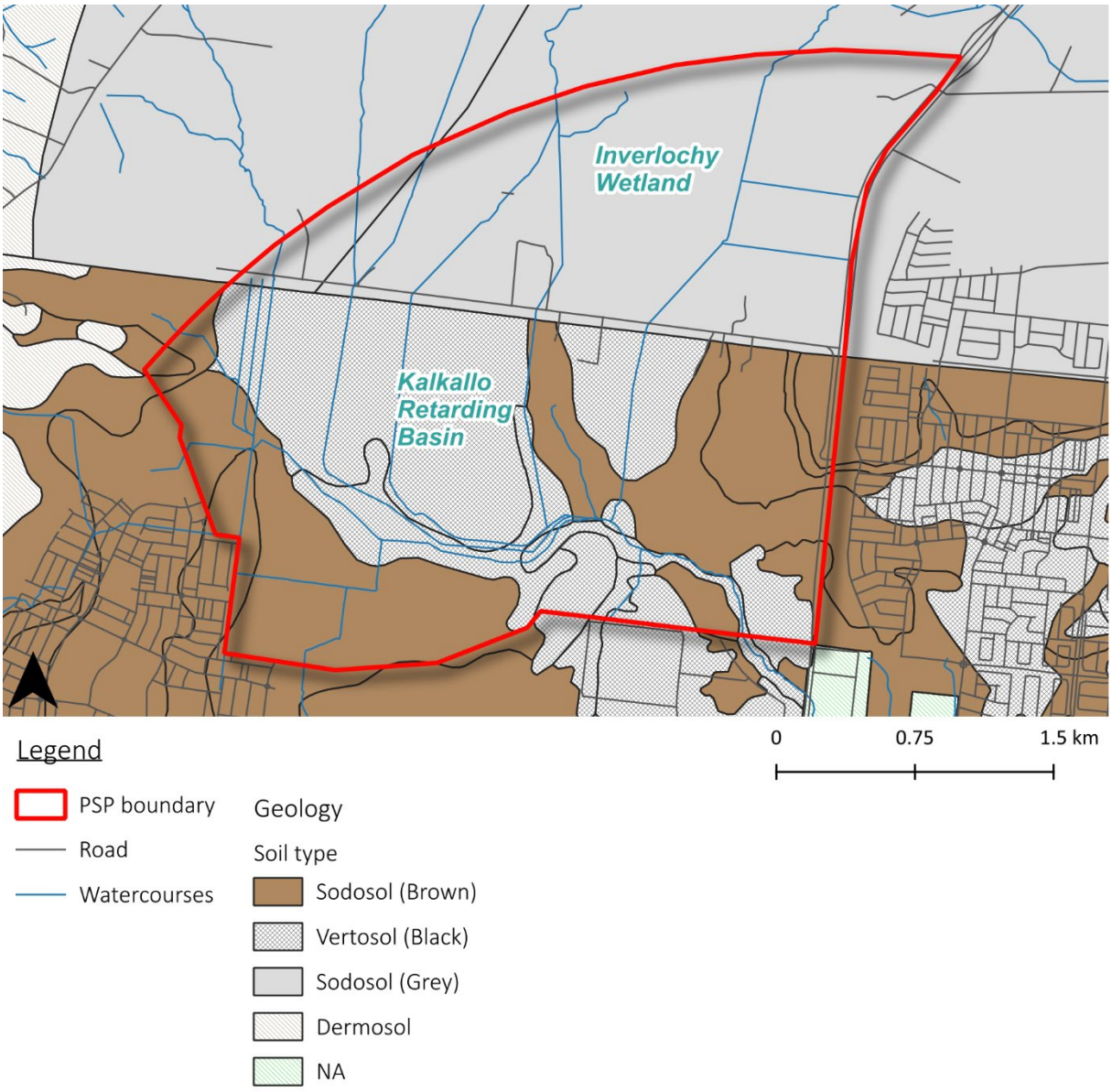


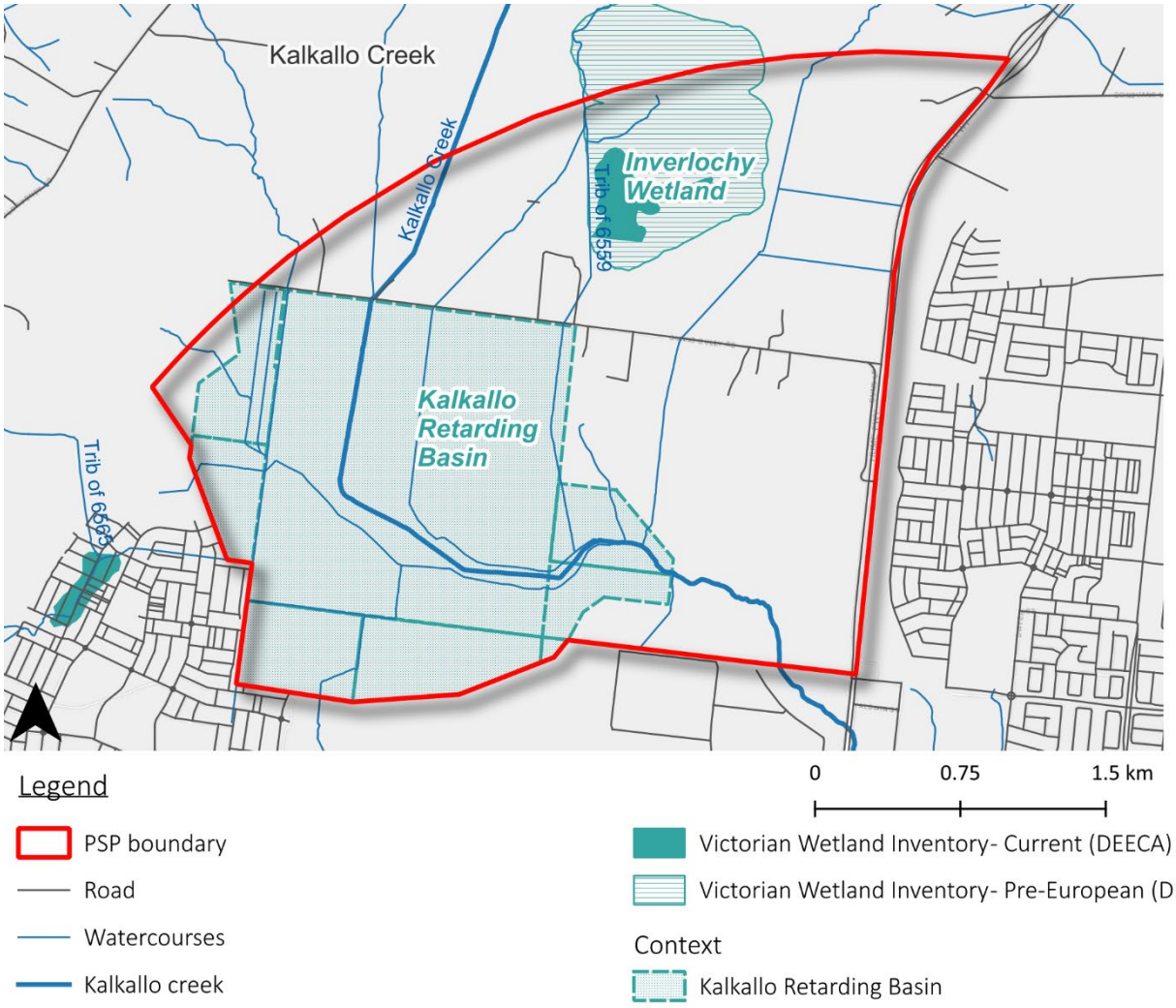
Figure 3-5 Geotechnical context within and surrounding Merrifield North precinct

3.1.4 Waterways and waterbodies on-site

The waterways within the precinct are shown in Figure 3-6. Multiple tributaries of Kalkallo Creek flow through the precinct and converge within the Kalkallo Retarding Basin (RB).

Portions of the precinct sits within the possible historical footprint of Inverlochy Wetland. The extent of Inverlochy Wetland is uncertain but may have contained the current Kalkallo RB and pre-European wetland (Alluvium, 2024).

Historic maps reviewed by Alluvium show inconsistent courses for Kalkallo Creek and its tributaries, and are often missing portions of the watercourses. As a result, the original path of Kalkallo creek before straightening, and its interaction with Inverlochy swamp are unknown.



This map reflects acknowledgement of existing publicly available information only, it does not identify Inverlochy Wetland as a Biodiversity Conservation Area under the MSA, and therefore does not imply a conservation retention requirement. The drainage footprint will be determined through the DSS (not DEECA mapping), while cultural heritage will be identified through existing information via the ACHIA and CVA, with the PSP seeking to avoid precinct infrastructure in culturally sensitive areas where possible and permit applications addressing requirements under the Aboriginal Cultural Heritage Act through any CHMPs

Figure 3-6 Waterways within the Merrifield North precinct

3.1.5 Waterway health

The HWS report card for the upper Merri Creek sub catchment lists access, instream connectivity and vegetation extent as very low; participation and vegetation quality as low; and physical form, stormwater condition and environmental water quality as moderate. The ecological values are moderate to very low however amenity, community connection and recreation are considered high.

The HWS datasets rate the current habitat suitability of the waterways within the study area as low or very low for fish and platypus, and moderate for macroinvertebrates. Most of the waterways are considered high priority due to the possible impacts of development on waterway health.

As discussed further in section 3.1.3, sodic soils are prevalent within the precinct. As a result, the waterways are more vulnerable to erosion due to disturbance and increases in runoff. This results in poor bank stability and high levels of turbidity which each impact waterway health.

As visible in Figure 3-6, the water courses outside of the parkland have been straightened to follow property boundaries and efficiently convey water for irrigation. This has contributed to the degradation of Kalkallo Creek and its tributaries. Pre-colonisation, the catchment was highly ephemeral.

3.1.6 Groundwater

As shown in Figure 3-8, the depth to water table is less than 5 m for the majority of the precinct. This is expected due to Kalkallo Creek and the wetlands and basins present within the precinct. A shallow water table suggests limited opportunities for infiltration as the soil will quickly reach saturation.

Water table salinity ranges from 3000-7000 mg/L for the entire precinct as shown in Figure 3-7. No terrestrial groundwater dependent ecosystems (GDEs) were identified.

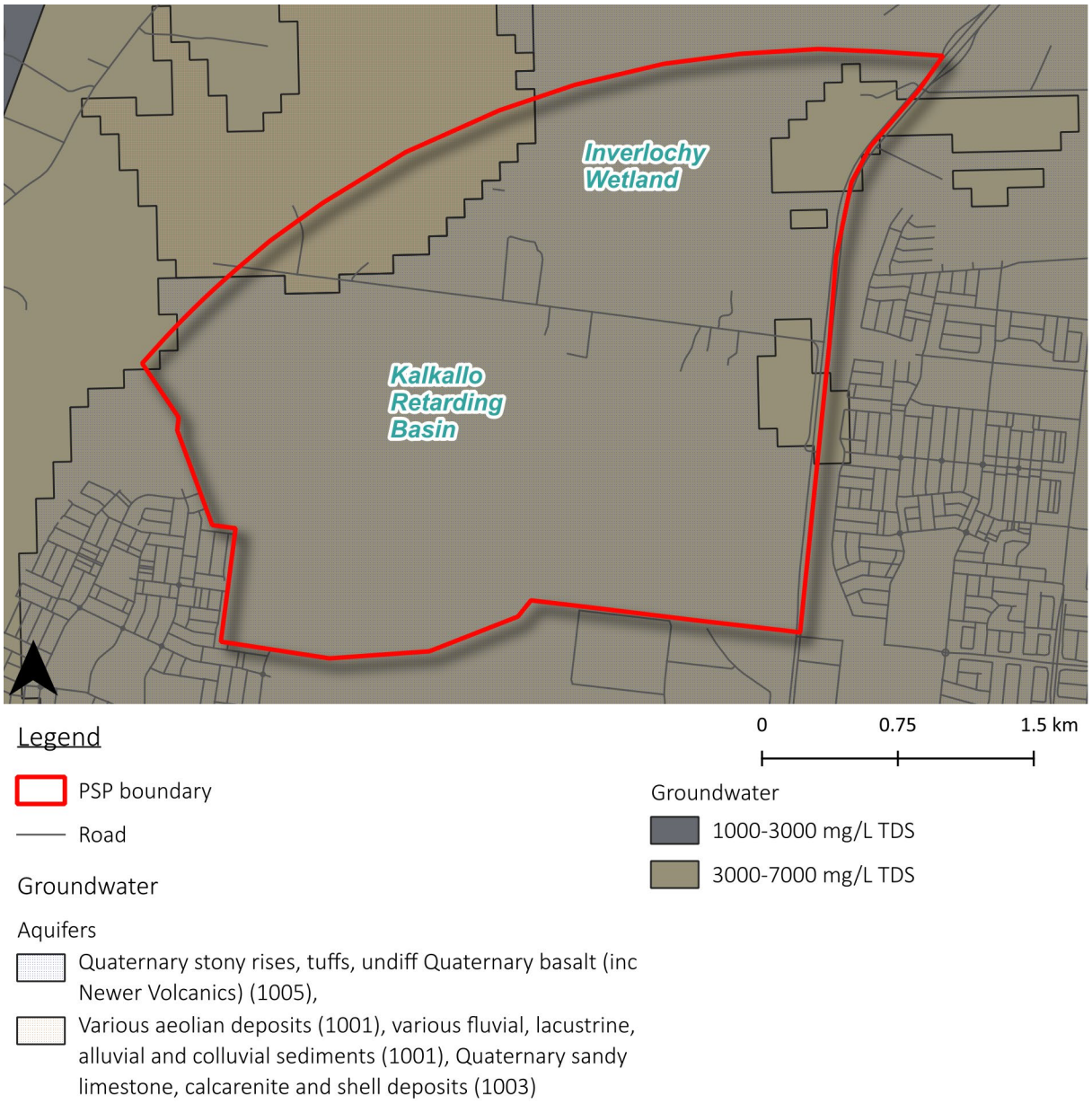


Figure 3-7 Groundwater within and surrounding Merrifield North precinct

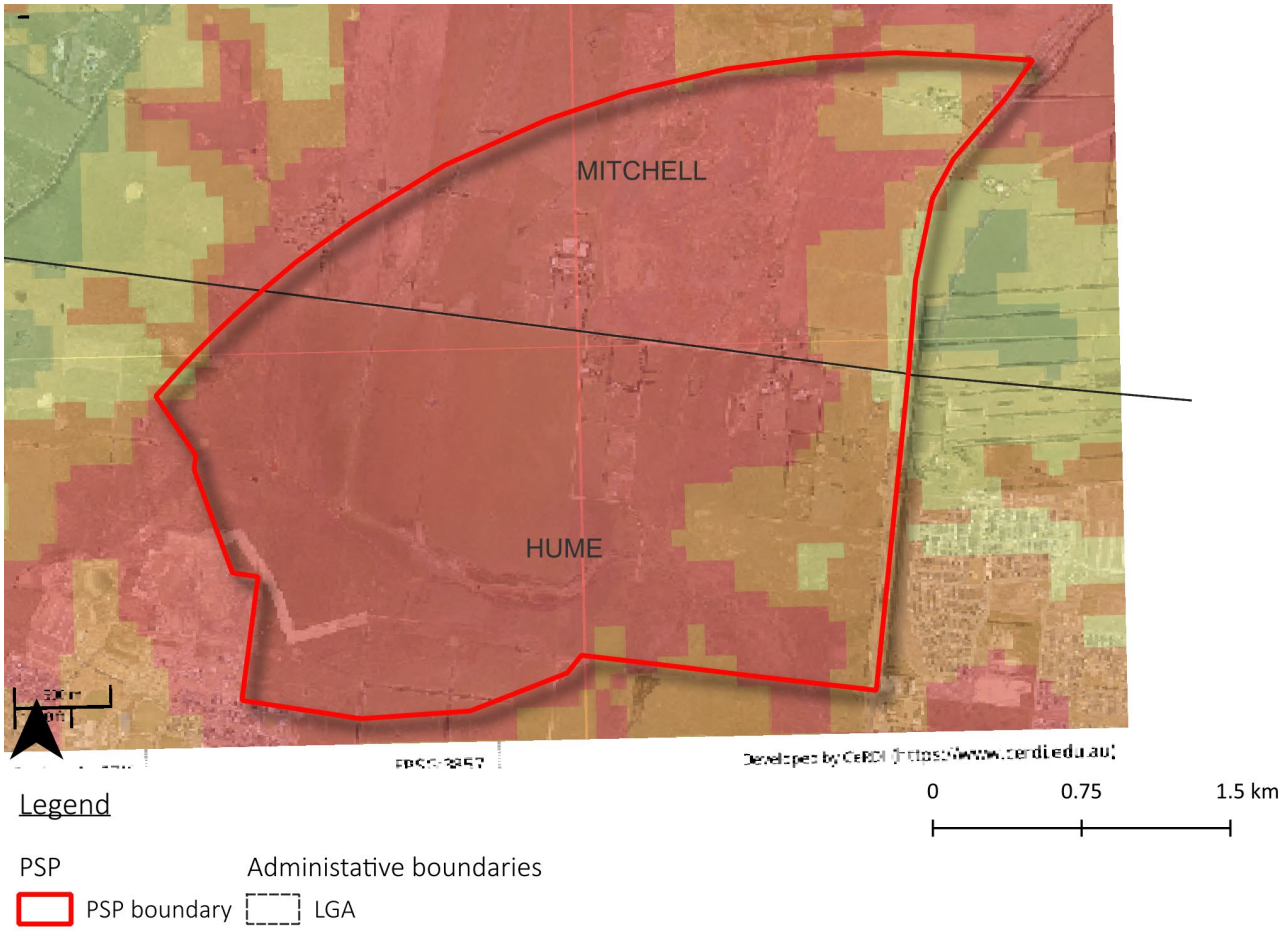


Figure 3-8 Depth to water table within and surrounding Merrifield North precinct (Visualising Victoria's Groundwater)

3.1.7 Inundation and flooding

As discussed in section 3.3.1, both the Land Subject to Inundation Overlay (LSIO) and Rural Floodway Overlay (RFO) apply to sections of Kalkallo Creek and the Kalkallo RB. The RFO applies only to sections within marram baba Merri Creek parkland.

Alluvium conducted modelling in 2024 of flood risk in the combined area of Merrifield North and Beveridge South-West. Under existing conditions, the maximum inundation extent for a 1% AEP event is reached at 134 m3/s, inundating 901 ha. While this area includes Beveridge South-West, the inundation is concentrated within the Merrifield North boundary, particularly within the retarding basin, Kalkallo Creek, and its tributaries.

Under pre-European conditions, the peak flow was lower (119 m3/s), however the inundation area was larger (961 ha). The majority of this additional inundation area sits outside of Merrifield North. This can be attributed to channelisation containing flows, reducing the area inundated, and conveying them more efficiently, increasing peak flows. This is an important consideration with respect to creek naturalisation.

3.2 Existing landscapes and land uses

3.2.1 Current land uses

Figure 3-9 shows a map of current land use in the Merrifield North precinct. Key features relevant to this assessment are as follows:

- The Victorian Land Use Information System (VLUIS) shows the precinct as predominantly domestic livestock grazing, with some rural residential usage, and some areas marked as residential. Land use information from 2017 showed the precinct as predominantly dryland agriculture, with some non-agricultural rural residential use. The north-eastern areas do not appear to be in residential use currently despite the VLUIS data.

- The precinct includes large areas owned by Melbourne water for the Kalkallo retarding basin, and marram baba Merri Creek Regional parkland which overlaps partially with the retarding basin area. This is discussed further in section 3.2.3.
- The surrounding land is predominantly zoned for growth under other precincts within the Northern Growth Corridor in varying stages of development. This includes residential precincts Beveridge South West, Lockerbie, Merrifield West and employment precincts such as Merrifield Central Employment Area.

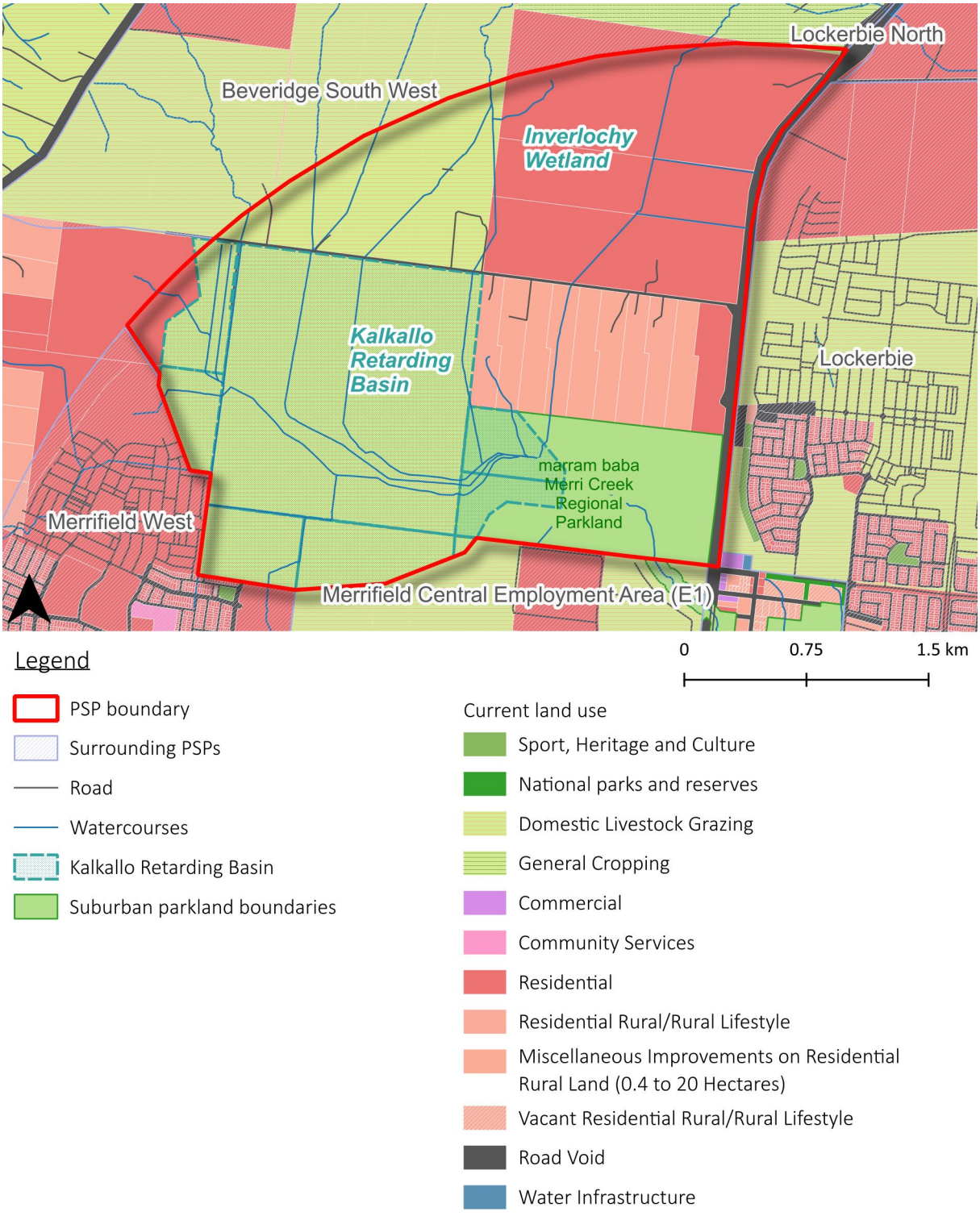


Figure 3-9 Current land use in Merrifield North precinct

3.2.2 Cultural Heritage

As shown in Figure 3-10, there are areas of Aboriginal cultural sensitivity along Kalkallo Creek. An extensive number of Aboriginal Cultural Heritage Places (ACHP) have been identified within marram baba Regional Parkland (Wurundjeri Woi-wurrung Cultural Heritage Aboriginal Corporation, 2023) including a significant number of artefact scatters.

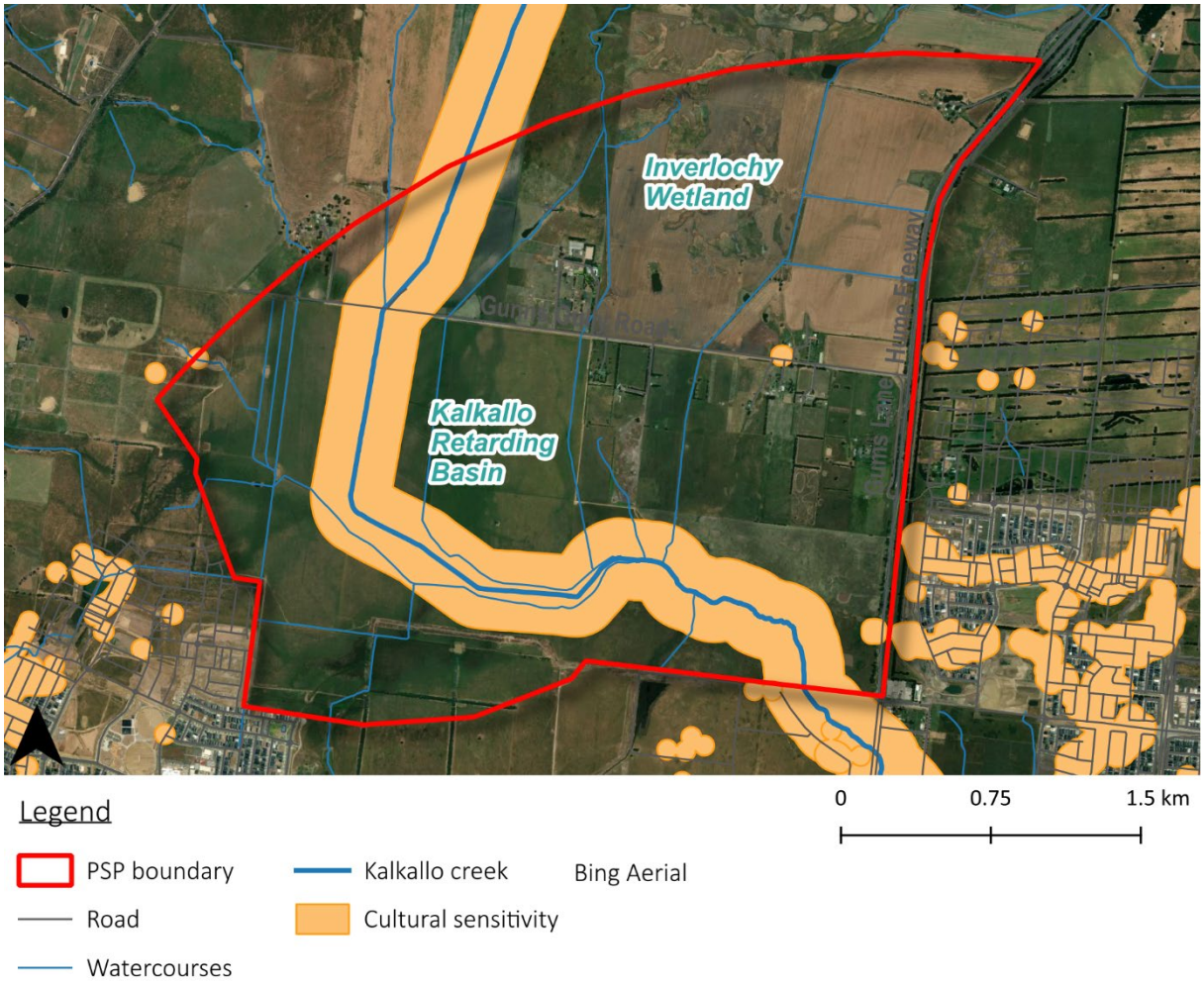


Figure 3-10 Cultural Sensitivity within and surrounding the Merrifield North precinct

3.2.3 Kalkallo Retarding Basin

The Kalkallo RB site is a 370ha site that is owned by Melbourne Water is in the Merrifield North precinct and plays a key drainage and flood management function. It is a strategic site for potential stormwater harvesting and waterway protection and associated assets. This area has high potential for integration of recreation, amenity, drainage, flood management and stormwater harvesting. Melbourne Water is currently reviewing the functionality and future land use of the retarding basin site.

3.2.4 Inverlochy Wetland

Inverlochy wetland is indicated in historical maps, extending across the northern boundary of the precinct, into Beveridge South West. The area has been partially drained to enable agricultural use of the land.

Field assessments by Alluvium in 2023 found that Inverlochy wetland was used for cropping and was no longer functioning as a wetland (Alluvium, 2024). However, the presence of water logging indicated it likely still experiences some intermittent or seasonal inundation.

The current extent and functionality of Inverlochy wetland is unknown.

3.2.5 Environmental and ecological values

The south-eastern corner of the precinct has significant areas of remnant native vegetation as shown in Figure 3-11. The Environmental Vegetation Classification (EVC) for these areas is predominantly Plains Grasslands and Chenopod Shrublands however prior to land clearing for agriculture, the majority of the precinct would have consisted of wetlands. The eastern edge of the precinct also includes remnant Plains Woodlands and the outgoing section of Kalkallo Creek maintains Riparian Scrubs. All EVCs within the precinct are considered endangered.

A summary of other ecological values within the precinct can be found in Table 3-1.

Table 3-1 Summary of ecological values within Merrifield North

Ecological value	Description	Location
Golden Sun Moth (*Synemon plana*)	The golden sun moth is listed as critically endangered under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).	The Golden Sun Moth has been identified as present within the RB site and marram baba Regional Parklands. Portions of the parkland are Biodiversity Conservation Area 23 which correspond with Golden Sun Moth conservation.
Growling Grass Frog (*Litoria raniformis*)	The growling grass frog is listed as threatened under the EPBC Act.	Portions of the parkland are Biodiversity Conservation Area 23 which correspond with Growling Grass Frog corridor. Reaches of Kalkallo creek immediately downstream of the precinct and Merrifield Central are considered areas of strategic importance for the Growling Grass Frog.
Victorian Grassland Earless Dragon (*Tympanocryptis pinguicolla*) (VGED)	The VGED is critically endangered and had not been sighted in Victoria since 1969 prior to rediscovery in 2023.	VGED habitat has been identified within the precinct
Matted Flax-Lily (*Dianella amoena*)	The matted flax-lily is listed as endangered under the EPBC Act and critically endangered under the Flora and Fauna Guarantee Act 1988 (FFG Act).	Several of the rural residential properties are marked as SLTR type Matted Flax-Lily
River red gum (*Eucalyptus camaldulensis*)	The subspecies likely to be found within the study area is not considered threatened under the FFG Act. However, the species is characteristic of the endangered Plains Grassland EVC.	There are small patches of significant vegetation (Eucalyptus camaldulensis) in north-east of the precinct. These are contained within the vegetation protection overlay surrounding Hume Freeway.

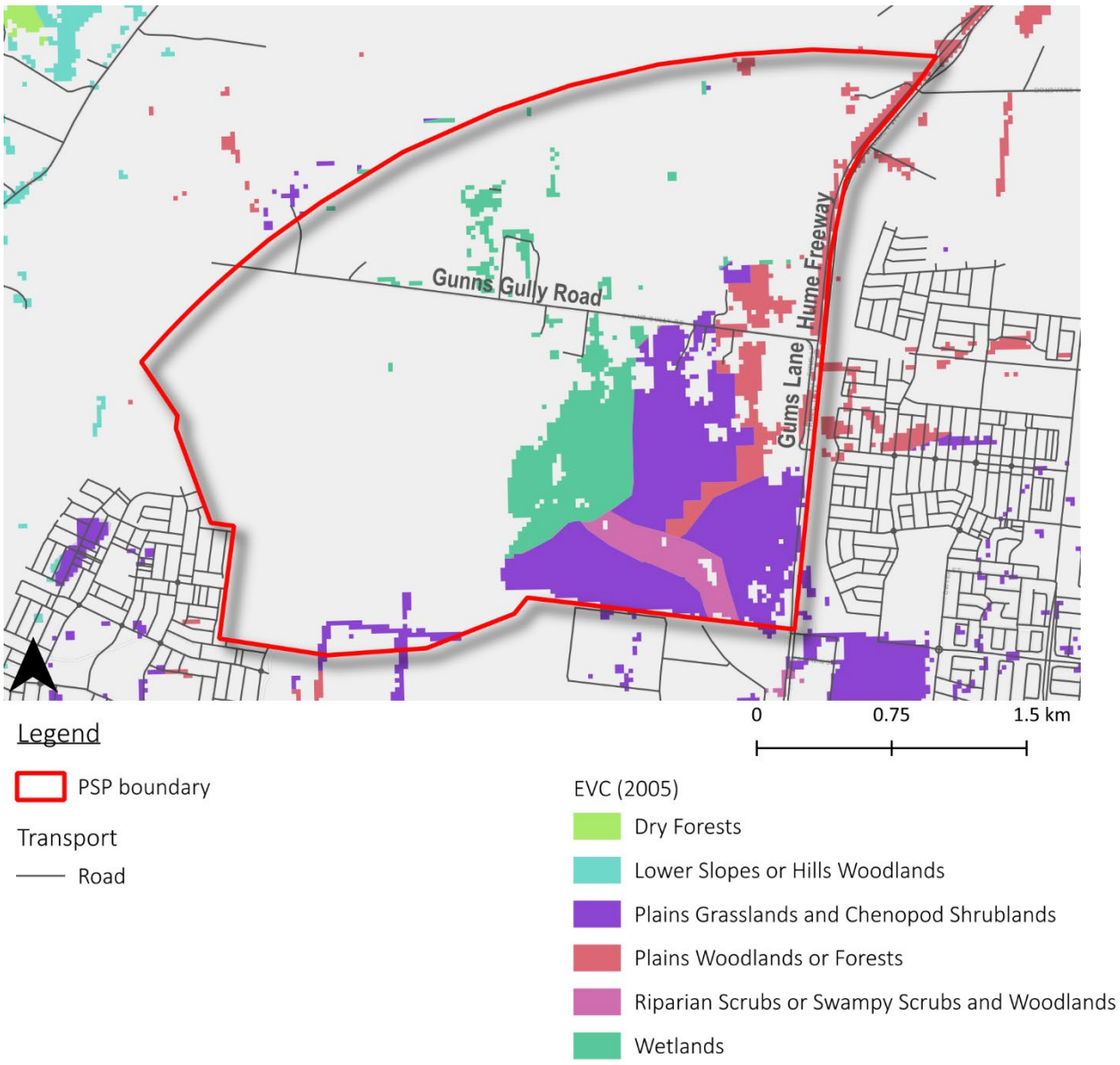


Figure 3-11 Modelled 2005 Ecological Vegetation Classes for Merrifield North precinct

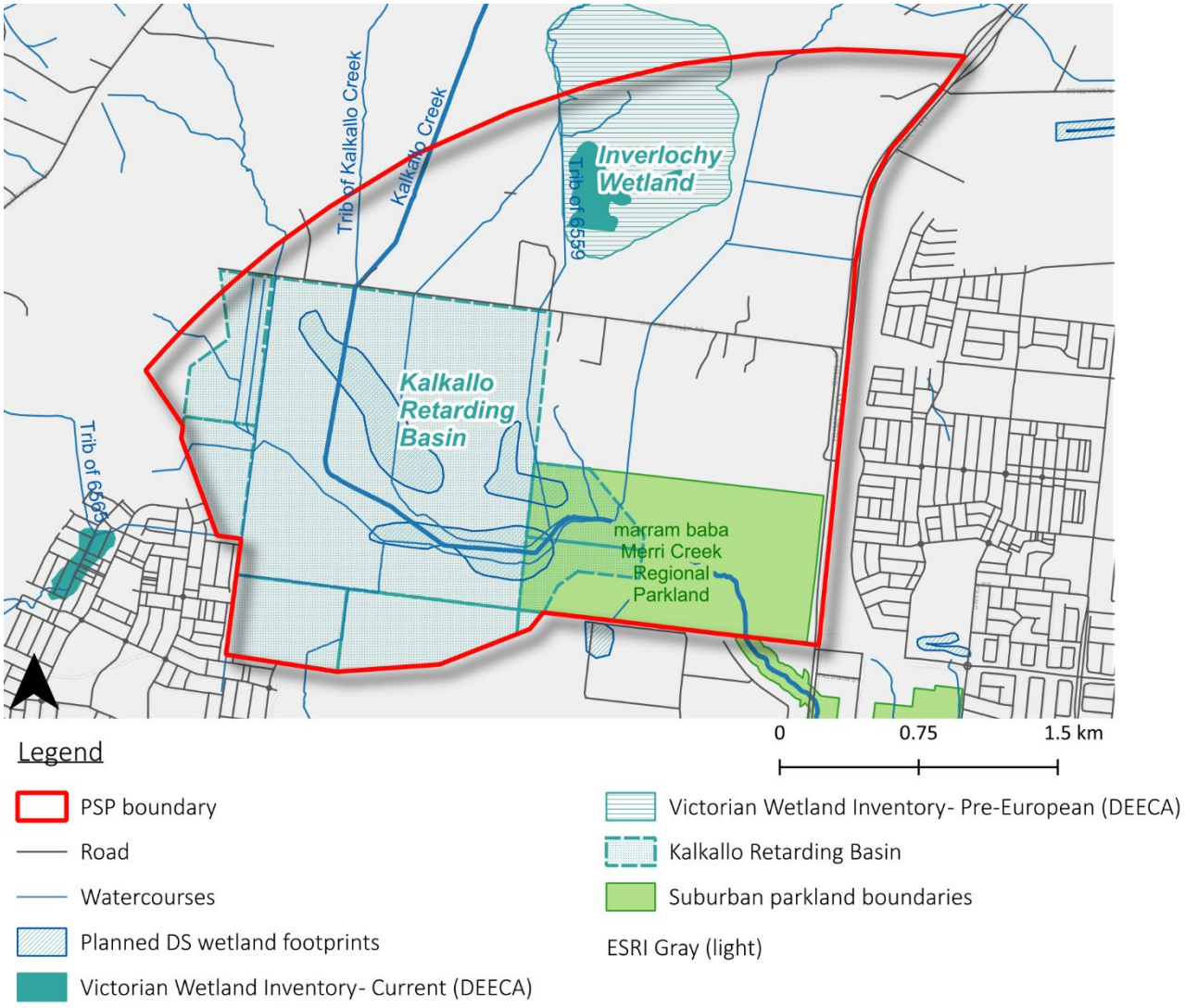


Figure 3-12 Modelled 1750 Ecological Vegetation Classes for Merrifield North precinct

3.2.6 marram baba Regional Parklands

Merrifield North includes a northern portion of the marram baba Regional Parklands. The strategic direction of the parklands is discussed further in 2.3.9.

The western side of the parkland overlaps with the footprint of Kalkallo RB. Kalkallo Creek continues from the RB and flows through the park, which contains the remaining reaches of Kalkallo Creek and a significant length of Merri Creek.



This map reflects acknowledgement of existing publicly available information only, it does not identify Inverlochy Wetland as a Biodiversity Conservation Area under the MSA, and therefore does not imply a conservation retention requirement. The drainage footprint will be determined through the DSS (not DEECA mapping), while cultural heritage will be identified through existing information via the ACHIA and CVA, with the PSP seeking to avoid precinct infrastructure in culturally sensitive areas where possible and permit applications addressing requirements under the Aboriginal Cultural Heritage Act through any CHMPs

Figure 3-13 Blue-Green infrastructure within Merrifield North precinct

3.3 Future land use

3.3.1 Planning overlays

The Merrifield North precinct lies within the urban growth zone. Figure 3-14 shows the existing planning overlays within and around the precinct boundaries. The following overlays impact the Merrifield North precinct:

- Land Subject to Inundation Overlay: south of Gunns Gully Road, mostly contained within the Kalkallo RB; lower portions of Kalkallo Creek.
- Rural Floodway Overlay: in marram baba Merri Creek Regional parkland around outlets of Kalkallo retarding basin and around Kalkallo Creek.
- Vegetation protection overlay: Hume Freeway north of Gunns Gully Road, corresponding with an environmentally significant stand of River Red Gums (Eucalyptus camaldulensis).

- Public acquisition overlay: Gunns Gully Road, Hume Freeway and the northern boundary of precinct, corresponding with the planned outer metropolitan ring transport link.

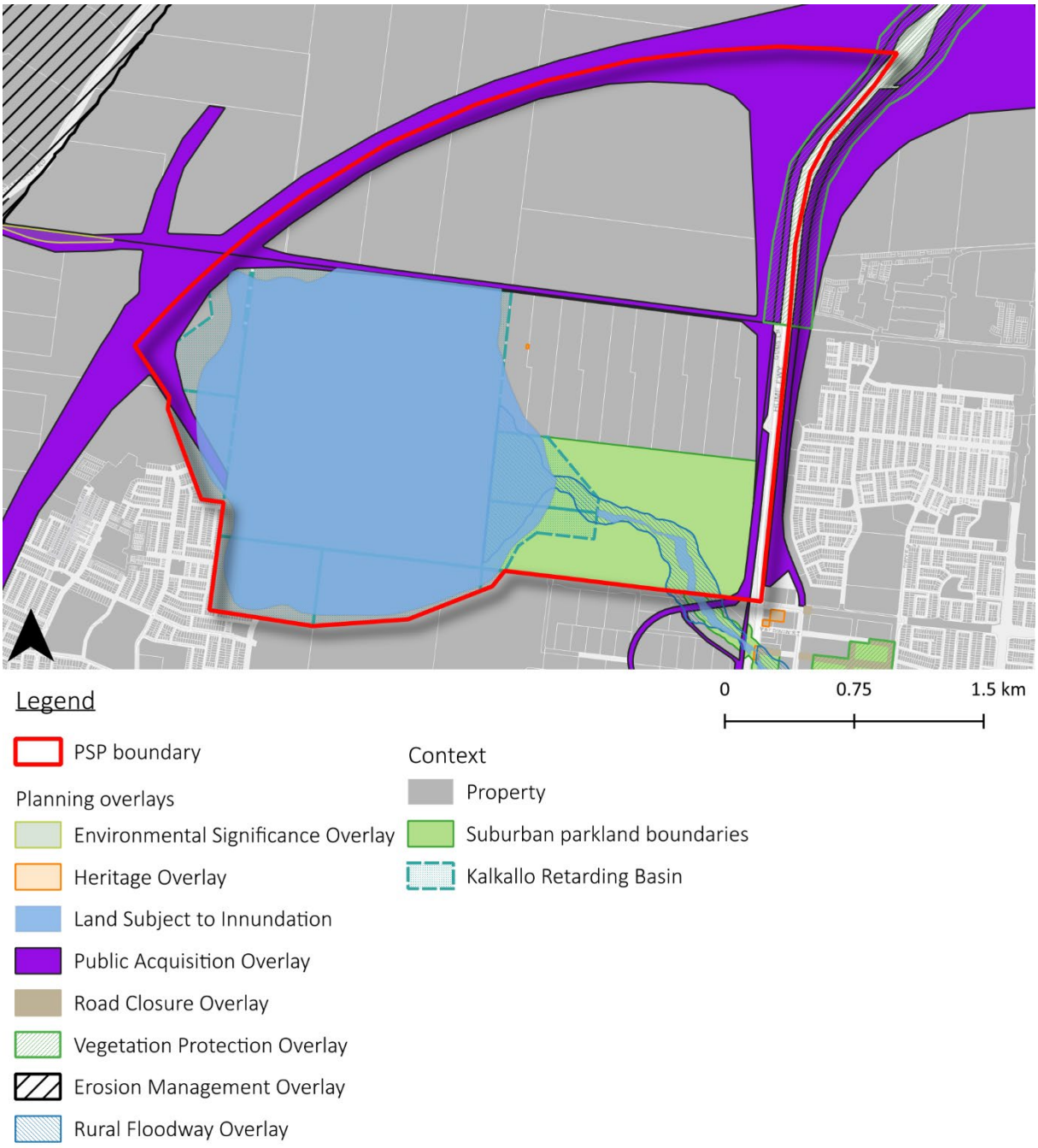


Figure 3-14 Planning overlay for Merrifield North precinct

3.3.2 Precinct Structure Plan Vision

The precinct is planned to be a predominantly industrial employment area. The retarding basin and riparian corridors will be retained as open space and providing drainage and water management functions, though the extent of the retarding basin is subject to confirmation by Melbourne Water. Merrifield Park is a proposed regional park intended to be located within the Merrifield North precinct.

Major roads projects are planned for the precinct included the upgrading of the existing unsealed Gunns Gully Road and the construction of the Outer Metropolitan Ring Road along the north-west boundary.

A stakeholder consultation session was held for the precinct in 2025 by DTP. The findings from the pitching activities were organised into the following emerging themes:

- Respect and enhance the existing cultural heritage and environmental values of the area.

- Support development of an employment precinct that will attract a range of economic development opportunities, industry and jobs to the region.
- Create a transport network that connects people to jobs and services efficiently.
- Manage water and drainage solutions on site effectively while protecting the natural environment.
- Establish service network infrastructure that is optimised and efficient.
- Coordinate staging that supports timely and orderly PSP implementation.

3.4 Planned water infrastructure

3.4.1 Drainage Scheme

Merrifield North is part of the 6550 Kalkallo Creek Drainage Scheme (DS). Figure 3-15 shows the existing Kalkallo Creek drainage scheme which is currently being reviewed and amended by Melbourne Water. The current scheme utilises the retarding basin area for flood management as well as stormwater treatment of the upstream Kalkallo Creek catchment, with three wetland areas allocated to filter stormwater entering the basin from the main drainage inflow points. Melbourne Water developer services team have been actively working on functional designs for stabilisation of Kalkallo Creek with the consideration of future urban development. This situational analysis report has been developed concurrently with the update of the drainage scheme.

Previous studies have identified the potential for stormwater harvesting from the wetlands within Kalkallo RB, and transfer of stormwater to Bald Hill for potential blending with the recycled water supply to the Northern Growth Corridor. As part of the potential Kalkallo RB stormwater regional stormwater harvesting solution, Yarra Valley Water (YVW) have planned for a stormwater pipeline asset to transfer treated

stormwater at the RB to a storage asset at Bald Hill, located outside the precinct boundary.

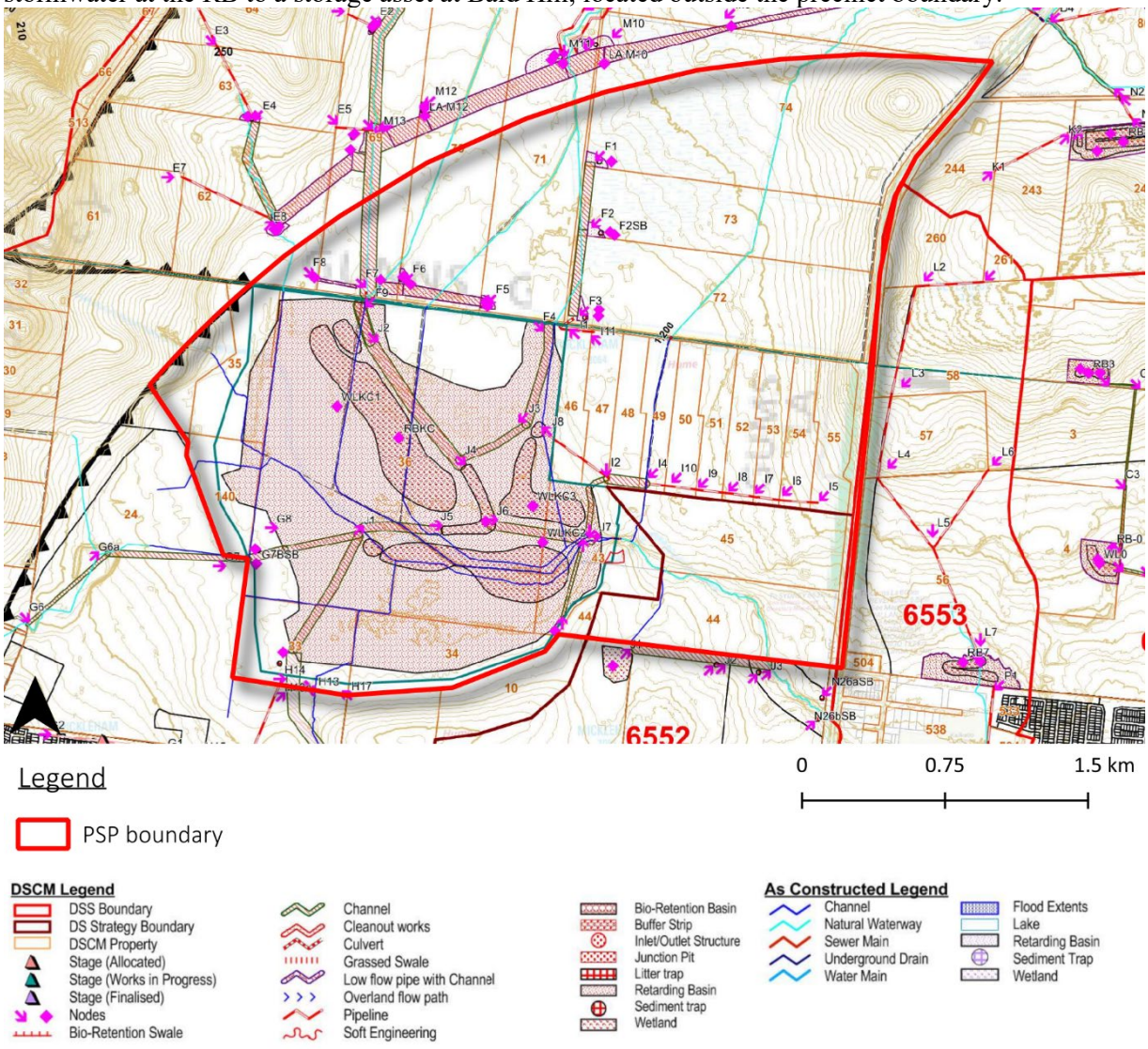


Figure 3-15 Current Drainage Scheme applying to Merrifield North precinct (being updated)

3.4.2 Local stormwater drainage

There is minimal existing stormwater drainage infrastructure within the precinct, seen in Figure 3-16. Localised drainage infrastructure will be built out with development, and connected to catchment scale drainage infrastructure planned through the Melbourne Water drainage scheme (see below).

There is a 2250 mm reinforced concrete pipe linking the southern end of Kalkallo RB to Merrifield West, and a short pipe 1350 mm concrete pipe in Kalkallo RB following the convergence of several tributaries. Additionally, there is a 1200 mm culvert passing under Gunns Gully Road at the eastern-most unnamed waterway. No culverts are recorded at other waterway crossings.

3.4.3 Potable water supply

Yarra Valley Water is the potable water retailer responsible for potable water servicing to the precinct. This infrastructure will be built out with development. A dataset of compiled existing and planned water services infrastructure is shown in Figure 3-16.

There is a 400 mm Mild Steel Cement Lined Transfer pipe running along the western edge of Hume Freeway. There are also proposed 450 mm pipes which would connect the precinct to a larger 600 mm pipeline in Lockerbie. The proposed timing of these pipes is after 2034.

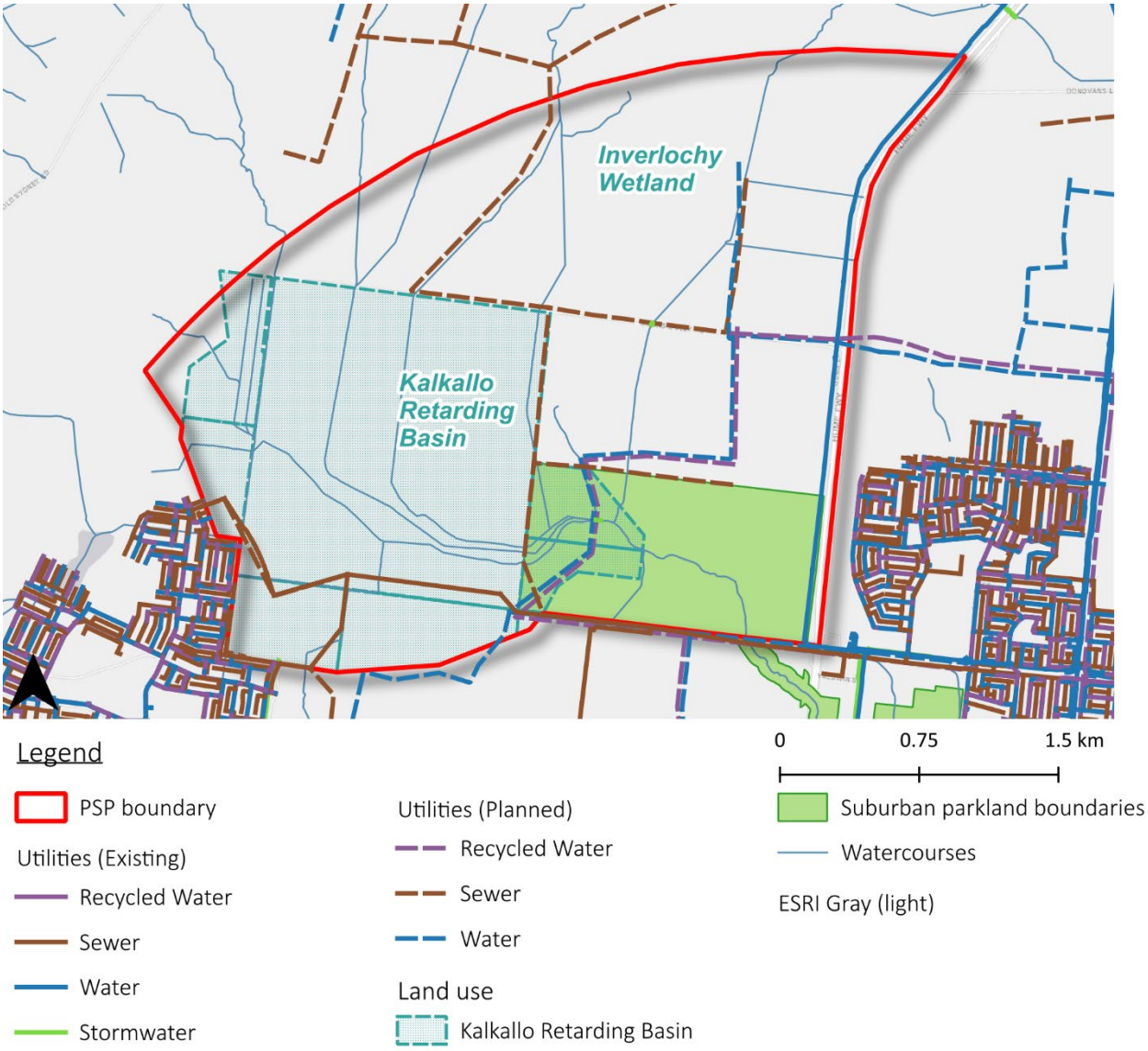


Figure 3-16 Existing and proposed utilities within and surrounding the Merrifield North precinct. Proposed works are marked with dashed lines.

The Hume council online stormwater asset map also includes a 1350 mm and 900 mm RCP from Merrifield West to the precinct.

3.4.4 Recycled water supply

YVW is the responsible water retailer for potable water and wastewater services to the precinct area. The precinct is mandated for recycled water use, however this was put in place when Merrifield North was zoned for residential use. YVW have indicated that the employment focus of the precinct will mean that recycled water will be available for use but not mandated[1].

3.4.5 Wastewater management

Merrifield North sits within the Kalkallo sewer catchment (Yarra Valley Water, 2026). Wastewater services will be provided by Yarra Valley Water and local wastewater networks will be constructed with the development of the precinct.

There is a 638mm glass reinforced plastic sewer pipeline bisecting the Kalkallo RB which restricts the flood retardation to the northern portion of the RB (Merrifield North Precinct Structure Plan Pitching Summary Report, 2025). There is a proposed 1200 mm sewer pipe following a tributary of Kalkallo Creek, Gunns

[1] Update provided during the Merrifield North IWM Plan check in with YVW staff on the 8th April 2026

Gully Road, and then the eastern boundary of the Kalkallo RB site where it joins an existing 1603 mm sewer pipe to the south of the precinct border. There are also two proposed 300 mm sewer pipes that would connect to the 1200 mm pipe, connecting the eastern portions of the precinct. The larger pipe and smaller pipes are scheduled for 2030 and 2033 respectively.

3.4.6 Required lot- and street-scale water sensitive urban design

The stormwater treatment requirements for the site are likely to be met at a precinct scale through the implementation of large-scale wetlands planned via the drainage scheme. However, there are drivers for some lot and street scale initiatives through other guidelines and local policies.

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.

Hume council requires industrial developments to have a stormwater management system designed to meet the stormwater treatment performance objectives unless these objectives will be met by offsite treatment.

3.5 Summary constraints map

The key constraints for Merrifield North precinct are shown in Figure 3-17.



Figure 3-17 Key constraints applying to Merrifield North

4. Water and Pollutant Base Case

A ‘base case’ has been 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 an indicative land use budget provided by DTP to Arup in March 2026. This land use budget is indicative in nature and will vary as the precinct 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.

4.1 Development scenarios

This report investigates the base case for two possible land use budget scenarios, which represent an upper and lower bound of developable area:

- Scenario A: This scenario assumes an employment land area of 255 ha with the assumption that 15% of this area would be roads and 2% would be open space within the precinct.
- Scenario B: This scenario assumes an employment land area of 450 ha with the assumption that 15% of this area would be roads and 2% would be open spaces within the precinct.

Figure 4-1 shows the assumed land use budgets for Merrifield North precinct based on the two scenarios.

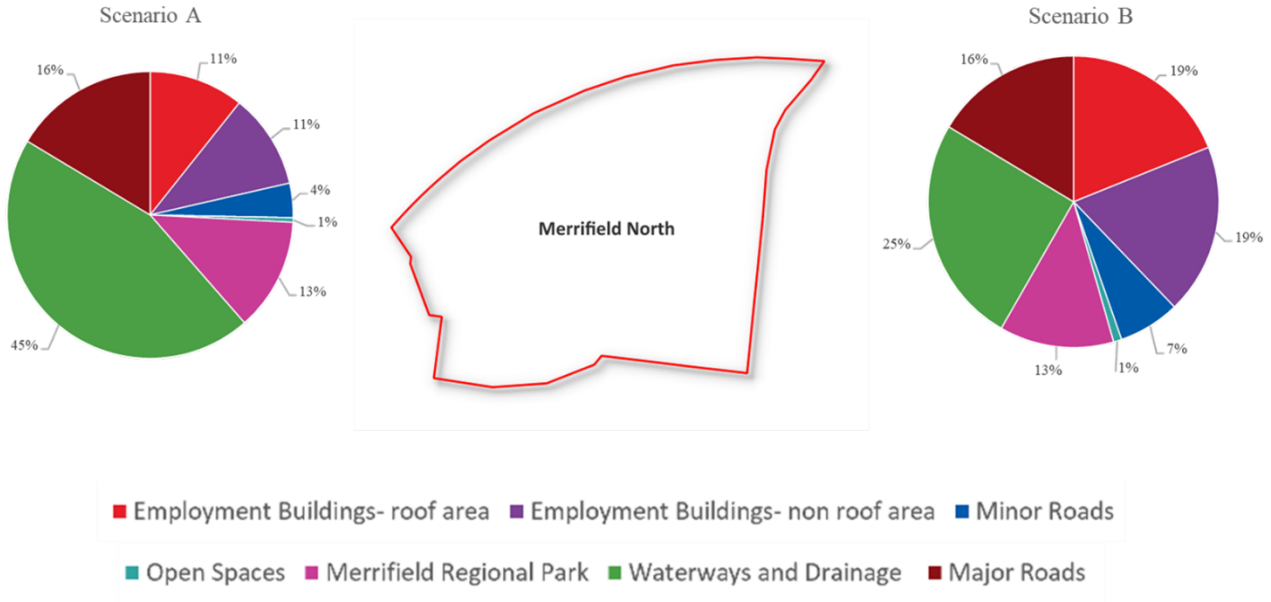


Figure 4-1 Assumed land use breakdown for Merrifield North precinct

4.2 Water demands

As Merrifield North is a predominantly employment precinct, assumptions on anticipated water demands and wastewater generation volumes are shown in Table 4-1 were adopted.

Table 4-1 Water demand assumptions

Type	Water Demand	Unit	Assumption source
Commercial/Industrial	1861	kl/ha/year	Review of non-residential water use (Sydney Water)
Active open space	4.5	ML/ha/year	Based on Yarra Valley Water (2023) Water Planning and Design Principles.

Type	Water Demand	Unit	Assumption source
			For an active open space, 100% of the OS area is irrigated.
Passive open space (Merrifield Regional Park)	4.5	ML/ha/year	Based on Yarra Valley Water (2023) Water Planning and Design Principles. For a passive open space, only 5% of the OS area is irrigated. This is the assumption for Merrifield Regional Park.
Water to wastewater generation	80	%	Industry assumption

The assumptions outlined in Table 4-1 were applied to the assumed land use as described in Section 4.2. Figure 4-2 represents estimated demands for Scenario A and B.

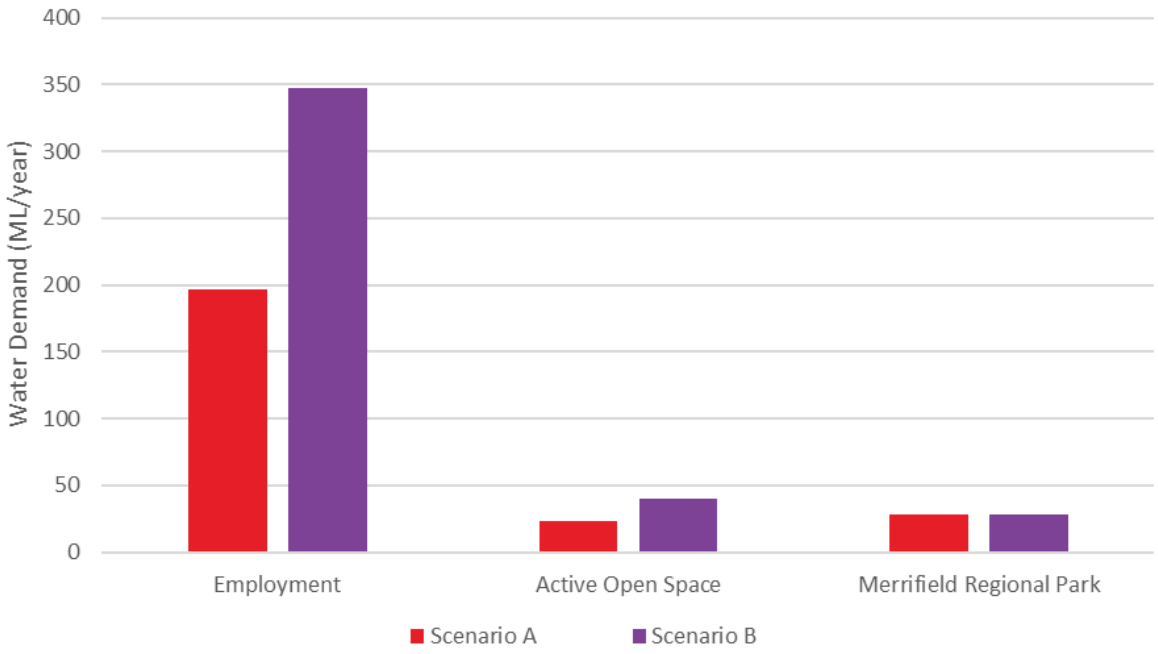


Figure 4-2 Water demand for Scenarios A and B

4.3 Stormwater Base Case

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 086282 Melbourne Airport) from Bureau of Meteorology over a 10-year period to determine flows and pollutant loads for pre-development 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.

In both cases, it is assumed that precinct-scale stormwater treatment wetlands would be constructed to achieve BPEM standards for stormwater pollutants. These are currently planned to be located within the Kalkallo Retarding Basin under the drainage scheme. Accordingly, for the base case, two options have been assessed for Scenario A and B.

Table 4-2 shows the assumed impervious fraction for the land use budget and key model inputs based on Melbourne Water MUSIC Guidelines (2024) 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 4-2 Land use budget assumptions

Land Use Type Source Nodes	Assumed Imperviousness	Scenario A	Scenario B
Major Roads	70%	162	162
Merrifield Regional Park	10%	445	250
Waterway and Drainage	10%	126	126
Assumed Employment area		255	450
Employment buildings (roof area)	100%	106	187
Employment buildings (non-roof area)	60%	106	187
Open Space	10%	5	9
Minor Roads	60%	38	67
TOTAL (ha)*		**988**	**988**

*Since completion of the modelling in this report, the total PSP area has been revised from 988ha to 970.4ha.

Table 4-3 summarises the stormwater treatment results using wetland sized 110,000 m^2 and 140,000 m^2 for Scenario A and Scenario B respectively.

Table 4-3 MUSICX results for Scenario 1 and 2

	Scenario A			Scenario B		
	Source	Post-treatment	% Reduction	Source	Post-treatment	% Reduction
Flow (ML/yr)	1,954	1,811	7.3%	2,489	2,308	7.3%
Total Suspended Solids (kg/yr)	343,700	54,680	84%	392,100	61,870	84%
Total Phosphorus (kg/yr)	709	207	71%	846	258	69%
Total Nitrogen (kg/yr)	4,828	2,625	46%	6,192	3,378	45%
Gross Pollutants (kg/yr)	70,800	0	100%	95,570	0	100%

Based on the stormwater pollutant results, the target reductions for TSS, TP and TN are achieved (80%, 45%, 45% respectively) to meet the water quality targets in the Urban Stormwater Management Guidance. In terms of stormwater harvesting and infiltration targets (74% and 8% respectively) set out in the Urban Stormwater Management Guidance (see Section 2.2), opportunities to meet both the harvesting and infiltration targets will be explored through the analysis of possible IWM opportunities, having regard for local site conditions e.g. the presence of sodic soils.

4.4 Water Balance Summary

Figure 4-3 and Figure 4-4 summarise the water balance results for Scenario A with 255 ha employment area and Scenario B with 450 ha employment area.

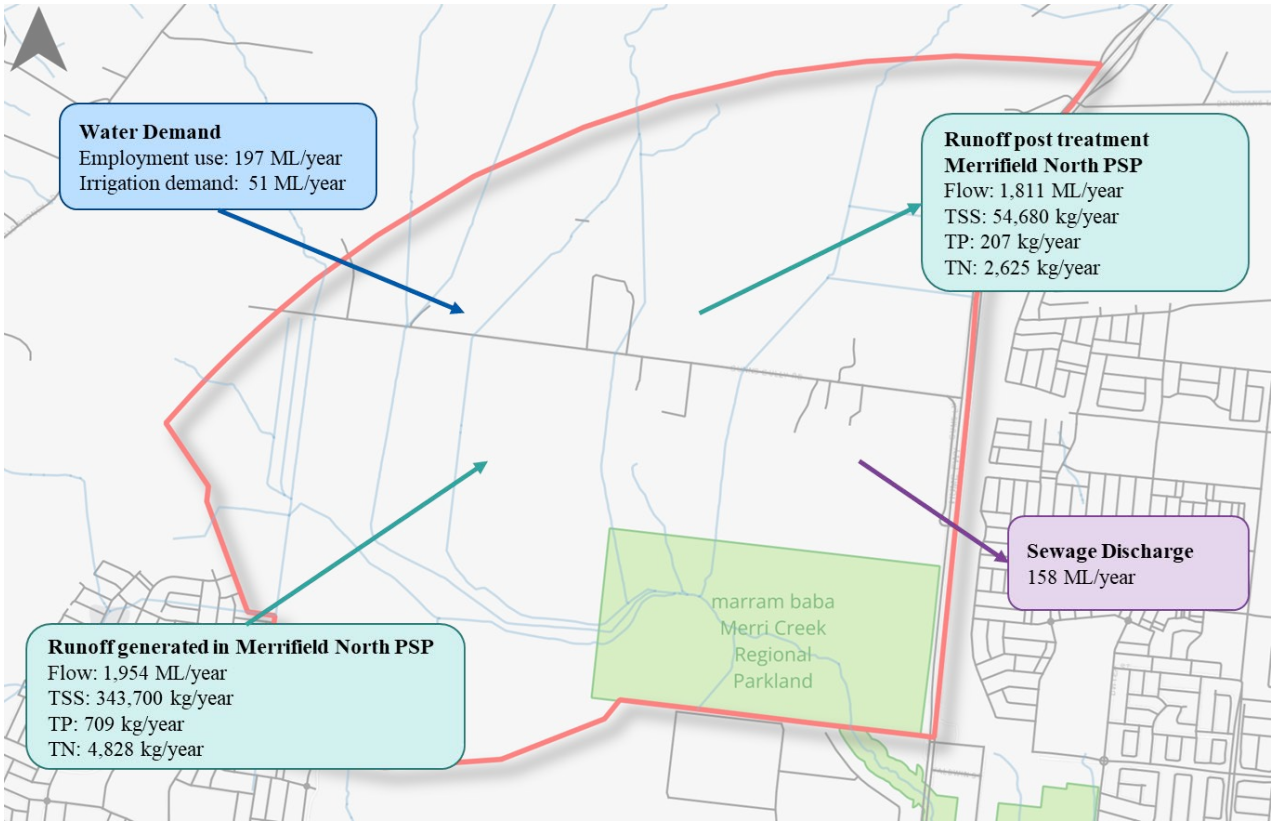


Figure 4-3 Scenario A: Water Balance Summary

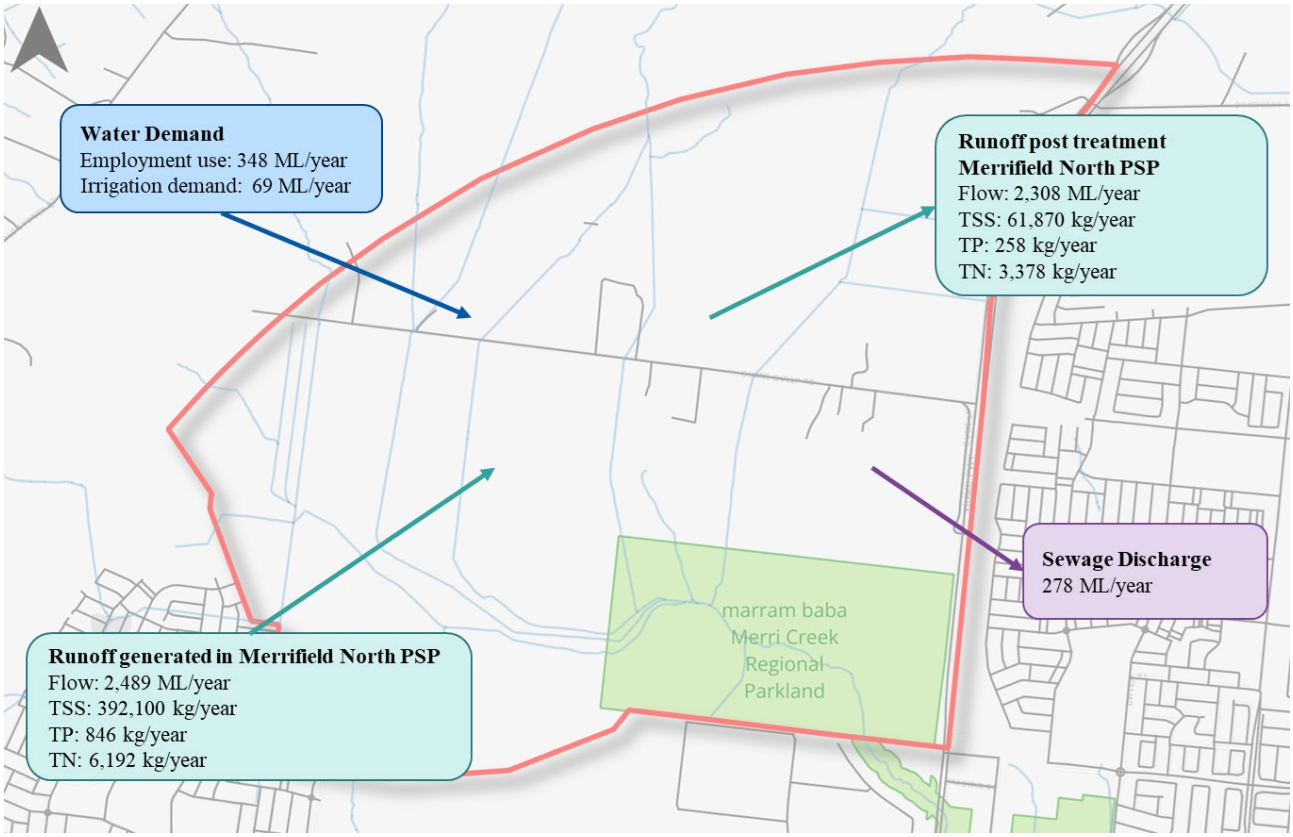


Figure 4-4 Scenario B: Water Balance Summary

5. IWM objectives and emerging opportunities

Based on the situational analysis, a number of objectives for integrated water management, as well as possible IWM opportunities have been identified. These are set out in the sections below.

5.1 IWM objectives for Merrifield NorthThe Yarra Catchment IWM Plan sets out strategic outcomes for IWM in the catchment. These have been developed into place-based objectives, which have been reviewed and adopted for Merrifield North precinct.

Strategic IWM Outcome	Place-based IWM objectives for Kalkallo Creek Sub-Catchment and Merrifield North precinct
Safe, secure and affordable water supplies in an uncertain future 	• Deliver an alternative water supply to all in the Northern Growth Corridor to service non-potable demand to reduce potable water demand.
Effective and affordable wastewater systems 	• Leverage the Class A recycled water scheme that is currently planned across the whole of the Northern Growth Corridor
Existing and future flood risks are managed to maximise outcomes for the community 	• Effective utilisation of the Kalkallo Retarding Basin and Kalkallo creek corridor as part of a multi-functional flood storage and conveyance system
Healthy and valued waterways and marine environments 	• Reduce the mean annual runoff to mimic natural runoff volumes (meeting Healthy Waterways harvesting target) • Reduce the impacts of urban development on waterway water quality • Create a waterway geometry in equilibrium to manage sodic soils • Create waterway conditions to support healthy marine life.
Healthy and valued urban and rural landscapes 	• Healthy native vegetation communities are preserved and enhanced. • Active and passive open spaces are supported by alternative water source(s)
Community values are reflected in place- based planning 	• Engagement of Wurundjeri' s Narrap team to care for Country • Utilise planning of water assets to foster connections with urban form to support community and livability. • Connection to Country is fostered through water related initiatives. • Healing Country by restoring Kalkallo Creek and its catchment so that it is considered healthy by Wurundjeri people
Jobs, economic benefits and innovation 	• Enable utilisation of rainwater, stormwater and recycled water in the broader region to support agricultural, industrial, residential and cultural water users or new potable supplies.

Strategic IWM Outcome	Place-based IWM objectives for Kalkallo Creek Sub-Catchment and Merrifield North precinct
Enablers 	• Ease of Adaptability • Ease of Delivery • Rating of Feasibility

5.2 List of IWM opportunities

The list of IWM Opportunities for Merrifield North is shown below in Table 5-1. The selection of appropriate opportunities considered the employment-focused nature of the precinct. These opportunities were developed based on the review of background information including the Kalkallo IWM plan as well as check in with key stakeholders from Yarra Valley Water, Mitchell Shire Council, Hume City Council and Melbourne Water. Some of these opportunities are likely to be delivered as the 'base case' through existing commitments and the Melbourne Water drainage scheme (though this is currently under review

Table 5-1 Long list of IWM opportunities

	No.	Opportunity
Base case	A	Standard water efficient employment building fixtures and fittings
	B	Wetland treatment at strategic locations defined by Kalkallo Creek drainage scheme
	C	Standard waterway remediation works
	D	Utilising Kalkallo RB to mitigate downstream flooding
Lot scale	1	Advanced water efficient employment building fixtures and fittings
	2	Rainwater harvesting for non potable uses in individual employment buildings
	3	Permeable paving in employment car park areas
	4	Biofiltration systems on lot
Street scale	5	Biofiltration systems in streets
	6	Passively irrigated street trees
Precinct scale	7	Class A recycled water for non potable water supply
	8	Micro grid rainwater harvesting to non potable network
	9	Stormwater harvesting at Kalkallo RB for marram baba regional park and nearby open spaces
	10	Stormwater harvesting at Kalkallo RB for regional use
	11	Advanced waterway remediation works
	12	Realignment and enhance agricultural drains
	13	Spongy riparian zones

The following IWM opportunities were not included in the list for Merrifield North precinct:

- **Preserving existing tributaries of Kalkallo creek:** there are no know intact tributaries of Kalkallo creek within the Merrifield North precinct. With all waterways having been straitened for agricultural drainage.
- **Restoration of Inverlochy Wetland:** Uncertainty around the extent and functionality of the Inverlochy Wetland combined with a lack of mechanisms within the existing planning and regulatory framework to allocate land and reestablish the wetland have meant that the wholesale regeneration of an ephemeral wetland in a dedicated area has not be examined further in this study. A key limitation identified is the absence of any mandate or statutory mechanism under the Planning and Environment Act 1987 to protect pre-European wetlands where these areas are not designated as Areas of Cultural Heritage Sensitivity. As a result, there is reliance on the Cultural Heritage Management Plan (CHMP) process, which applies to formally recognised Areas of Cultural Heritage Sensitivity only. However, further opportunities to integrate ephemeral landscapes and wetlands can

be further explored through the design of the Kalkallo Retarding Basin and associated stormwater management assets delivered through the Developer Services Scheme with it is recommended these opportunities are developed with WWCHAC and Melbourne Water.

- **Green roofs:** With employment type typology not confirmed, there is too much uncertainty around the practicality of this option at this point in time (e.g. delivery challenges would exist for wide span warehouses).
- **Increased permeability at the lot scale:** Considered impractical in industrial and commercial settings due to heavy vehicle use. Also aligns with decisions made as part of Kalkallo IWM Plan. Permeable paving may be possible for a portion of carparking areas and this has been included as an option.
- **Rainwater harvesting for potable water supply:** While enabled through the DEECA water security plan[2], timing for delivery within a policy, community and change management lens not considered to align with timing of delivery of the PSP for the Merrifield North precinct.

[2] https://www.water.vic.gov.au/our-programs/water-monitoring-and-reporting/water-security-plan

Appendix A

Summary of documents reviewed for contextual analysis

Title	Organisation	Year
Merrifield North Employment and Beveridge South West PSP Pre-European Wetland Investigation	Alluvium	2024
Swamps and Wetlands of the Upper Merri Creek Catchment	Merri Creek Management Committee	2018
Merrifield North Employment Precinct – Sodic and Acid Sulfate Soil Assessment	Jacobs	2023
Merrifield North Precinct Structure Plan Pitching Summary Report	VPA (DTP)	2025
Arboricultural Assessment and Report Merrifield North PSP	Tree Logic	2026
Integrated Water Management: Issues and Opportunities Report	Jacobs	2023
Integrated Water Management Assessment: Existing Situational Analysis Report	Jacobs	2022
Kalkallo Creek DSS	Melbourne Water	2017
marram baba Merri Creek Regional Parklands Wurundjeri Woi-wurrung Cultural Values Position Statement	WWCHAC	2023
Kalkallo Creek Sub-Catchment IWM plan	Arup	2025