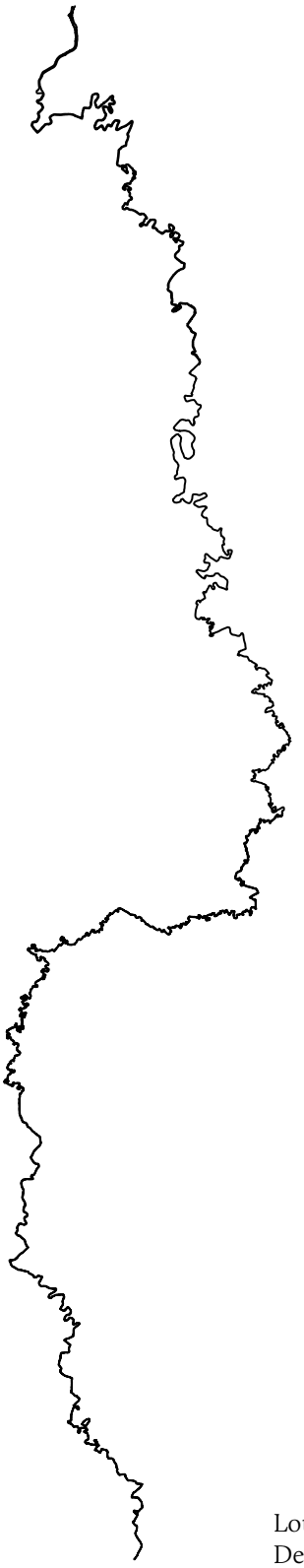
Rethinking Birrarung

Regenerating a dynamic
Yarra River corridor



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Master Thesis Report

Rethinking Birrarung: Regenerating a dynamic Yarra River corridor

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To my mentors, thank you for supporting me throughout this journey. Your patient guidance have both shaped the project and my professional perspective & abilities in ways that wouldn't have been possible without it.

To my friends, thank you for your continued presence and positivity throughout this year. Your wise words have been immensely valuable in this process.

To Ilse, mama & papa, your unconditional love and support have been incredibly important in guiding me through this process. I could not have done this without your trust and belief. Thank you.

I would like to acknowledge the Wurundjeri people of the Kulin Nations as the traditional owners of the Yarra River and its environs, where this research has taken place. I pay my respects to their Elders past, present, and emerging and recognize the ongoing custodianship of the land and water by all members of their communities.

Abstract

This thesis investigates the regeneration of the riparian corridor of Birrarung (the Yarra River) as a dynamic landscape system that supports ecological connections, water retention, and meaningful human-river engagement. Post-colonisation development, agricultural land use, water extraction and climate change have fragmented the corridor, disrupted seasonal flows, and reduced floodplain inundation. Steep and privatised riverbanks limit river access, contributing to a disconnect from the river in urban life and underutilisation as public space. Literature highlights the value of ecologically connected riparian corridors with space for natural dynamics, supporting both river health and human wellbeing.

Using a landscape-based design approach and the Research Through Design method, this project proposes an integrated spatial framework for riparian regeneration. As a form of landscape infrastructure, the river links spaces along its course, enabling local interventions to generate system-wide effects. The framework is built around four strategies derived from layered analysis and precedent studies: (1 & 2) resilient and (re)connected riparian ecological networks, (3) improved riparian water buffer capacity, and (4) enhanced human-river connections. These strategies are translated into design principles and tested through a system-wide vision and two detailed interventions.

The design interventions restore ecological structure and function through riparian revegetation, increase water retention, and create opportunities for public engagement with seasonal river dynamics. Features such as slow recreation trails and spaces, reshaped riverbanks, and revegetated floodplains reframe the river as a system to be experienced rather than resisted.

The outcome is a spatially adaptable strategic framework that bridges ecological and social needs. While specific to the Yarra River, the approach offers relevant insights for other urbanised river systems seeking to reconnect fragmented corridors, improve hydrological performance, and promote deeper human-river connections through landscape-based design.

Fascination

Cycling daily along the Yarra River for several months, I became increasingly aware of its underused potential as a recreational and social structure. Covered by lush green vegetation, mature gum trees, and steep, dramatic banks, with no cars and (almost) no city noise, the river corridor felt like a different world from the urban context on top of its banks. Despite this richness, I experienced that access to the trails was often difficult to find, and getting close to the water, let alone engaging with it, proved especially hard. In many places, the river felt like a physical boundary rather than a connecting public space, which became especially apparent when I observed the cultural and spatial differences between the suburbs north and south of the river. In comparing this to other river cities I have visited, such as Copenhagen, where a strong sense of community is present along the waterfront, I began to see the unused potential of the Yarra to offer similar experiences of leisure and connection to a river system. Early research into the river system strengthened these impressions, and learning about the Yarra's cultural significance for Traditional Owners before colonisation, and the shift in its use and perception after European settlement, revealed a deeper layer of disconnection. These first observations led me to a question that shaped the direction of this thesis: What could the Yarra River become if we rethink our relationship with it?

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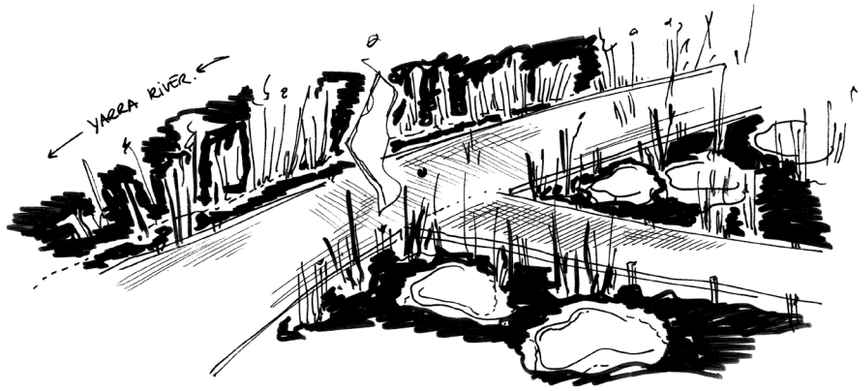


01 Introduction

1.1. The Yarra River & Catchment

The Yarra River (originally named Birrarung by the Traditional Owners of the land) is located in the state of Victoria, Australia. It flows approximately 240 kilometres from its source at the Upper Yarra Dam (completed in 1957) in the Yarra Ranges National Park through rural and urban landscapes before emptying into Port Phillip Bay, draining a catchment of over 4,000 square kilometres (Commissioner for Environmental Sustainability Victoria [CES], 2023). Along its course, the river passes through four sections: the upper rural reach, defined by forested slopes and national parkland; the lower rural reach, an open floodplain landscape shaped by agricultural land; the suburban reach, a semi-natural corridor of bushland, parkland and residential development; and the inner urban reach, a highly urbanised landscape (Melbourne Water, 2022).

Value of the Yarra: Pre- and post-colonisation

For tens of thousands of years, Birrarung was central to the cultural, spiritual, and everyday life of the Wurundjeri Woi Wurrung people, the Traditional Owners of part of land of the Eastern Kulin Nation (current Greater Melbourne region) (Melbourne Water, 2022). The river was understood as part of a living and interconnected system including land, water, people, animals, and ancestral law, described as 'Country' (Gummage & Pascoe, 2021). 'Caring for Country' involved taking care of the land using long-lasting ecological knowledge. However, colonisation and the founding of Melbourne in 1835 followed by rapid urban development, changed the general perspective on and use of the river (Gummage & Pascoe, 2021), no longer recognising it as a living entity, but as a structure to be contained and built around (Wurundjeri Woi-wurrung Cultural Heritage Aboriginal Corporation, 2022).

Figure 1. Yarra River and the Yarra River Catchment.

Map made by author, based on data from: DataVic, Melbourne Water Open Data Hub, NEXTGIS, DEECA's Spatial Data, GoogleEarth, Vicmap

Figure 2. Impression of the Yarra River (Birrarung) during the first years after colonisation. Source: (Environment Victoria, 2018).

Riparian zone: a multifunctional landscape

Within upstream rural reaches of the river, agricultural activity took over large sections of the riparian zone of the river (CES, 2023; Yarra Riverkeeper Association, 2021b). A river's riparian zone is the transitional area between land and a river, extending from the riverbank to adjacent land and shaped by topography and river dynamics (ex. flood events). It plays a crucial role as an ecological migratory corridor, providing habitat for terrestrial and aquatic species, stabilising banks, filtering water runoff and retaining water in times of high flow (Lind et al., 2019). For the Yarra River, the riparian zone is roughly defined as extending at least 50 meters on either side of a waterway, although its true extent varies based on topography, soil type, and flood frequency (Yarra Riverkeeper Association, 2021b). The Yarra River riparian zone is a wetland-like landscape often with billabongs (cut-off meanders of a river path) which form ecological habitats for species like the platypus, providing breeding ground, shelter and food resources (Yarra Riverkeeper Association, 2021b).

Fragmented riparian corridor

Change in land-use from intensive agriculture resulted in the fragmentation of the ecological corridor and disturbed these riparian habitats (Yarra Riverkeeper Association, 2021b). Additionally, water extraction practices, mainly for agricultural use and urban drinking water, and climate change destabilised the river's flow pattern of high volumes in summer and low volumes in winter (Bureau of Meteorology, 2024). This resulted in an overall lower baseflow and less frequent flooding of the riparian zone and billabongs, causing further loss and alteration of riparian habitat. Species and habitats dependent on the seasonal flow patterns and riparian habitats are increasingly impacted by these changes, and

Figure 3. Agricultural land is directly bordering the Yarra River within the riparian zone. Source: (FlyHigh Visuals, 2022).

Figure 4. Flooding in Melbourne CBD in 1972. Source: (Bowler, 1972).

several are now endangered (Greet et al., 2023).

Connection to the river

Within the downstream reach, following colonisation, the river was straightened, channelised, and floodplains were narrowed and cleared of vegetation to make space for urban development (Yarra Riverkeeper Association, 2021b). Pairing with sections of naturally steep banks and the general perception of the river as being 'dirty' from industry and urban waste, this resulted in a limited opportunity (and desire) for physical and visual engagement with the river, and the city facing away from the river, causing the river to become increasingly disconnected from urban life (Davison, 2022). Eventually, as the city developed and water quality regulation came into practice (Department of Sustainability and Environment, 2006), the perception of the river changed, and potential and desire for engagement returned. Although some attempts have been made to improve engagement, this potential for enhanced physical and visual engagement remains.

Engaging with the river also means engaging with its natural dynamics, including flooding. Currently, these dynamics are often perceived negatively, particularly in urban areas where they disrupt trails, roads, housing, and sports fields. However, it is important to shift toward a more positive outlook on river dynamics, as they are essential for maintaining the health and resilience of the riparian corridor, an ecological system on the river's natural floodplain.

1.2. Rethinking Birrarung

The importance of a well-functioning river system with resilient habitats extends beyond its ecological and hydrological roles. In recent years, well-integrated green-blue infrastructure has gained recognition for its contribution to urban liveability and wellbeing, as well as its capacity to reconnect people with their environment. Along the Yarra River, however, much of this potential remains underused. The riparian landscape still offers limited public access and engagement, despite its capacity to support both ecological processes and recreational experiences. Seasonal dynamics such as flooding, while critical to the river's health, are often perceived as disruptive. This presents an opportunity to reframe these dynamics as a visible and valuable part of the landscape, fostering a more positive relationship with the river as a living system.

Given the current challenges, rethinking the Yarra River's multifunctional role across urban and rural contexts offers a pathway to regenerate its ecological corridor while enhancing opportunities for human interaction. This project takes a landscape-based approach, using riparian regeneration as the foundation for restoring ecological function and enabling renewed human engagement with the system.

1.3. Research Objective & Questions

The research explores the potential for regenerating the riparian zone of Birrarung (the Yarra River) into a continuous ecological corridor, while enhancing human engagement with its dynamics through proposing a strategic spatial framework using a landscape-based design approach.

To support this objective, four sub-questions guide the research process, aligned with the phases of the Research Through Design method (see Chapter 2).

SQ1 - Understanding the Yarra River system – Chapter 3
How can the Yarra River system, including its flow dynamics, riparian land use, ecological role, and human engagement with it, be understood, and what spatial opportunities and challenges can be identified?

SQ2 - Design Strategies & Principles – Chapter 4
Which strategies and design principles are suitable for regenerating the riparian corridor of the Yarra River while promoting human engagement with the river system?

SQ3 - Design Exploration – Chapter 5
How can the defined strategic framework and design principles be translated into spatial landscape architectural interventions at both regional and urban scales along the Yarra River corridor?

SQ4 – Synthesis – Chapter 6
To what extent has the spatial strategic framework and adopted approach supported the regeneration of the riparian corridor, and what insights does this offer for future river regeneration projects with similar aims?

1.4. Reading Guide

This thesis is structured into the following chapters, each contributing to the overall research and design process. Chapter 2, Methodology, outlines the research structure and introduces the methodological framework. Chapter 3, Understanding the Yarra River System, presents an analytical foundation, examining current conditions, challenges, and opportunities. Chapter 4, Design Strategies & Principles, develops the strategic framework which highlights the areas with potential for regeneration. In Chapter 5, Design Exploration, the river-scale vision is translated into local-scale design interventions. Chapters 6, Synthesis, evaluates the research process and outcomes, addresses the project's relevance and reproducibility, and proposes directions for future research and application.

02 Methodology

This chapter outlines the theoretical foundation on which the research and design outcome are based, as well as the adopted research and design methods.

2.1. Theoretical Framework

Formative and operative green and blue infrastructures

The theory of urban landscape infrastructure by Nijhuis & Jauslin (2015) states that landscape itself can be seen as a type of infrastructure, referred to as a network of 'space of flows'. This reflects the dynamic processes and systems related to the infrastructure, and opposes itself to the conventional 'space of places', reflecting location-bound environments. The infrastructure can be seen as both operative and formative, indicating that it can both shape a design and be a functioning structure within the design, a relevant notion for the regeneration of the Yarra River riparian zone. The theory proposes three types of urban infrastructure: transport, green and water infrastructure. Green and water (blue) infrastructures hold the potential to facilitate ecological corridor restoration, and promote human wellbeing by providing recreational use (Pinto et al., 2023), making it possible to define the Yarra River system as both a green and blue infrastructure and use this river system as both as a formative tool for design and an operative structure (Nijhuis & Jauslin, 2015).

Human-river interaction through recreational development

Kondolf & Pinto (2017) state that many urban rivers have become inaccessible or invisible to the public as a result of urban development, which they describe as the loss of social connectivity. This results in a loss of public awareness and unacknowledged value of the river system. This disconnection is significant because, as they state, social connectivity is as critical as ecological or hydrological connectivity in ensuring that urban river restorations are embraced,

maintained, and supported by the public. Kondolf & Pinto (2017) state that many river restoration projects have focused solely on ecology or flood control and miss opportunities to strengthen human-river relationships. They argue that river projects should aim to increase the permeability of the river, described as the ease with which people can physically and visually access the river. They suggest restoring lateral and vertical connectivity through recreational development that enhances the river's physical and visual accessibility (Kondolf & Pinto, 2017). With its steep banks and limited points of access, the Yarra River reflects similar disconnection, particularly within the urban context. Restoring lateral and vertical connectivity offers the opportunity to fostering human engagement, re-establish the river as part of daily urban life, and strengthening support for its long-term regeneration.

Ecological relevance of river dynamics

Rivers are dynamic systems characterised by a 'natural flow regime', a principle defined by Poff et al. (1997) as the characteristic pattern of a river's flow variability, shaped over long periods by the climatic and geologic setting of the river basin. The concept of natural flow regime is based on the understanding that the preservation or mimicking of the natural variability of river flow, instead of a constant flow volume, is essential for maintaining ecological integrity within the river system (Poff et al., 1997). Using this regime is suggested as the basis for restoration and conservation strategies with a hydrologically based management approach. For the Yarra River system, in which the natural flow dynamics are now limited, taking the restoration of this dynamic as the goal could be a guide for design considerations.

Engaging with river dynamics

This concept of 'River Rhythmicity', refers to both the ecological function of river dynamics and the way humans have historically lived with them (Jackson et al., 2022). People once responded to these river level fluctuations and seasonal flooding through practices that were adjusted to this river's behaviour, forming a sense of place, belonging, and creating the feeling of responsibility for the system (Jackson et al., 2022). Urbanisation and river engineering have increasingly concealed these rhythms from everyday life, leading to a loss of understanding and empathy for the river. Natural dynamics, especially flooding, are now often seen as disruptive rather than essential to the system's

health (Wantzen et al., 2016). The 'River Culture' framework argues that restoring human awareness of river dynamics can foster stronger positive connections towards and deeper ecological understanding of the river, creating increased support for regeneration. Additionally, this approach can have a positive effect on human wellbeing, with the potential of reducing psychological stress, sleep disorders, obesity, and chronic diseases (Wantzen et al., 2016). Although the Yarra River dynamics are compromised, the river still follows a seasonal and (in some sections) daily flow pattern. Creating spaces that make these visible can help shift public perception, turning natural fluctuations into meaningful experiences that support long-term care and connection.

Synthesis

Establishing green blue infrastructures through rivers has been shown to support ecological health by creating connected habitat corridors, while also enhancing human wellbeing by improving access to natural areas and engaging with the recreational qualities of river landscapes. Within such systems, facilitating human interaction with river dynamics has demonstrated further benefits for wellbeing, and fostering a stronger connection to the natural environment through an improved understanding of its seasonal and spatial rhythms. This connection often translates into greater public support and care for these ecosystems, contributing to their long-term resilience. Integrating Indigenous land management practices into regeneration efforts offers an approach that is not only sustainable and ecologically grounded but also place-sensitive, strengthening the cultural identity of a place.

The Yarra River system, with its river and riparian landscape, is a linear green-blue structure running through both rural and urban contexts. Its clear seasonal pattern of river level fluctuation provides an opportunity to promote human engagement with the dynamic river system, particularly when linked to its recreational potential. This connects Melbourne citizens to these natural processes in a way that builds awareness and understanding of the (spatial) needs of the Yarra River system. Taking the natural flow regime of the river as the basis for the design can aid in regenerating the river into an ecologically resilient, hydrologically dynamic and engaging system.

2.2. Research Structure & Methods

The research structure of this thesis is based on the Research Through Design (RTD) approach (Nijhuis & De Vries, 2020), in which the research process is guided by spatial design thinking. This design thinking is done from a landscape-based perspective. Through this perspective, the logic of the landscape itself serves as the guiding element and enables a transdisciplinary design process with a outcome that is place-sensitive and prioritises the landscape system (Nijhuis, 2022).
The RTD approach is divided into three main stages:

Research for design
This stage addresses SQ1, creating a comprehensive understanding of the existing conditions of the river system, using the methods of literature review, desktop study, GIS mapping, spatial analysis, site visits, and interviews (on-site).

Research about design
Addressing SQ2 to form design principles and strategies that align with the research objective, through performing precedent studies, literature review, and desktop analysis.

Research by design
This stage addresses SQ3 through testing the developed design principles and strategies on defined design sites.

The RTD approach is inherently iterative, allowing for design hypotheses to be tested, evaluated, and refined through ongoing feedback loops across all three stages. This process results in a site-specific design proposal, which is evaluated during the synthesis phase, answering SQ4.

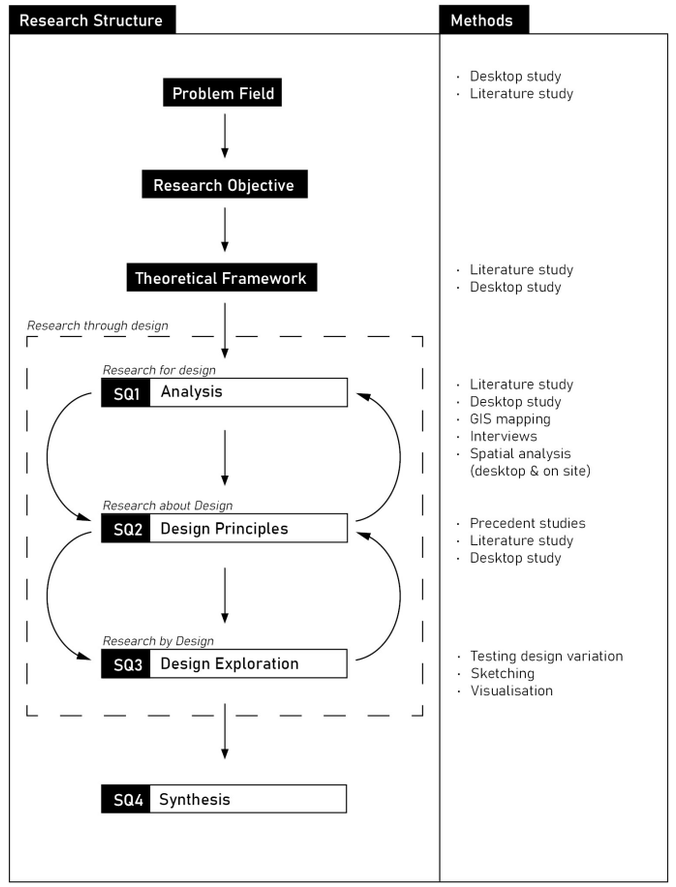


Figure 5. Research structure following the Research by Design methodology.

Moving through scales & layers
To both build an understanding of the Yarra River system and design outcome responding to it, a multi-scalar approach is adopted. This involves moving between the full river system and detailed design sites, allowing the impacts and interrelations of interventions to be explored across scales. Working through scales ensures that insights gained at the regional level inform detailed design explorations, while site-based findings contribute to a deeper understanding of the river's system at a larger scale (Nijhuis & Jauslin, 2015). This is combined with a layered approach, which dissects the Yarra River system into the project layers of riparian ecology, hydrology, human engagement and culture. A simplification that allows for unravelling the complexity of the river system and creates the opportunity to design on and with it.

03 Understanding the Yarra River system

3.1. The Yarra River as ecological corridor

Characteristics of the corridor

The Yarra River can be divided in an upstream, midstream and downstream section. The width and structure of the Yarra River's riparian zone vary along the length of the river. In the upstream reaches, where the river is surrounded by a mountainous landscape, the floodplain and thus the riparian zone is relatively narrow, averaging a width of 200m. In contrast, sections with less topographical constraints (midstream) allow for a wider riparian landscape of up to 2000m, historically shaped by seasonal flooding and riparian vegetation. A literature review on riparian zone spatial requirements in agricultural settings described a minimum width of 30m to be required to achieve a high diversity in plants and animals along the river. Additionally, to preserve bird diversity, a 144m riparian buffer is required (Lind et al., 2019).

Ecological vegetation classes (EVC)

The landscape typologies of the riparian zone and surrounding landscapes along the Yarra River are classified as Ecological Vegetation Classes (EVCs) (Department of Sustainability and Environment, 2007). Floodplain Riparian Woodland (FRW) dominates along the full reach of the river and supports a high concentration of billabongs. It is an open woodland dominated by Eucalyptus camaldulensis (River Red Gum), occurring on fertile alluvial floodplains with a diverse ground layer of grasses, herbs, and sedges, seasonal inundation of this EVC is common. Swampy Riparian Complex (SRC), is present along the flat rural sections of the river and consists of dense sedgelands and wetland shrubs such as Melaleuca ericifolia (Swamp Paperbark), forming a landscape adapted to seasonal waterlogging. Along most stretches of the river, land bordering the riparian zone is classified as Plains Grassy Woodland (PGW), an eucalypt woodland

characterised by species such as Eucalyptus melliodora (Yellow Box) over a diverse and herb-rich grassy understorey, dominated by native tussock grasses like Themeda triandra (Kangaroo Grass) (Department of Sustainability and Environment, 2007).

Substantial undisturbed areas of these vegetation classes contribute to the overall health of the Yarra River system, as these areas contain the habitats of a large variety of birds, frogs, mammals, reptiles and insects in the riparian zone (Yarra Riverkeeper Association, 2021a). Unfortunately, due to a large shift in land use, all three EVCs mentioned above are now endangered (Department of Sustainability and Environment, 2007).

Compromised riparian corridor

Urban growth & land-use

Since colonisation, land use in the catchment has changed significantly. The full catchment has a total surface area of 4046 km2, of which 55% remained forested or covered with native vegetation after colonisation (CES, 2023). Agriculture & farming (including vineyards) now account for 30% of the total surface area. Within the rural reaches of the catchment, intensive monocultural agriculture extends to the riverbank, replacing native riparian vegetation (SRC) with monocultural grasslands and cleared grass fields (Yarra Riverkeeper Association, 2021). The remaining 15% of the catchment area is covered by urban development, with the largest section belonging to Melbourne and its suburbs (including privatised land, golf courses and sports fields) (CES, 2023).

Fragmentation of corridor

Alterations in land use fragmented the corridor and influenced the ecological functioning of the river system. Although some billabongs remain visible in the landscape, their ecological value is reduced as

Figure 6. Combined Ecological Vegetation Classes (EVC) within the Yarra Catchment pre-colonisation.

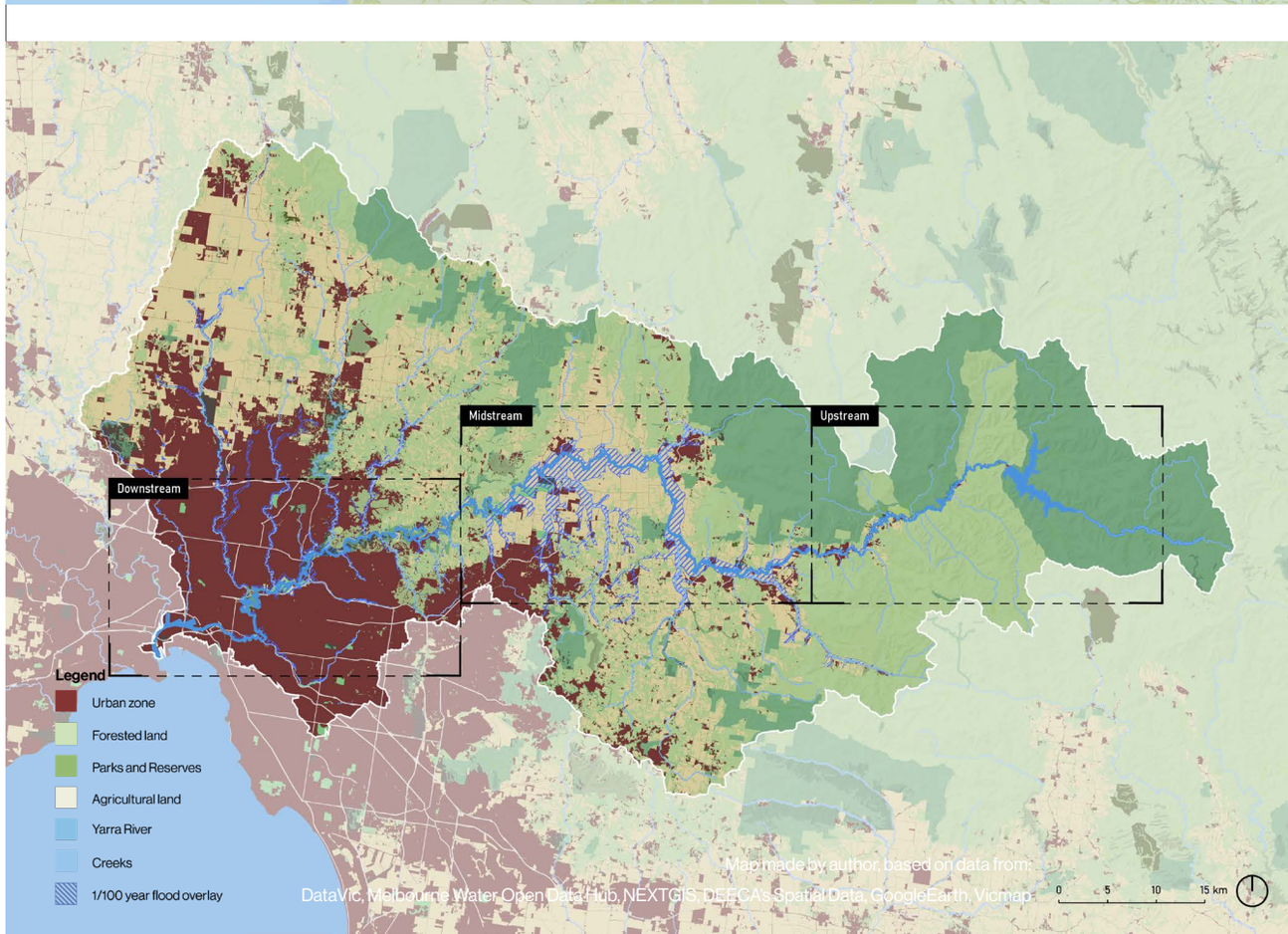
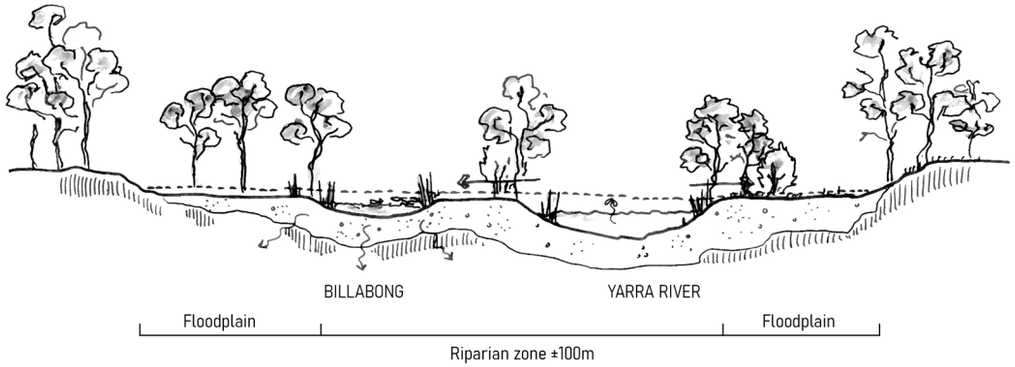


Figure 7. Post-colonisation Yarra River Catchment. Urban development and agricultural land have resulted in significant loss of EVC coverage.

a result of the vegetation clearing and the change in river dynamics (Melbourne Water, 2018). The spread of monocultural agriculture along the riverbanks disrupts the continuity of the riparian corridor, reducing its effectiveness as a habitat link between larger natural reserves (ex. Yarra Ranges National Park & Kinglake National Park), limiting the movement of species that rely on this linear connectivity (Melbourne Water, 2018). The most clear example of this is the platypus (Ornithorhynchus anatinus), which uses the corridor to migrate up and downstream and makes its burrows in the river's stable banks (Yarra Riverkeeper Association, 2021a). This dependency on the linear riparian corridor is increasing further, as the landscape directly surrounding the riparian zone has largely lost its habitat value (Melbourne Water, 2018).

Within the urban context, several sections of the river are fully channelised with hard-edge banks, like the lower reaches near the Port of Melbourne, leaving the river without its original floodplain and functional riparian zone. In suburban areas, although limited hard-engineered channelisation has occurred, urban encroachment and intensive managed riparian land, such as golf course maintenance, have nonetheless significantly changed the riparian zone (Commissioner for Environmental Sustainability Victoria, 2023). Although the riparian zone along this stretch of the river remains spatially connected, its capacity to support habitat formation through riparian vegetation has diminished (Melbourne Water, 2018). In some sections of the river, billabong wetlands completely disappeared from the landscape as they were built over by urban development, privatised land and golf courses.



River Red Gum
Eucalyptus camaldulensis

Swamp Paperbark
Melaleuca ericifolia

Common Reed
Phragmites australis

Water Ribbons
Cycnogeton procerum

Nankeen Night Heron
Nycticorax caledonicus

Platypus
Ornithorhynchus anatinus

Growling Grass Frog
Ranoidea raniformis

Macquarie perch
Macquaria australasica

Australian Grayling
Prototroctes maraena

Figure 8. Schematic image of the Yarra River riparian zone with flora and fauna dependant on the health of this zone.

3.2. River dynamics

Water retention & river pollution

Riparian zones function as natural water buffers that reduce surface runoff by enhancing soil infiltration and slowing water flow through deep-rooted vegetation, thereby supporting flood mitigation and improving water quality (Lind et al., 2019). Although specific data on the buffer capacity of the Yarra River riparian zone is lacking, it is known that agricultural practices significantly reduce this buffering capacity by compacting soils, removing deep-rooted vegetation, and thereby increasing runoff (Lind et al., 2019). Additionally, agricultural runoff is a major contributor to nutrient and pesticide pollution of the river, particularly where riparian vegetation has been cleared (Melbourne Water, 2022). In urban reaches, stormwater drains and industrial runoff introduce additional pollutants, including heavy metals, litter, and pathogens (Commissioner for Environmental Sustainability Victoria, 2023).

Seasonal dynamics

The flow dynamic of the Yarra River is determined by both seasonal variation and human intervention. The majority of precipitation and the highest river volume occur during the cool season (April to October), as cooler temperatures reduce evapotranspiration, allowing a greater proportion of rainfall in the catchment to become runoff (Department of Environment, Land, Water and Planning [DELWP] et al., 2020). This seasonal pattern originally supported a relatively stable baseflow in summer and floodplain inundation in winter and spring, which defines the 'flow regime' of the Yarra River (DELWP et al., 2020; Poff et al., 1997). These dynamics translate to a yearly variation in river level of around 1 to 1.5 meters, with a baseflow at 0.2m and high flow at 1.5m, based on monthly average river levels at the measuring location in Alphington. The river experienced higher-than-usual river levels with accompanying

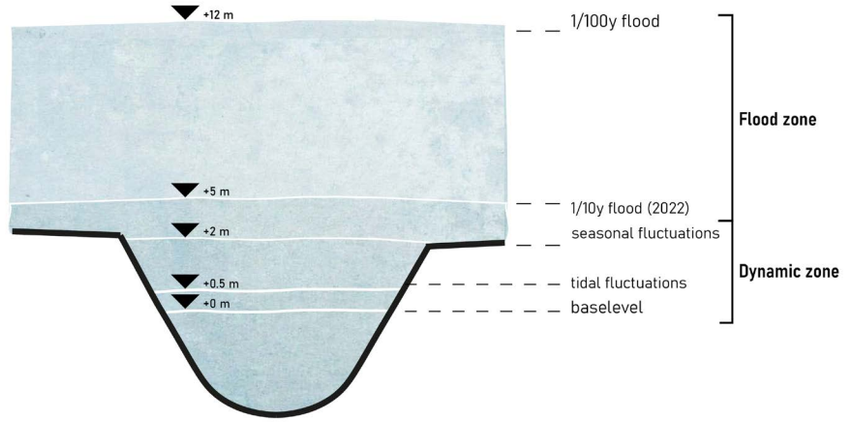


Figure 9. The dynamics of the Yarra River with predicted river levels during seasonal, 1/10 year and 1/100 year floods.

flooding in the summer of 2022, in which water levels rose to an average of 2.5m in November, with daily levels up to 5 meter average (Melbourne Water, n.d.-a).

Day-to-day dynamics

Besides seasonal and monthly variation, the river also experiences some variation in water levels from day to day. At Alphington, in February 2025 (summer), the river expressed a 20cm total range in river levels. In September 2024 (winter), this range was 50cm (Melbourne Water, n.d.-a), giving a first indication of an experienceable difference in daily dynamics between winter and summer.

Tidal influence in Yarra River

At the Merri Creek confluence to the Yarra River, a waterfall artefact (Dight Falls) forms a transition from the midstream to downstream reaches of the Yarra River. This boundary separates the brackish water influenced by tidal dynamics from Port Phillip Bay from the freshwater non-tidal upstream. Downstream of Dight Falls, a clear pattern in daily river fluctuation of about 0.5m is revealed when river levels are measured hourly; this pattern is not observed when performing similar measurements upstream of Dight Falls (Melbourne Water, n.d.-a). These findings indicate that the dynamics of the Yarra River can be visually observed within the timespan of 24 hours.

Altered dynamics

Water extraction

Since colonisation, approximately 1,300 surface water diversion licenses have been issued across the Yarra Catchment, allowing water to be taken for agricultural irrigation, golf course maintenance, industry and drinking water supply (Melbourne Water, n.d.-b). In 2016–17, 58% of the annual inflow into the Yarra Catchment was recorded leaving the basin. Comparing this to unregulated rivers, in which

the annual outflow can be 90 to 100%, this indicates a decrease of annual river volume of up to 42% (Commissioner for Environmental Sustainability Victoria, 2023).

Climate change

Climate change is increasingly influencing the seasonal dynamics of the Yarra River. The Victoria region is experiencing a shift toward warmer and drier conditions with a decrease of around 9% in rainfall since 1994, particularly during the cooler months (April to October), which historically contributed the most runoff to the river system (Bureau of Meteorology, 2024).

While the overall precipitation for summer periods is largely unchanged, rainfall is becoming more concentrated in short, high-intensity events (Bureau of Meteorology, 2024). These rain bursts increase the risk of flash flooding, even with average annual rainfall decreasing, and disrupt the river's seasonal dynamics. In urbanised sections of the catchment, where much of the landscape is sealed and thus lacks infiltration capacity, flood vulnerability increases (Bureau of Meteorology, 2024).

A severe flood event is predicted to take place once every 100 years, with the extent of its flood boundaries covering trails, agricultural land, sports fields and infrastructure. At Alphington, the boundary of this predicted flood is approximately 17.5 meters. This indicates that the flood event of 2022, with the river level being roughly 5 times higher than average, was still 3.5 times smaller than the predicted centennial flood. As the 2022 flood already caused major disturbance to infrastructures and urban life, this highlights the importance of substantial improvement in (storm) water retention capacity throughout the Yarra catchment and Yarra river system.

Figure 10. Flooding of golf courses on the urban floodplain in October 2022. Source: (FlyHigh Visuals, 2022).

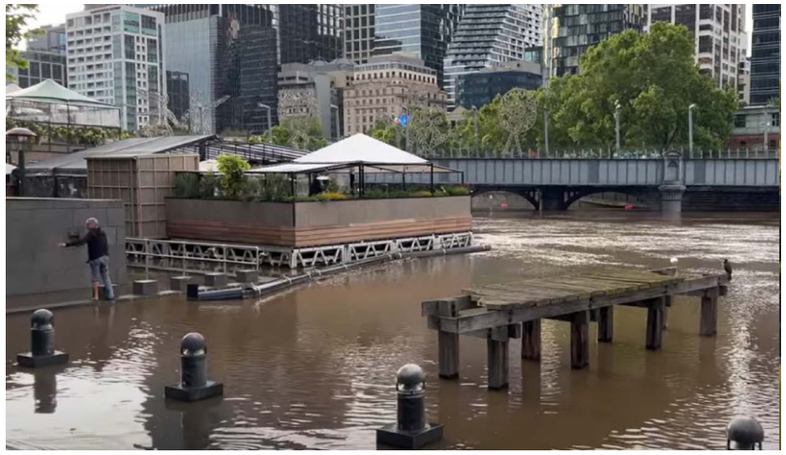


Figure 11. Flooding in Melbourne CBD in October 2022. Source: (FlyHigh Visuals, 2022).

Dynamic affected ecology

Due to the altered river baseflow by water extraction and the climate change-related drying trend, floodplains and billabongs now flood less frequently than in pre-colonisation times. For example, the Bolin Bolin Billabong, which historically filled almost annually, is now inundated only every three to four years (Commissioner for Environmental Sustainability Victoria, 2023; Greet et al., 2023). These Billabong habitats depend on seasonal inundation to support aquatic vegetation and provide breeding grounds for a large variety of species. Without this frequent filling, the riparian zones and billabongs are at risk of drying up and losing their habitat value for species like the Growling Grass Frog (Ranoidea raniformis), which is currently listed as endangered (Yarra Riverkeeper Association, 2021).

The change in flow dynamics additionally influences species dependent on flow-related cues. For instance, the Australian grayling (Prototroctes maraena) requires flow pulses to trigger its migration downstream for breeding, while River Red Gums (Eucalyptus camaldulensis) rely on frequent partial submersion to maintain their health and reproductive cycles (Yarra Riverkeeper Association, 2021).

Environmental watering

Melbourne Water (the local waterboard) implements seasonal environmental watering to support the health of the Yarra River and its connected ecosystems. Water is released from upstream reservoirs (like the Upper Yarra and O'Shannassy) to mimic natural flow regimes at strategically chosen moments, maintain riparian habitat by reactivation of the billabong habitats and facilitate dynamic dependent ecology, like the downstream migration of the Australian Grayling. They are always performed in a way that maintains river levels below flood risk (CES,2023). Additional strategies of reconnecting billabongs to the Yarra River through targeted water releases have also proven to be effective in increasing the frequency of inundation, with reported increased aquatic native vegetation cover, and an increase in frog and birdlife (Heard et al., 2018).

3.3. Human connection with the Yarra River

Current opportunities for river engagement

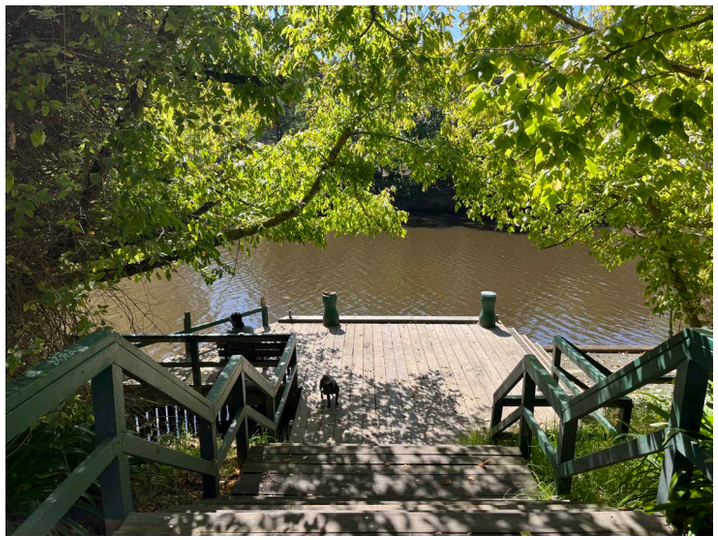
Even though the riparian zone of the Yarra River holds potential for recreational use, partly due to its linear structure and proximity to dense urban areas (Kondolf & Pinto, 2017; Pinto, et al., 2023), the recreational use is currently limited to linear movement along shared paths like the Main Yarra Trail. On this trail, activities like cycling, jogging, and walking dominate, with little space for slow recreation (CES, 2023).

When spaces for slow recreation do exist along the Yarra River, they often lack the visual or physical connection to the river itself, a missed opportunity in stimulating engagement with the river system. Some examples exist of places along the river that do promote this engagement, but the number of them is limited, and they are often hard to find or reach. On-site conversations with users of public spaces within the riparian corridor confirm this observation.

Aylish (30), on the question whether these types of spaces are visited by many citizens, explains: "*Well actually, I feel like not many people know about it, so it doesn't get too crowded, which I like.*" (personal communication, 2025).

Users of these spaces do, however, express a clear appreciation and desire for (more of) these spaces.
"*I love coming down here with my little girl [dog], it's my escape from the city. I work night shifts in a bakery. You come down here and it's like you're in a different world*", explains Oscar (47), a Melbourne citizen, while spending time on a river platform (personal communication, 2025).

Additionally, Sarah (35), while taking a rest from bike riding on a hot day, explains:
"I grew up in the country, always



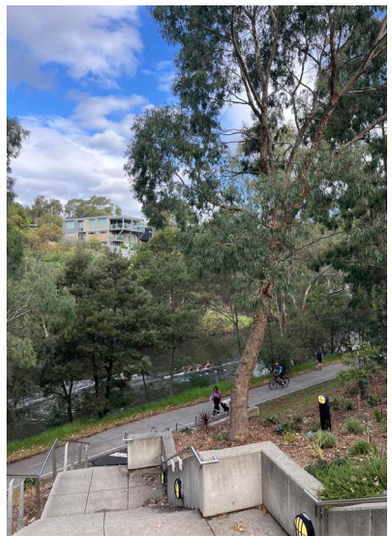


Figure 12 & 13. Opportunities to access the river and river banks through recreational trails and river platforms.

very close to nature. In the city, I feel like there are definitely not enough places close to nature. ... I would love more places like this along the river." (personal communication, 2025).

Experiencing Yarra's dynamics

The current experience of river dynamics and associated flood events is predominantly negative (Davison, 2022). Flood markers within the public realm in urban context tend to reinforce this perception, indicating disturbance and warning visitors to 'keep out' during high water levels. One reason floods are poorly understood is that they remain largely invisible to the public until the moment they cause disruption. Rising water levels often go unnoticed, especially in areas lacking visual or physical connection to the river, until they reach the top of the riverbanks and trails and urban infrastructure becomes inaccessible.

Beyond this lack of public awareness and support for the river's needs, it additionally reflects a missed opportunity for human-river interaction. Interacting with a river's natural fluctuations has been shown to promote human wellbeing and foster stronger connections to the natural system (Wantzen et al., 2016).

Creating a public understanding of the importance of the Yarra River dynamics can therefore create support for riparian regeneration and other strategies to improve the system's wellbeing. Potential to take the development of recreational spaces along the river as an approach to achieving more visual and physical engagement with the river. In this way, engaging with the river system can be seen as a form of recreation and provides the opportunity for a more positive connection to the dynamics of the river.

Figure 14 & 15. Signage along the Merri Creek and Main Yarra Trail warning visitors for flood events.

INNER CITY ZONE

DENSE SUBURBAN ZONE

SUBURBAN PARK ZONE

LOW RURAL RANGES

Legend

- Forest
- Shrubland
- National parks and reserves
- Privatized land
- Golfcourses
- Built-up area
- Port Phillip Bay
- Public parks and gardens
- Main infrastructure
- Trails
- Yarra River

0 1 2 3 km

Figure 16. Urban stretch of the Yarra River. A large part of land surrounding the river is taken up by privatized land or golf courses.

Map made by author, based on data from:

DataVic, Melbourne Water Open Data Hub, NEXTGIS, DEECA's Spatial Data, GoogleEarth, Vicmap

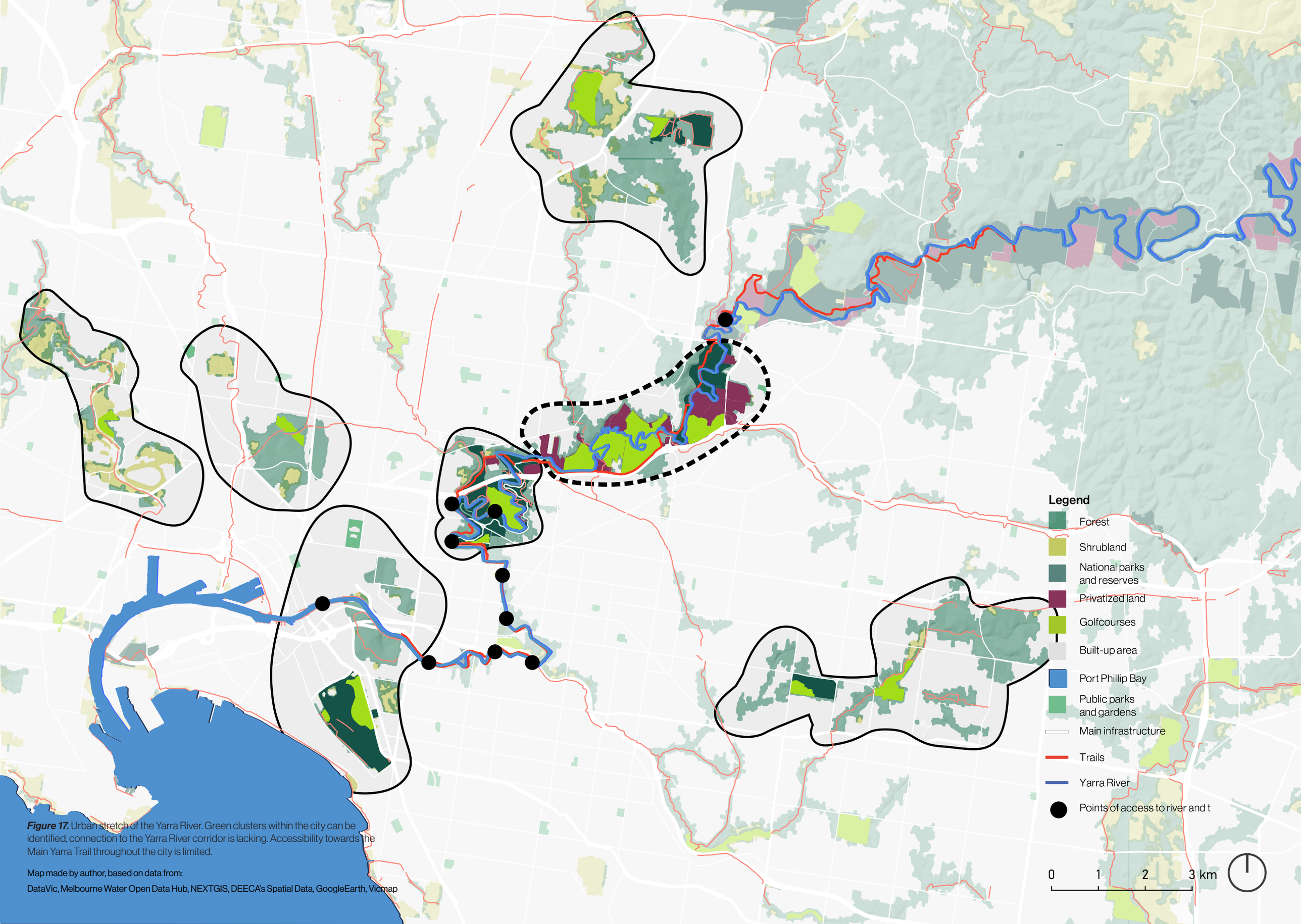


Figure 17. Urban stretch of the Yarra River. Green clusters within the city can be identified, connection to the Yarra River corridor is lacking. Accessibility towards the Main Yarra Trail throughout the city is limited.

Map made by author, based on data from:

DataVic, Melbourne Water Open Data Hub, NEXTGIS, DEECA's Spatial Data, GoogleEarth, Vicmap

3.4. Challenges & Opportunities

The Yarra River functions as a connected linear system, both through the continuity of its riparian corridor and the flow of its water. However, changes in riparian land use have disrupted this connectivity. Agricultural practices and urban development have fragmented riparian habitats, weakening the ecological corridor and reducing the system's natural buffering capacity.

At the same time, the river's flow dynamics have been significantly altered by extensive water extraction and the impacts of climate change. Baseflows have decreased, while short-duration, high-intensity rainfall events have become more frequent, raising the risk of flash flooding downstream. The disturbance caused by relatively moderate flood events in recent years highlights the need to improve (storm)water retention throughout the catchment. Because the river operates as a connected system, improvements in upstream retention help reduce downstream impacts. However, the increasing intensity of rainfall also calls for substantial buffering capacity within the lower reaches of the river system.

Lower baseflows have reduced the frequency and extent of floodplain inundation, causing many billabongs to dry out or disappear entirely. As a result, habitat conditions in these areas have changed significantly, putting numerous plant and animal species at risk. While environmental watering programs aim to mimic seasonal flow patterns and support regeneration, these efforts remain limited in both scale and impact.

Within the urban reach, opportunities for physical and visual connections with the river remain constrained by naturally steep banks, shared trails, and a lack of purposefully designed public spaces along the water's edge. However, like many urban rivers, the Yarra River holds unused recreational potential and existing areas that support human interaction with the river are already highly valued by local users. Expanding such spaces could allow more people to engage with both the seasonal and daily dynamics of the river. This has the potential to strengthen public wellbeing and build broader support for the river's long-term care and regeneration.

In summary, regenerating the Yarra River's riparian zone offers the potential to reconnect the ecological corridor, increase water retention capacity, reduce flood risk, improve water quality, and foster meaningful human engagement with the river. A strategic framework that keeps these dynamics in mind, can help re-establish the river as both a functional ecological corridor and a valued public landscape.

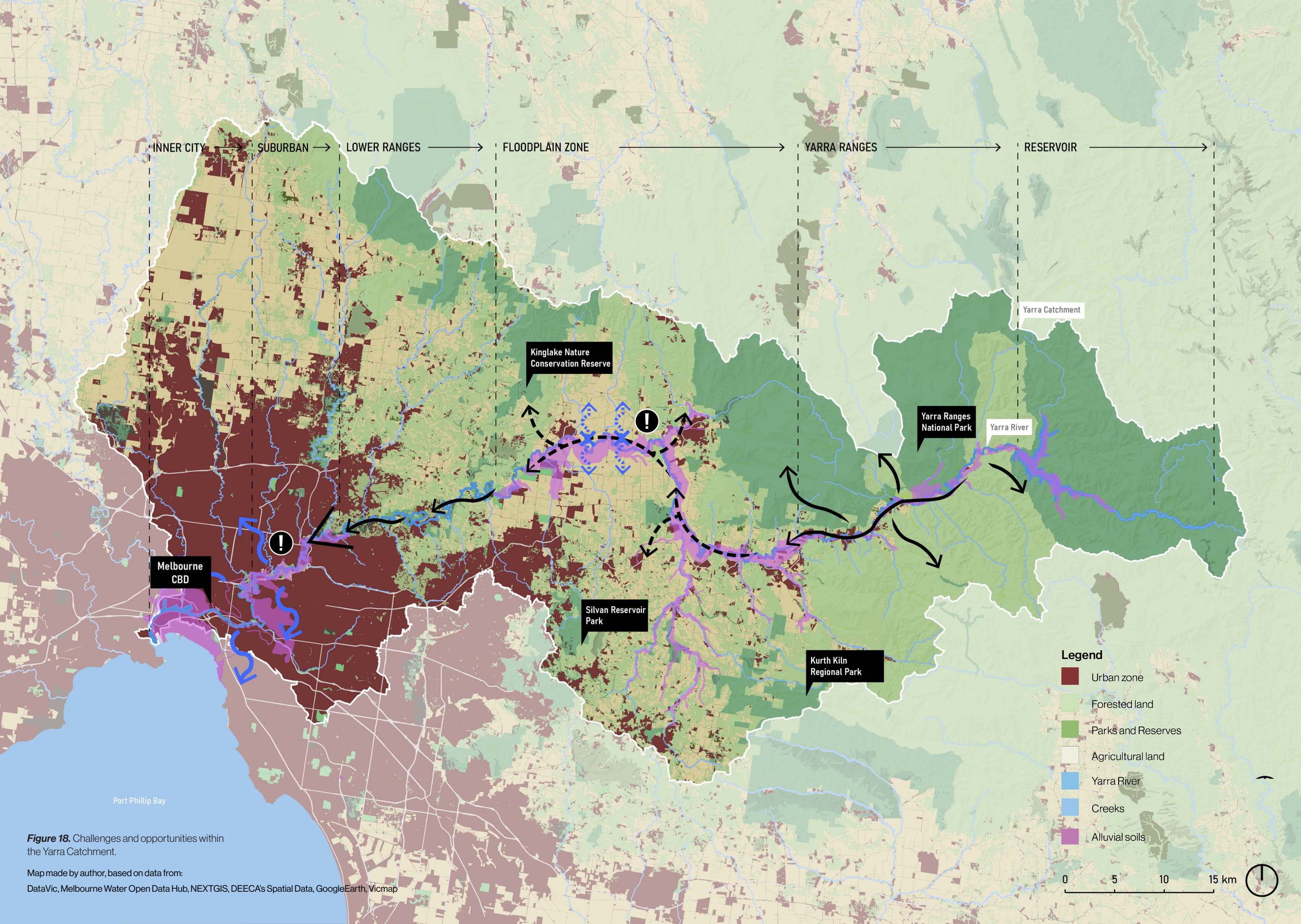


Figure 18. Challenges and opportunities within the Yarra Catchment.

Map made by author, based on data from:

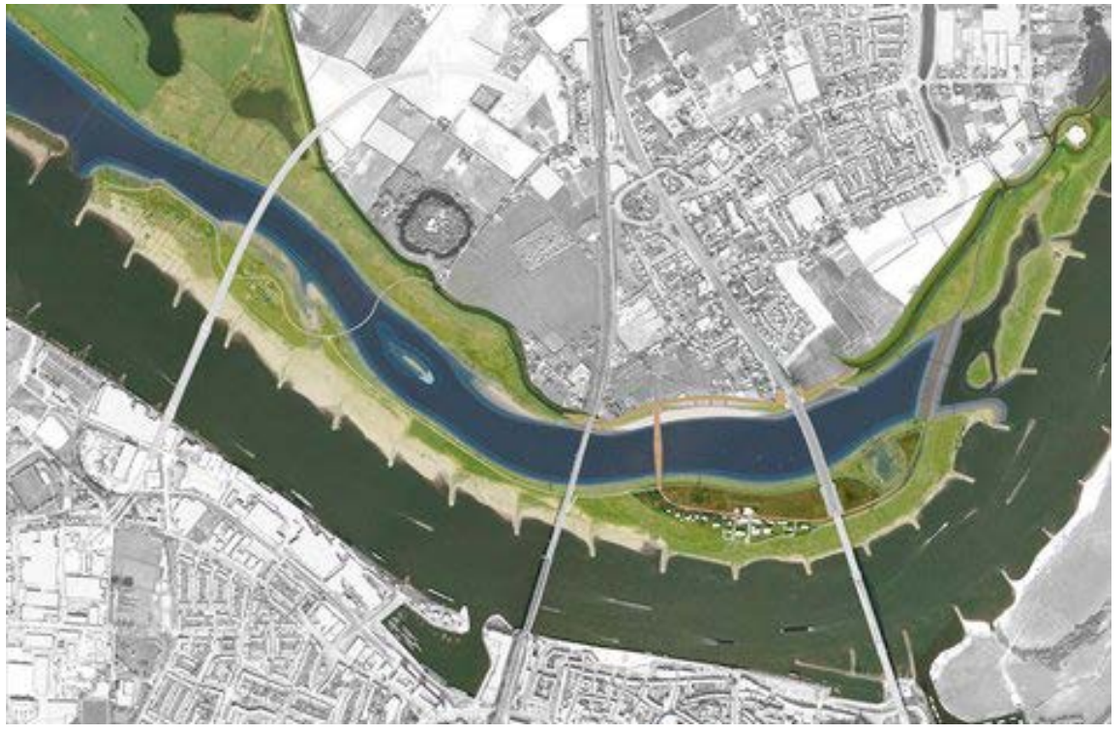
DataVic, Melbourne Water Open Data Hub, NEXTGIS, DEECA's Spatial Data, GoogleEarth, Vicmap

04 Design Strategies & Principles

The previous chapter described the challenges within the Yarra River system and identified opportunities for regenerating its riparian zone to enhance ecological resilience and human engagement. This chapter introduces a strategic framework for regeneration that spatially translates the systemic understanding from Chapter 3 and forms the foundation for local-scale design development in Chapter 5.

4.1. Learning from precedents

Precedent project on other river system facing similar challenges have informed the development of the strategic framework and associated design principles for the regeneration of the Yarra River riparian corridor.



Room for the River – Nijmegen

Figure 19. Ruimte voor de Waal, Source: (HNS, 2016).

The Room for the River project in Nijmegen demonstrates how flood protection and public interaction with the river can be combined through spatial interventions. In this case, the floodplain was enlarged and reimagined as an accessible urban parkland. The project draws upon the vision of Plan Ooievaar, a strategy developed in the 1980s to restore ecological function within the Dutch river landscape (Bruin et al., 1987). Plan Ooievaar proposed giving rivers more space by reconnecting them to their floodplains, thereby allowing processes such as erosion, sedimentation and seasonal flooding to shape the land. It introduced the idea of multifunctional land use, combining low-impact agriculture, grazing and recreation with ecological restoration. The notion that a dynamic, functioning river system can guide spatial strategy aligns closely with the approach taken in this project.

Isar River – Munich

Figure 20. Isar River. Source: (Urban Waters, n.d.).

The Isar River restoration in Munich combined flood risk reduction, ecological repair and urban amenity. Previously seen as a flood threat and channelised for industrial use, the river was disconnected from the city and its residents (Rossano, 2016). The restoration involved widening the floodplain, encouraging natural meanders and reintroducing dynamic forms to the river landscape. Low-gradient riverbanks and shallow sections supported physical access and recreational use. The use of riparian space as unprogrammed public realm proved successful in encouraging people to re-engage with the river. This precedent demonstrates that in dense urban settings, ecological restoration and public access need not be mutually exclusive, and that restoring function does not require returning a river to its pre-industrial state.

Figure 21. Platform on the River Aire. Source: (Atelier Descombes Rampini. n.d.).

River Aire – Geneva

For the River Aire project in Geneva, Descombes took the channelised river as a point of departure, rather than attempting to restore a historic condition (Descombes, 2018). He argued that striving for an 'original' state overlooks the cultural and physical changes already embedded in the landscape. The project instead created space for natural processes to shape the landscape within clear boundaries. Descombes described this method as 'making and not making', in which formal gestures reveal dynamic systems and foster new perceptions of the river. Framed interventions along the corridor activated the user experience through perception, engagement and provocation. These strategies are relevant to the Yarra River project, which similarly engages with a modified river landscape.

Riparian (billabong and floodplain) regeneration

Several local interventions along the Yarra River have tested methods for restoring floodplain and billabong ecologies. The Yering Billabong project reconnected 60 hectares of floodplain to Olinda Creek via a controllable water gate. During periods of high rainfall, the gate opens to allow inundation, improving biodiversity and water quality. Weed control and revegetation with native shrubs and pioneer wetland species support ecological regeneration. During drier periods, the gate remains closed to retain water in the landscape (Yarra Ranges Council, n.d.).

At Banyule Billabong, stormwater is redirected into the site via an inlet and constructed wetland, facilitating more frequent inundation (Heard et al., 2018). This has proven effective in improving ecological conditions. Weed control and native planting during dry phases are essential to support long-term success.

4.2. Strategies

Within this research, a strategy is defined as a spatial intervention that contributes to a broader vision. The overall goal of regenerating the Yarra River's riparian corridor to reconnect the ecological network, support river dynamics and enable human engagement is translated into four strategies. Criteria for applying these strategies along the river are spatially defined and organised into upstream, midstream and downstream reaches, as outlined in Chapter 3.

Overarching principle: Indigenous value of the Yarra River

The strategic framework and related design responses will reflect an understanding of the Yarra River as a living entity, a view embedded in Aboriginal culture. A strategic vision informed by this lens balances ecological and hydrological resilience of the river system with human use and takes the overall health of the river system as the primary objective.

1. Riparian regeneration

Reclaiming the riparian zone and creating the conditions for riparian regeneration.

In which a functional riparian zone is defined as a riparian zone that:

- Provides habitat for a diversity of target species
- Is characterised by native vegetation and limited invasive species
- Retains water for extended periods following rainfall or flooding

The spatial extent for reclamation is derived from an overlay of 1-in-100-year flood risk, pre-colonial EVCs and soil mapping, representing the area needed to accommodate high water levels while supporting ecological function.

2. (Re)connecting habitats

Establishing a continuous habitat network by linking the riparian zone with nearby parks and reserves.

A functioning habitat network:

- Connects habitats either physically or through proximity to enable species movement
- Maintains consistent vegetation types and structures
- Offers multiple pathways between habitat nodes for resilience

The Yarra River is the primary drainage line within the Yarra Catchment, receiving flow from numerous creeks. These tributaries can serve as secondary ecological corridors, linking the river's riparian zone to surrounding green spaces. To do so, the regeneration of key creek corridors is essential.

3. Facilitating river dynamics and water retention

Increasing the frequency of riparian inundation and the landscape's capacity to hold water.

A resilient riparian buffer:

- Allows annual floodplain inundation
- Retains water within the zone for extended periods post-flood

This strategy is often paired with riparian regeneration, as water retention is closely linked to ecological and spatial conditions. The most suitable areas are those with minimal topographic constraints, such as midstream floodplains (currently used for agriculture) and downstream floodplains (often occupied by golf courses).

4. Enhancing visual and physical connection to the river

Creating a visually and physically engaging riparian landscape & river.

An engaging river landscape:

- Makes river dynamics perceptible and accessible
- Supports spatial and programmatic use within the riparian zone
- Exposes users to the range of riparian typologies and ecologies

This strategy is most applicable in downstream sections, where public access exists but spatial quality is often limited or underutilised.

4.3. Design Principles

Together, the four strategies define a spatial framework for riparian regeneration. To explore their practical application, they are translated into a set of design principles.

These principles are based on the precedents discussed earlier in this chapter and knowledge of the Yarra River system presented in Chapter 2. They are grouped per strategy.

These principles can be combined in different configurations depending on site conditions. Their application is explored through mapping, sketching and visual design testing in the following chapter.

STRATEGIES

Riparian regeneration

Reclaiming the riparian zone and creating the conditions for riparian regeneration

(Re)connecting habitats

Connecting the riparian zone to surrounding parks and reserves

Facilitate water dynamics and retention

Increasing the riparian flooding frequency and water retention capacity

Improve visual and physical connection to river

Creating a visually and physically engaging riparian landscape & river

DESIGN PRINCIPLES

Target species define (spatial) conditions

Continuous vegetation type and structure

Revegetation pattern based on existing vegetation

Creek corridors ecological activation

Hybrid land-use forms on riparian zone

Alternative habitat connectivity routes

Excavate floodplain and billabong inlets

Sightlines and trails encourage slow recreation

Direct stormwater runoff onto the floodplain

Access to riverfront through slow banks

Activated banks through architectural artifacts

Reduce river bank gradient

Activating public space on riparian zone

Materiality as a tool to indicate transitions

Use the topography for passive flow on floodplain

Target species are selected to define appropriate habitat conditions. The aim is not to restore the system to its pre-colonial state, as ecological and climatic conditions have changed. Rather, the focus is on restoring functionality.

Pioneer species selected for revegetation are grouped per EVC:

Floodplain Riparian Woodland:
Eucalyptus camaldulensis, Carex appressa, Juncus flavidus, Goodenia ovata

Swamp Riparian Complex:
Melaleuca ericifolia, Bolboschoenus medianus, Triglochin procera, Leptospermum lanigerum

Plains Grassy Woodland:
Eucalyptus melliodora, Themeda triandra, Acacia dealbata

Figure 22. Target species and habitat requirements as a guideline for revegetation practices along the Yarra River.

Growling Grass Frog
Source: (Victorian Government, n.d.).

Platypus
Souce: (lilkanyongmail, n.d.).

River Red Gum
Source: (Treeproject, n.d.)

Superb Fairy-wren
Source: (Davis, n.d.).

Habitat type	Target species	Significance	Habitat requirement
River + Riverbank	Platypus (*Ornithorhynchus anatinus*)	Absence is an early indicator of poor system health (water quality and aquatic habitat)	Intact stable banks Dense riparian vegetation Slow-flowing clean water
Billabong	Growling Grass Frog (*Litoria raniformis*)	Indicator of wetland health Restoration supports broader fauna	Semi-permanent wetland Varied edge conditions Aquatic vegetation
Understorey	Superb Fairy-wren (*Malurus cyaneus*)	Highly dependent on understorey for breeding and shelter	Dense understorey vegetation
Canopy	River Red Gum (*Eucalyptus camaldulensis*)	Foundational canopy tree on floodplain with cultural relevance. Supports fauna dependent on hollows	Requires bi-annual partial submersion Space for large roots Coexisting with understory species

Midstream

Upstream

Downstream

Port Phillip Bay

Legend

- Urban zone
- Forested land
- Parks and Reserves
- Agricultural land
- Yarra River
- Creeks

0 5 10 15 km

Figure 23. Upstream, midstream and downstream stretch of the Yarra River.

Map made by author, based on data from:

DataVic, Melbourne Water Open Data Hub, NEXTGIS, DEECA's Spatial Data, GoogleEarth, Vicmap

05 Design Exploration

With the strategies design principles defined, this chapter explores the translation spatial translation of these strategies and principles along the Yarra River corridor.

5.1. The systemic vision

The vision for riparian regeneration integrates strategies to improve ecological and hydrological functioning of the system, while also identifying zones with potential for enhanced human–river engagement.

Applying strategies on the Yarra River system

The four strategies introduced in Chapter 4 are applied across the river's upstream, midstream and downstream reaches, as defined earlier in Chapter 3. The result is a system-wide spatial vision for regeneration of the river system.

Legend

Strategies

- Riparian regeneration
- (Re)connecting habitats
- Floodplain water retention

Context

- Yarra River
- Creeks
- Forested land
- Parks and Reserves
- Agriculture
- Golfcourses
- Main infrastructure

Yarra Ranges National Park

Yarra River

Upper Yarra Dam

Yarra Ranges National Park

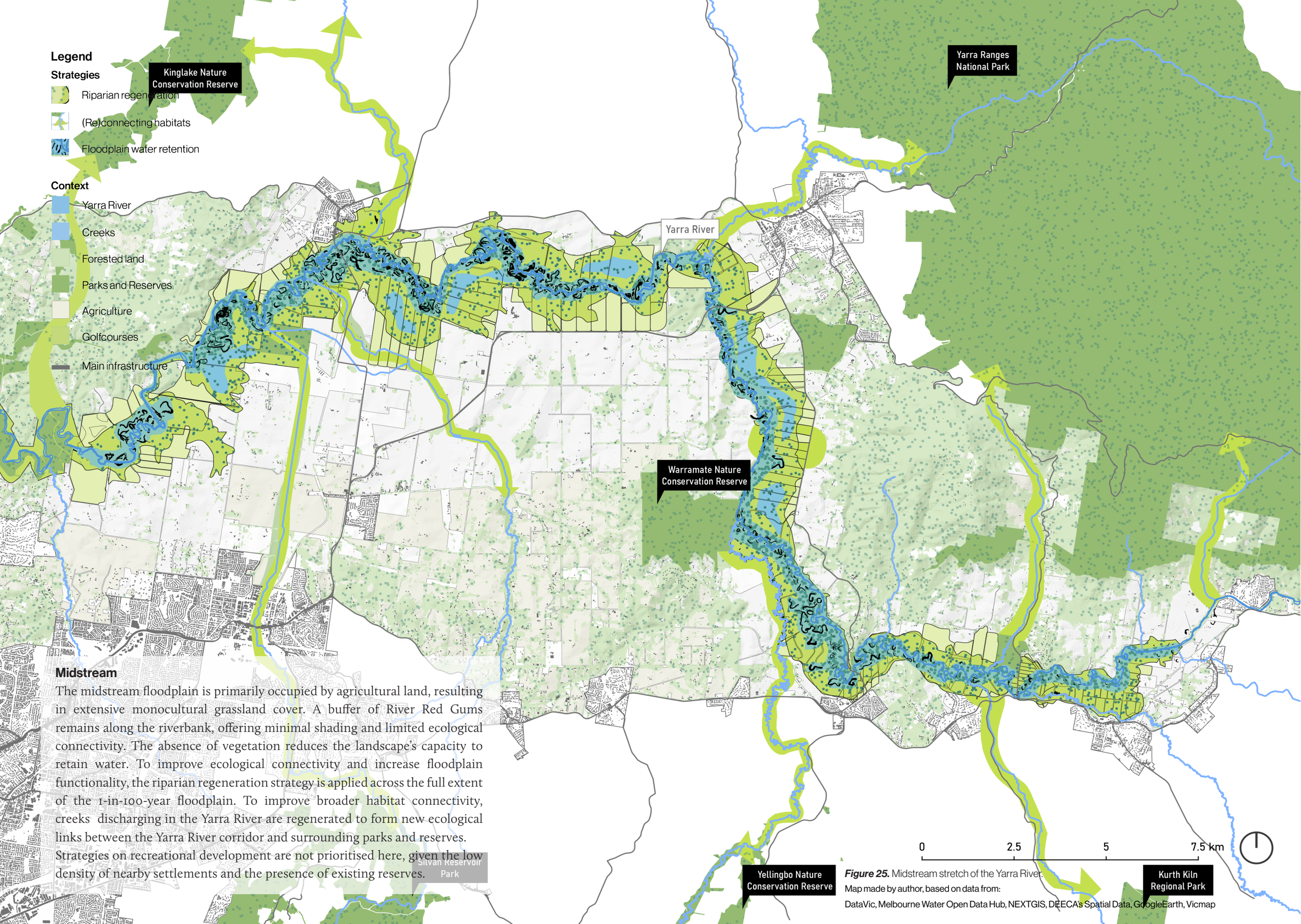
Warburton

0 2.5 5 7.5 km

Upstream

In the upstream section, the riparian zone is relatively narrow and closely bordered by the Yarra Ranges National Park. This ensures a high level of ecological connectivity. Due to topographic constraints, a floodplain is absent here, making the water retention strategy less relevant. The primary focus in this section is on maintaining corridor continuity, particularly where agriculture disrupts the riparian zone.

Figure 24. Upstream stretch of the Yarra River. Map made by author, based on data from: DataVic, Melbourne Water Open Data Hub, NEXTGIS, DEECA's Spatial Data, GoogleEarth, Vicmap



Midstream

The midstream floodplain is primarily occupied by agricultural land, resulting in extensive monocultural grassland cover. A buffer of River Red Gums remains along the riverbank, offering minimal shading and limited ecological connectivity. The absence of vegetation reduces the landscape's capacity to retain water. To improve ecological connectivity and increase floodplain functionality, the riparian regeneration strategy is applied across the full extent of the 1-in-100-year floodplain. To improve broader habitat connectivity, creeks discharging in the Yarra River are regenerated to form new ecological links between the Yarra River corridor and surrounding parks and reserves. Strategies on recreational development are not prioritised here, given the low density of nearby settlements and the presence of existing reserves.

Figure 25. Midstream stretch of the Yarra River.
Map made by author, based on data from:
DataVic, Melbourne Water Open Data Hub, NEXTGIS, DEECA's Spatial Data, GoogleEarth, Vicmap

Agricultural floodplain

Design testing through sketching and other methods of visualisation was conducted using section sketches and spatial configurations that combine various principles.

The design replaces mono-cultural agriculture with hybrid land uses that integrate ecological restoration. A 150-metre-wide riparian buffer zone supports species movement, especially bird migration, and provides water filtration and buffering. Outside this zone, sustainable agriculture is combined with revegetation practices with native pioneer species to aid in reducing runoff and pollution while radially extending the ecological corridor.

Floodplain inlets are excavated to support seasonal inundation. Combined with environmental watering practices by Melbourne Water, this approach increases retention capacity and reintroduces natural hydrological processes.

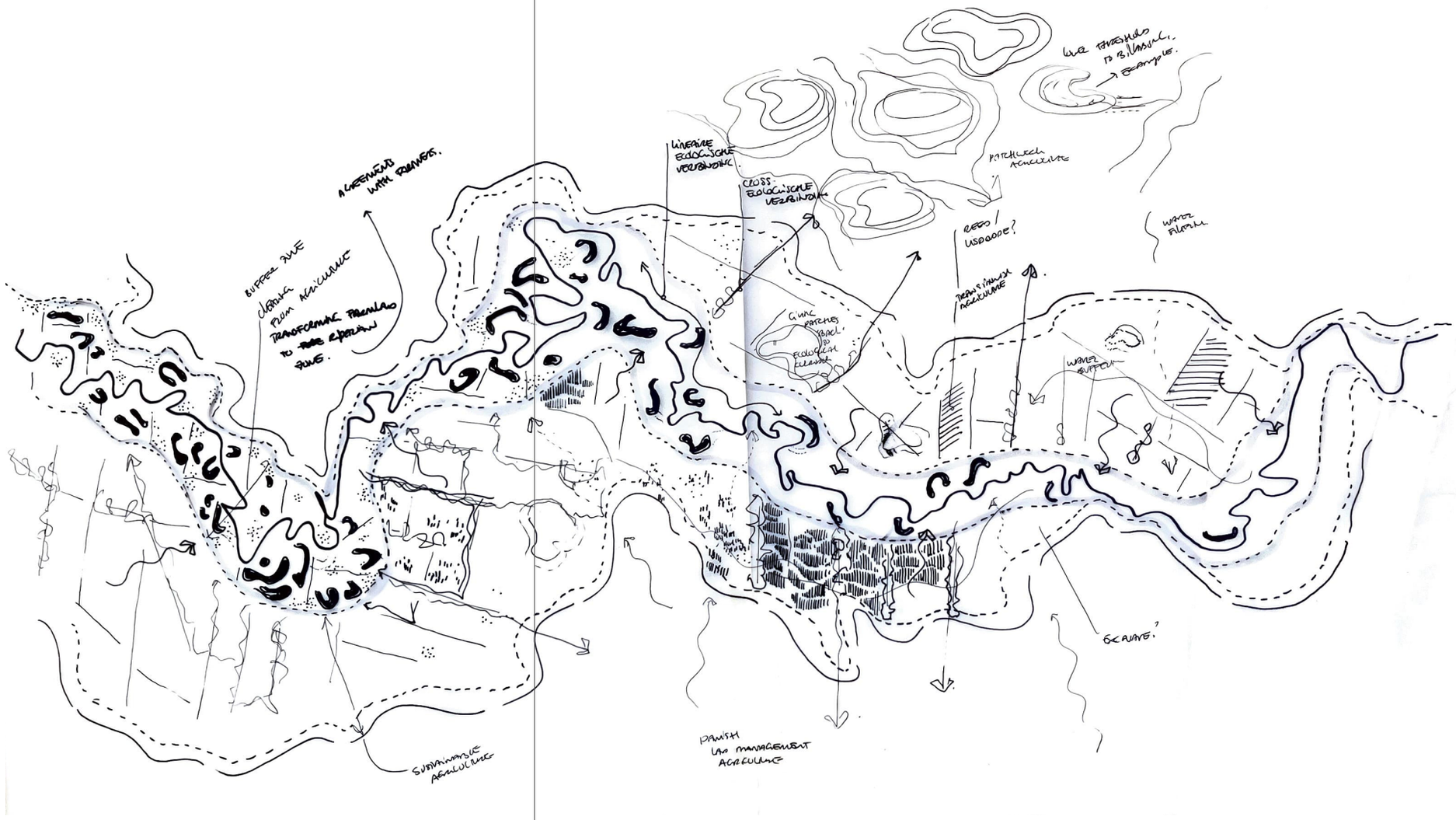


Figure 26. Concept sketch voor regeneration of the rural floodplain.

Target species define (spatial) conditions

Revegetation pattern based on existing vegetation

Hybrid land-use forms on riparian zone

Continuous vegetation type and structure

Alternative habitat connectivity routes

Creek corridors ecological activation

Use the topography for passive flow on floodplain

Excavate floodplain and billabong inlets

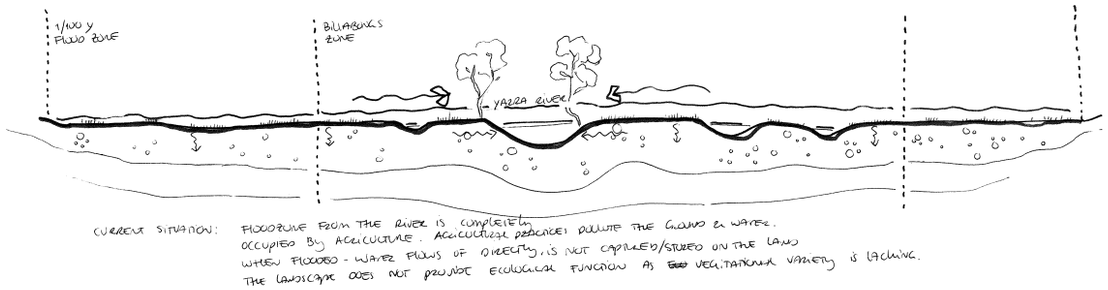


Figure 27. Preliminary sketch on the current situation of the Yarra River rural floodplain.

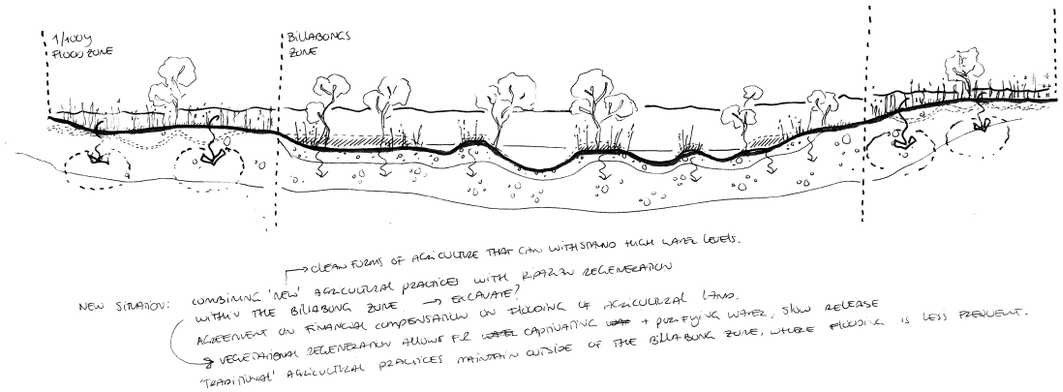


Figure 28. Preliminary sketch on the proposed situation of the Yarra River rural floodplain.

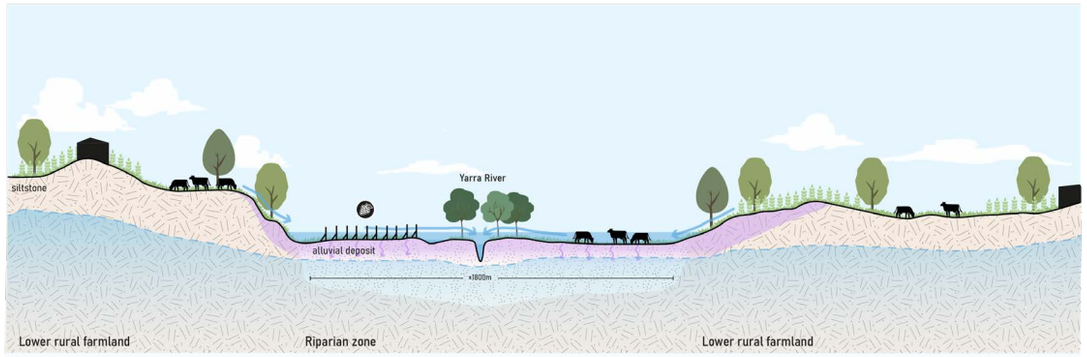


Figure 29. Floodplain in agricultural zone in current situation. Quick surface water runoff and water pollution are the result of polluting agriculture on the Yarra River floodplain and related clearing of (native) deep-rooted vegetation

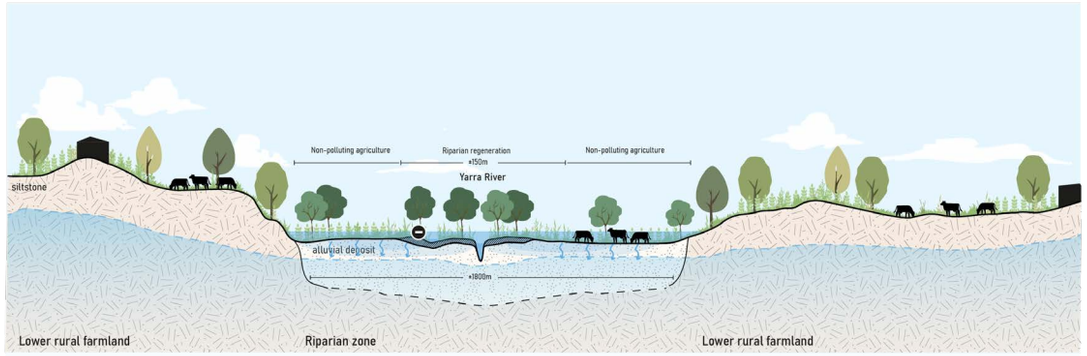


Figure 30. Floodplain in agricultural zone in proposed situation. Revegetation combined with sustainable agriculture on the Yarra River floodplain results in improved water buffering capacity and a reconnected ecological corridor.

Downstream

The downstream section of the Yarra River is currently framed by dense urban development, infrastructure and large topographic differences. The suburban floodplains currently used for golf courses provide potential for increased water retention and riparian regeneration, combined with recreational use. Strategies 1 and 3 are therefore applied throughout this floodplain. The riparian corridor is regenerated throughout the whole downstream stretch through revegetation practices and connects individual patches of parks and reserves to create a more resilient corridor. Tributary creeks and their riparian landscapes are regenerated to function as radial corridors linking the Yarra to surrounding green space. Along the river, existing access points from city to riparian corridor form the basis of a improved recretional network, with added recreational zones that support visual or physical connection to the river.

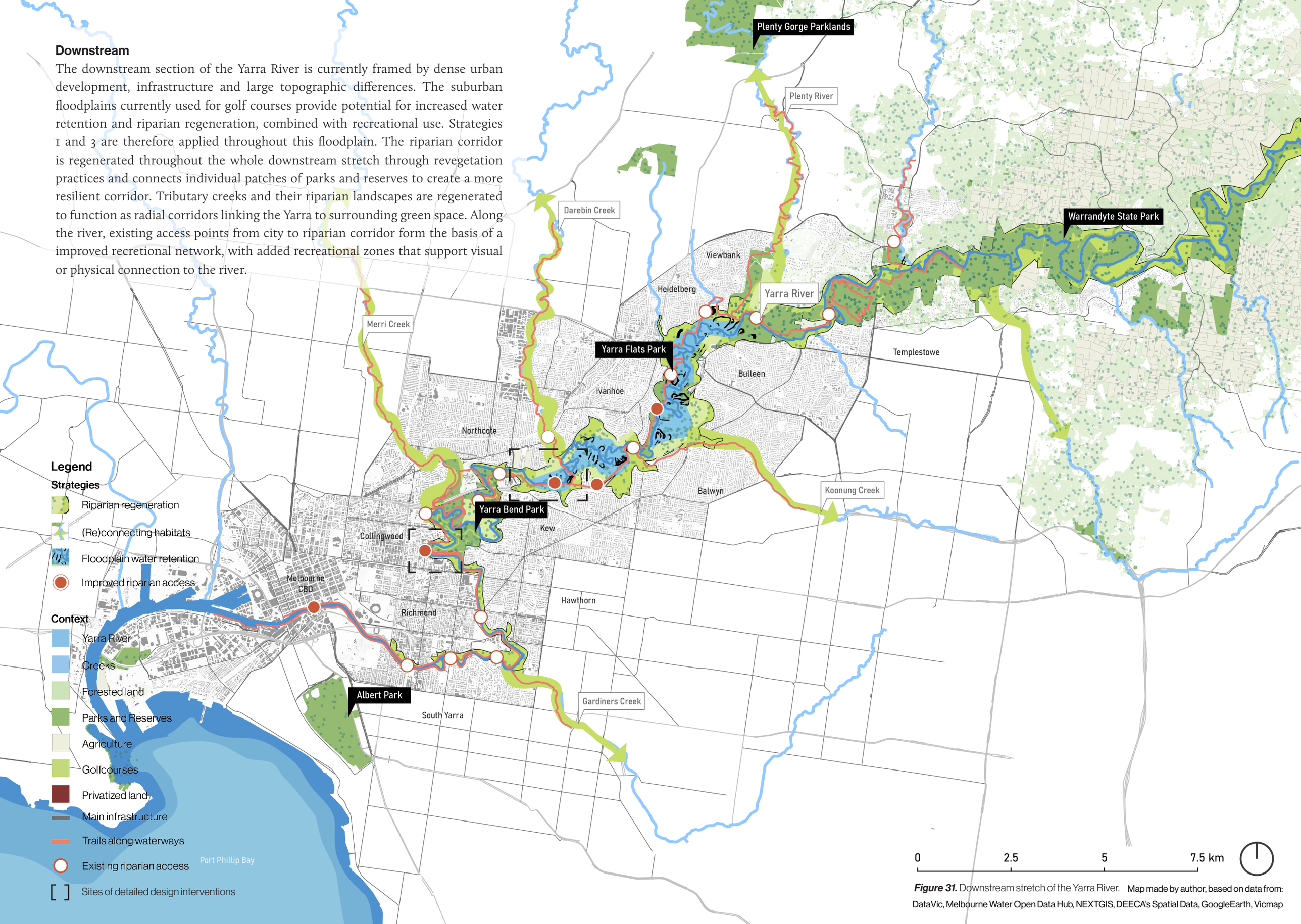


Figure 31. Downstream stretch of the Yarra River. Map made by author, based on data from: DataVic, Melbourne Water Open Data Hub, NEXTGIS, DEECA's Spatial Data, GoogleEarth, Vicmap

5.2. From framework to design

The systemic vision of the up-, mid- and downstream stretches of the Yarra River provides a strategic structure for regeneration. To understand how the four strategies translate to design interventions on local-scale, application of these strategies is explored in more detail on two sites within the downstream stretch of the river.

Floodplain Reserve

Current situation and potential

This urban floodplain, located within between the suburbs of Kew and Alphinghton, is currently used by privatized golf course, allowing limited public access. It's boundaries are accessible from the Main Yarra Trail and the site lies adjacent to the M3, a main freeway of Melbourne. The site is underutilised in its current form and offers potential for ecological restoration and recreation.

Remnants of billabongs and a buffer of River Red Gums still line the river's bank, but the surrounding grassland lacks mid-storey and understorey vegetation. The resulting absence of vertical structure reduces ecological value. Many of the billabongs are cleared of native vegetation and serve as irrigation ponds for the golf course. Public access is limited due to privatised land and trails that run along, but not through, the site.

Figure 32. Current situation of the urban floodplains: taken up by golf courses.

Figure 33. Proposed reclaimation and revegeation of the golf courses. Image depicts a situation during a period of no floodplain inundation.

Applied principles and design outcome

The design intervention responds to topography and predicted river fluctuations. The projected river levels of seasonal dynamics and flood events inform a network of trails that vary in elevation and type of access.

- Yearly flood level: Trails remain fully accessible, transitioning from ground-level paths to elevated walkways across lower situated areas like the permanent wetlands. These allow users to experience wetland vegetation and hydrological shifts.

- 1-in-10-year flood: Only the lowest trails become temporarily inaccessible.

- 1-in-100-year flood: Most trails are closed due to increased water velocity, reinforcing the floodplain's buffering role.

The new trails connect with the Main Yarra Trail to create a layered network for both fast and slow movement. Elevated areas within the floodplain are programmed as lookout points, but these also become inaccessible during the highest floods.

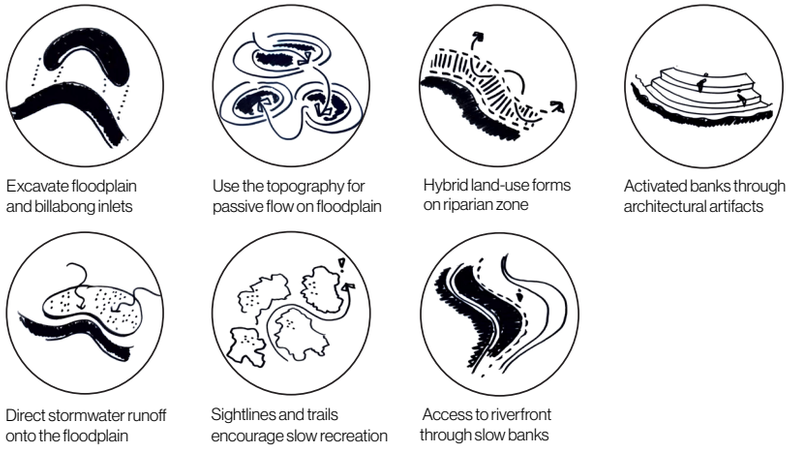


Figure 34. 1/10 flood prediction projected on the new floodplain.

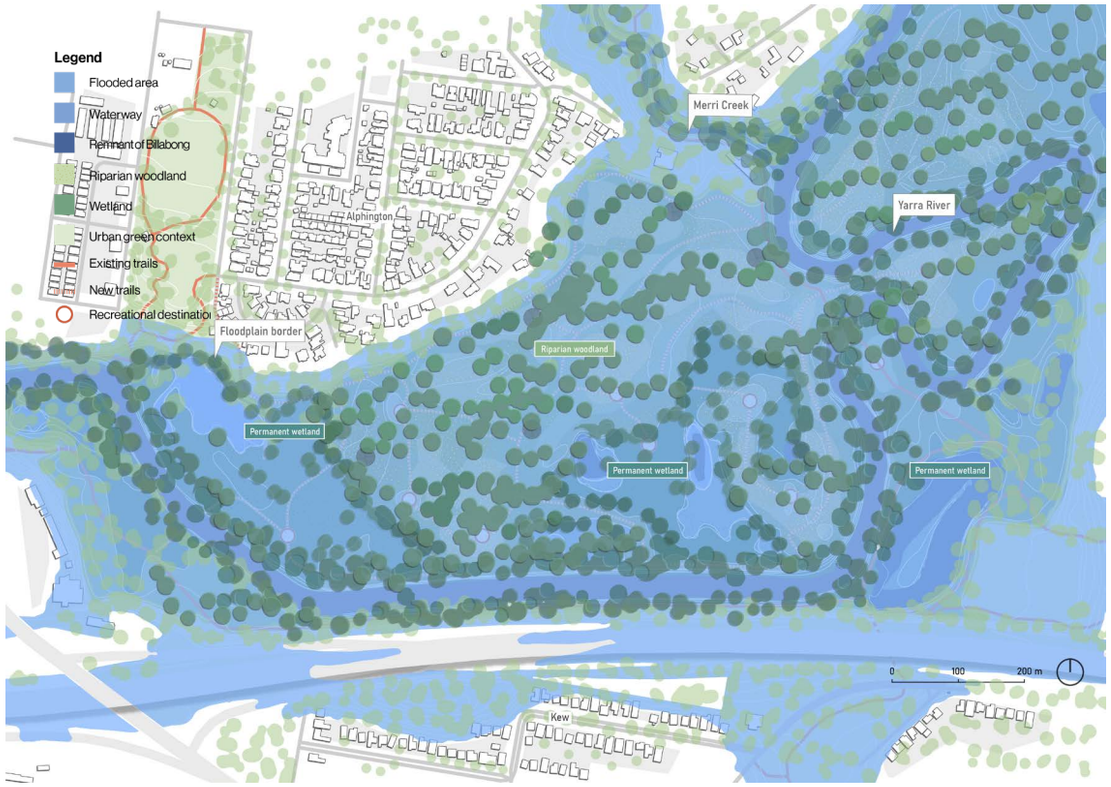


Figure 35. 1/100 year flood prediction projected on the new floodplain.

The Floodplain Reserve during seasonal flooding

During a seasonal flood, during which the river level rises approximaly 2m from everyday average, the floodplain is inundated, the newly formed wetlands fill up, and River Red Gums bordering the wetlands become partly submerged. All recreational nodes and destination points remain accessible. Visitors can enter the floodplain from the connected Main Yarra Trail, or through the in proximity situated parking lots on either side of the floodplain. Winding trails guide the visitors through the floodplain and provides experiences of open and closed spaces created by native vegetation gradients of riparian woodland species. Accessible platforms on the wetlands bring the visitor in direct contact with the landscape and river, and allows for unprogrammed interaction and connection with the river's dynamics.

Figure 36. Design proposal for regeneration of urban floodplain.

Map made by author, based on data from: DataVic, Melbourne Water Open Data Hub, NEXTGIS, DEECA's Spatial Data, GoogleEarth, Vicmap

Figure 37. Current (dried up) billabong wetland within the urban floodplain.

Figure 38. Proposed billabong wetland within the renewed floodplain reserve. A platform on the edge of the wetland allows for improved accessibilty and direct connection with the river's dynamics, riparian landscape and ecology.

Revegation on the floodplain

Ecological regeneration of the riparian corridor on this section of the river is concentrated along permanent wetlands and billabong edges. Pioneer species such as River Red Gum (Eucalyptus camaldulensis), Yellow Rush (Juncus flavidus), and Hop Goodenia (Goodenia ovata) are introduced through revegetation practices to promote habitat regeneration and reinstate vertical structure in the landscape. These revegetation practices are stretched towards Merri Creek, to form the starting point of a stronger radial network of connected habitats.

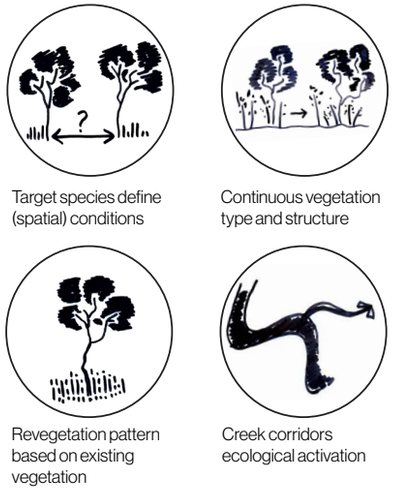


Figure 39. Recreational routing through riparian woodland.

Figure 40. Riparian border of gum trees along the Yarra River.

Figure 41. Seasonal river dynamics provide the right conditions for gum trees along the new wetland borders.

Figure 42. Replanting of the remainder of the floodplain is based on existing vegetation and focused on forming a more gradual gradient from ground cover to canopy.

Yarra Bend Park

Yarra Bend Park is currently a large public open space that borders the river near Melbourne's inner suburbs. Despite its proximity, the river is largely invisible and inaccessible due to steep, vegetated banks and topographic drop. The park consists mostly of grassland with sparse tree cover and lacks understorey or defined programmatic use.

River dynamics are not visible under normal conditions. Only during extreme floods does the river presence become apparent. However, this part of the Yarra experiences tidal influence, with daily fluctuations of around 0.5 metres.

Applied principles and design outcome

Rather than altering the river's course, the redesign of the Yarra Bend Park focuses on bringing the visitor to the river. A series of paths and stepped interventions are introduced to enable descent from the upper to lower banks. Thoughtful placement of trails allows for flexible routing and views of riparian vegetation. Tidal influences on this part of the river, can be experienced from the new boardwalks on the lower bank.

Target species define (spatial) conditions

Sightlines and trails encourage slow recreation

Materiality as a tool to indicate transitions

Revegetation pattern based on existing vegetation

Activating public space on riparian zone

Activated banks through architectural artifacts

Figure 43. Current spatial quality of the Yarra Bend Park.

Figure 44. Current spatial quality of the lower bank of the Yarra River at Yarra Bend Park.

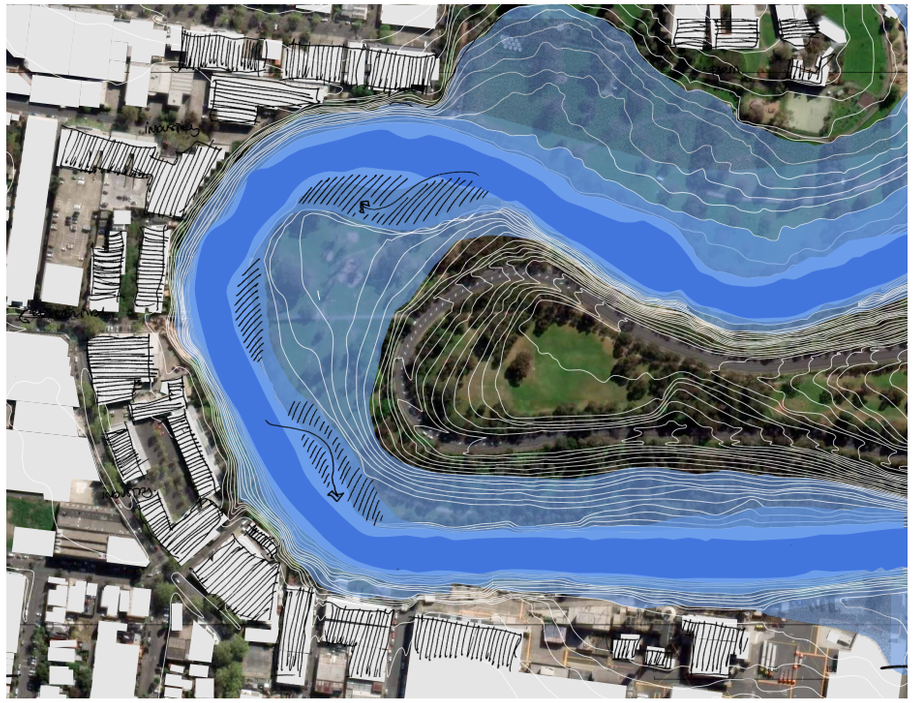


Figure 45. Projected river levels on the current situation of the Yarra Bend Park site.

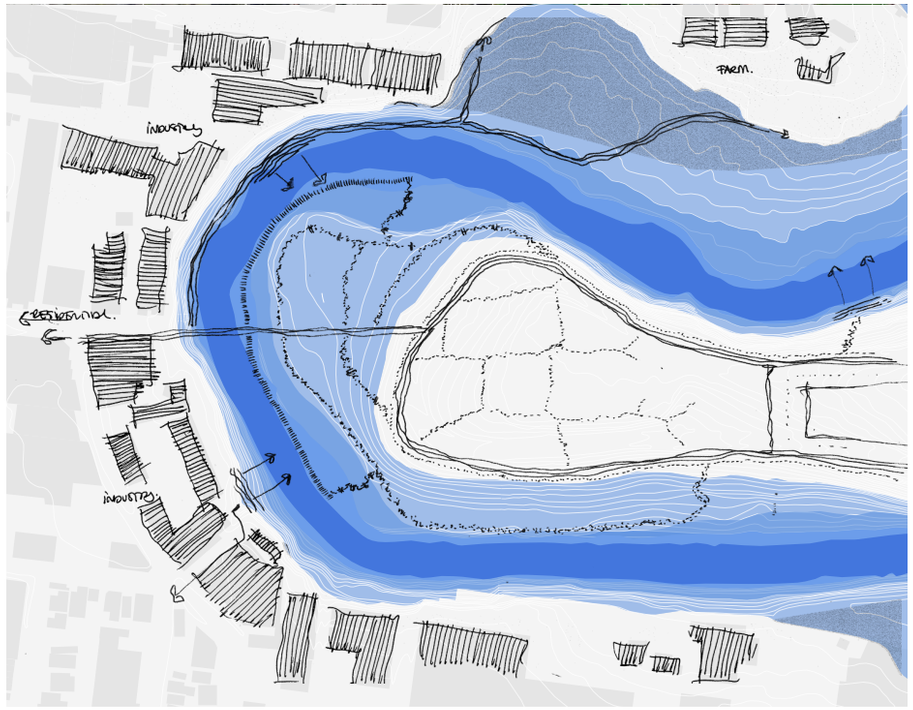


Figure 46. Proposed recreational routing through the Yarra Bend Park and along its upper and lower banks.

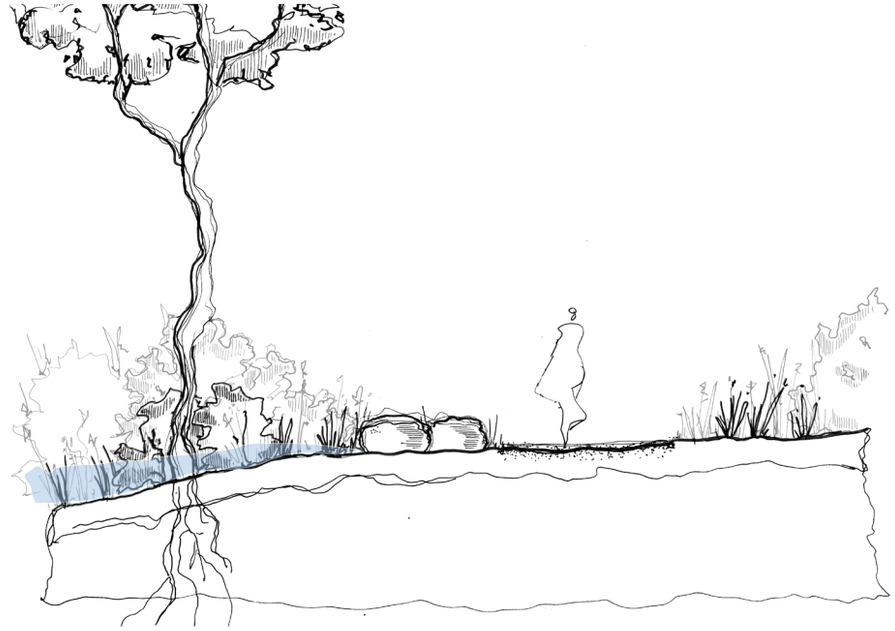


Figure 47. Sketched proposal for redesign of trails within the park and revegetation with native understorey species to improve vegetation gradient.

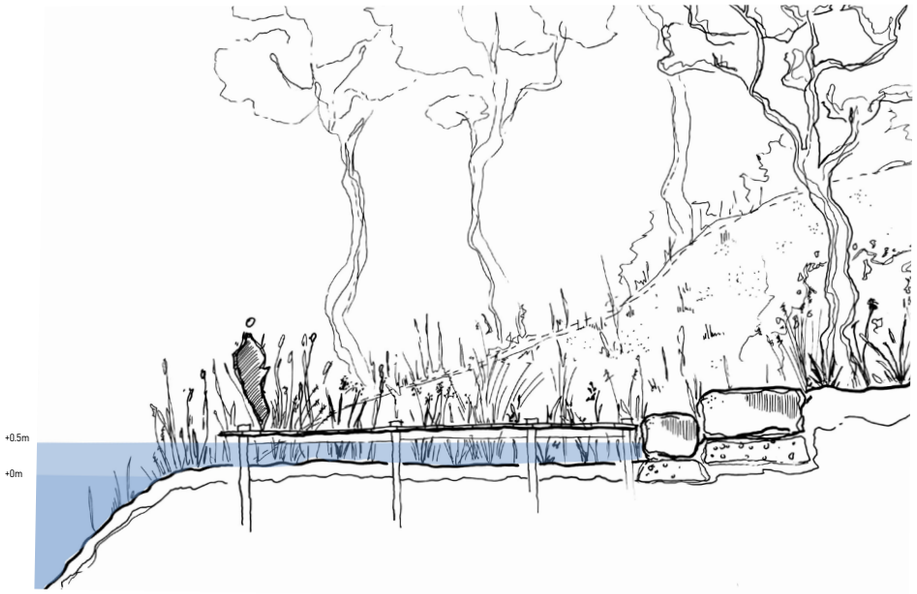


Figure 48. Sketched proposal for boardwalk on the lower bank of the Yarra River to allow for closer interaction with the river's dynamics.

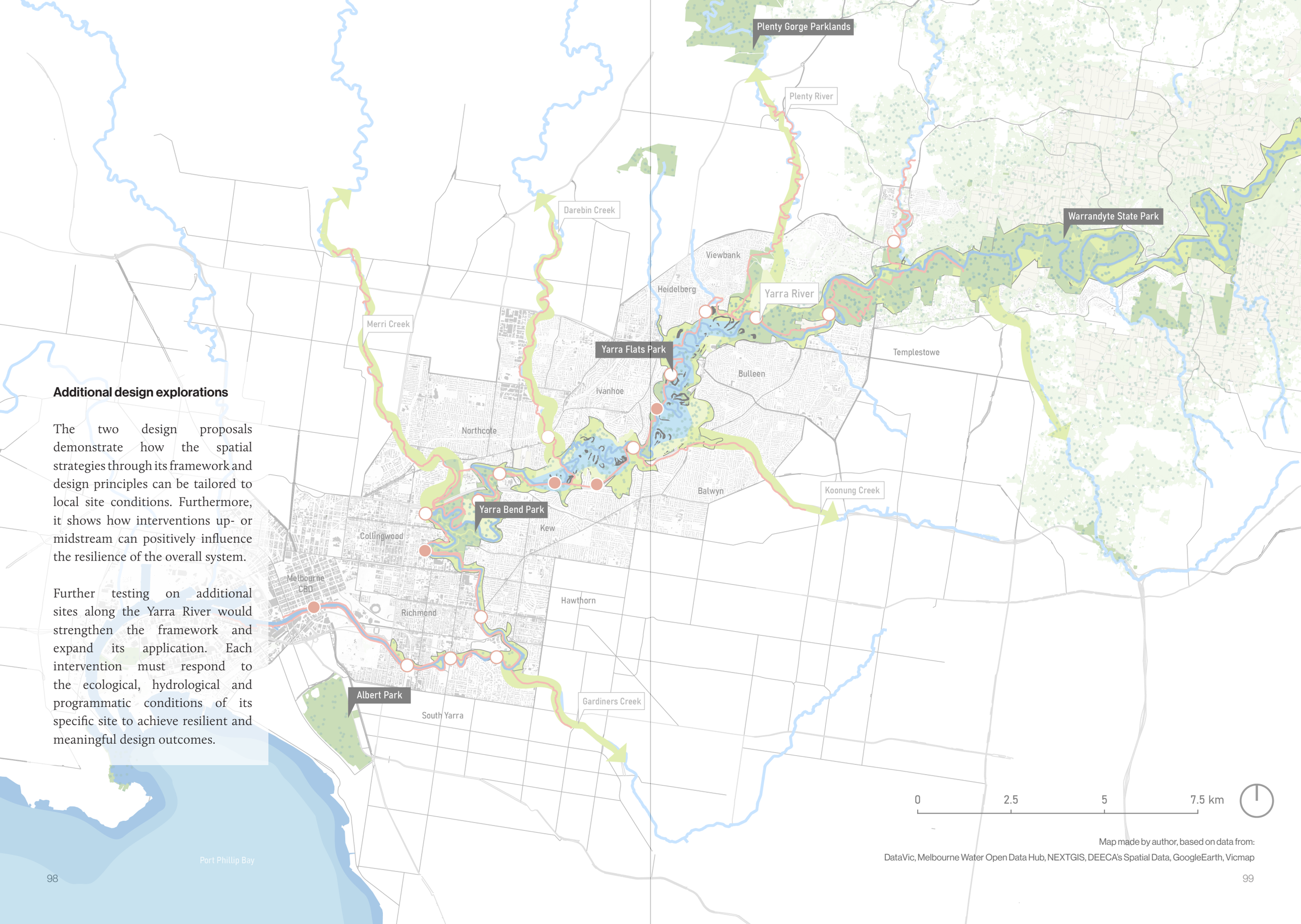
Figure 49. Current lower bank of the Yarra River at Yarra Bend Park.

Figure 50. Proposed lower bank at the Yarra River at Yarra Bend Park.

Additional design explorations

The two design proposals demonstrate how the spatial strategies through its framework and design principles can be tailored to local site conditions. Furthermore, it shows how interventions up- or midstream can positively influence the resilience of the overall system.

Further testing on additional sites along the Yarra River would strengthen the framework and expand its application. Each intervention must respond to the ecological, hydrological and programmatic conditions of its specific site to achieve resilient and meaningful design outcomes.



Map made by author, based on data from:
DataVic, Melbourne Water Open Data Hub, NEXTGIS, DEECA's Spatial Data, GoogleEarth, Vicmap

06 Discussion

Restoring vs regenerating

This project takes the position that restoring the Yarra River riparian zone to a pre-existing condition is neither feasible nor desirable. Restoration implies a return to an original state, but climate, urban development, culture and land use have all changed significantly, making those conditions no longer appropriate or functional. Moreover, the landscape before colonisation was not untouched or 'wild', Aboriginal people actively shaped it through cultural practices and land management strategies, adapting it to their needs and those of Country. Therefore, it is not necessary to recreate an earlier landscape, but to regenerate it in a way that responds to current conditions and supports the underlying systems that still depend on it. The goal is to develop a river landscape that supports ecological processes, cultural values and recreational engagement in a way that builds long-term resilience. Even though Melbourne Water has taken steps to mimic natural river dynamics, and the strategies proposed in this thesis build on those efforts, the river's baseflow will remain lower than in pre-colonisation times, and the riparian zones will flood less frequently. Combined with a significantly altered climate, this makes full restoration of Ecological Vegetation Classes (EVCs) neither possible nor desirable. Instead, the focus lies on regenerating and reactivating the ecological and hydrological function of the riparian zone.

Methodology

The Research Through Design method has proven valuable in this project, particularly through its use of iterative feedback loops between theoretical exploration, spatial analysis and design development. Here, design was not only the outcome but also a research tool to generate new knowledge about the system. This iterative process enabled continuous refinement

and adaptation, supporting a place-sensitive outcome.

The layered approach adopted in this research helped navigate the complexity of the Yarra River system. By separating the system into ecological, hydrological and recreational layers, the research was able to address specific challenges while maintaining a broader systems perspective. At the same time, it is important to acknowledge that this method represents a simplification. While it helps to structure and manage complexity, it cannot fully capture the dynamic and interconnected nature of processes on site. Real conditions will always be more nuanced, and the framework must therefore be applied with flexibility and a critical mindset.

Limited number of interviewees

The interviews conducted as part of this research offered meaningful insights into how people engage with the Yarra River and its riparian corridor. Although the number of participants was limited and the findings are not representative, they provide a first indication of the recreational needs and behavioural patterns of local users. They also highlight the value of accessible, experienceable river systems that support slow recreation. Further qualitative research could build on these findings to strengthen future design proposals.

Research and design outcome

The viability of the proposal is further supported by lessons drawn from peer-reviewed projects with similar aims, as discussed in Chapter 4. However, applying design principles from these precedents must be done with caution. Each case study operates under different hydrological regimes, cultural contexts, and geographical conditions, all of which influence how strategies perform. For this reason, further research is recommended to better understand the specific needs of communities along the Yarra River and ensure the suitability of interventions. Additionally, the current case study scope is limited. Future research should examine a broader set of precedents to inform design implementation.

The design principles developed in this thesis are intended to guide the translation of system-wide strategies into local interventions. However, they are not fixed solutions but conceptual guides, requiring adaptation to context-specific conditions, challenges, opportunities and goals. Currently, the toolbox of design principles covers a range of scales on which they operate. A more refined design toolbox could distinguish more clearly between regional strategies and those that apply at the local user scale.

Viability and transferability

The proposed strategic framework holds potential for transfer to other river systems facing similar environmental and social pressures. However, the approach developed in this thesis is highly context-specific, based on detailed spatial, cultural and ecological knowledge of the Yarra River corridor. The transferability of the framework and design principles must therefore be carefully assessed and adapted to ensure ecological relevance in different settings. Future research might explore how these principles perform under different climatic, ecological and socio-political conditions.

The proposed outcomes, including the system-scale vision and detailed site interventions, require further evaluation to assess their long-term effectiveness. Peer review can provide valuable feedback, but additional testing through modelling or small-scale implementation is recommended. Pilot projects, supported by long-term monitoring, could help evaluate whether the interventions meet their goals of ecological regeneration, flood resilience and public engagement.

Policy integration and stakeholder engagement

Successfully implementing the proposed strategic vision will require the integration of policies and parties across a wide range of sectors. Engagement with a wide range of stakeholders with diverse and sometimes conflicting interests is to be expected. Understanding stakeholder needs will be essential in the implementation of a resilient and widely supported river regeneration vision. This highlights the need for a strategic vision that acknowledges these interests while continuously communicating the broader benefits of a regenerated riparian system.

Recommendations for future research

A key opportunity not fully explored in this project is the integration of the Yarra River's riparian zone into Melbourne's broader green and blue infrastructure network. Understanding how the corridor connects with adjacent ecological and recreational systems could strengthen its spatial relevance at the metropolitan scale and amplify its impact. This offers a clear direction for future research. If this proposal is taken toward implementation, collaboration with Traditional Owners must be prioritised. As the river holds deep-rooted cultural value, acknowledging and using knowledge from Traditional Owners on both caring for and working with this system is both essential and beneficial in ensuring a well-implemented and culturally sensitive project. For example, when considering the use of fire, which plays an important and highly effective role in (cultural) land management, it must be aligned with cultural protocols, as misapplication of cool-burning could lead to ecological damage and cultural harm rather than regeneration.

Personal development and professional perspective

Just like the river is a fluctuating system shaped by dynamic processes, so too was this graduation year. Over the course of the project, I experienced growth both professionally and personally. Developing workflows, structuring a research process, and translating a full year of gaining knowledge into a meaningful design outcome was both challenging and rewarding. It enabled me to navigate moments of doubt and insecurity and gradually replace them with confidence and a sense of pride.

One of the key lessons I've learned is that, as a landscape architect, you are inherently a generalist. The profession requires a broad understanding across disciplines, along with the humility to recognise the limits of your knowledge. Trusting your professional intuition is essential, but equally important is knowing when to seek out others for expertise and perspective. Landscape architecture is not a one-person job, and collaboration is fundamental to the process.

This project has also shaped my professional perspective on the role of the landscape architect. It is a role grounded in care for natural systems, but one that extends far beyond ecological or hydrological boundaries. A landscape architect connects nature and landscape to the social and urban realm and therefore plays a vital and irreplaceable role in shaping the environments we live in, use, and experience. Through the regeneration and improvement of landscapes and natural systems, we hold the opportunity to reconnect people with nature and improve the spaces we live in in meaningful and lasting ways.

07 Conclusion

This thesis adopts a landscape-based design approach to address the interconnected issues of a fragmented ecological corridor, limited opportunities for engagement, and altered river dynamics. It proposes a strategic framework for the regeneration of the riparian zone of Birrarung (the Yarra River), one that supports ecological resilience and meaningful human engagement. Two sites were explored in more detail to test how this framework can be translated into context-specific design interventions. The following section reflects on the outcomes of this process by answering the posed research questions.

SQ1 – Understanding the Yarra River system

How can the Yarra River system, including its flow dynamics, riparian land use, ecological role, and human engagement with it, be understood, and what spatial opportunities and challenges can be identified?

Colonisation marked the beginning of changed land use along the Yarra River and shifted the perception of the river from an equal relationship with the landscape to seeing it as a threat. Urban development and agriculture encroached on riparian land, altering vegetation and narrowing the corridor. This fragmentation weakened species movement and impaired ecological function. The river's seasonal flow (typically higher in winter and lower in summer) has been disrupted by over 1300 water extraction licences and climate change, leading to lower baseflows and less frequent floodplain inundation. This has caused habitat loss and heightened downstream flood risk. In urban areas, steep banks and privatised edges limit physical and visual access to the river. As a result, its dynamics are often misunderstood and seen as disruptive. However, areas that do offer access are actively used and valued, indicating a broader need for spaces that support meaningful engagement. These observations reveal the opportunity for riparian regeneration to reconnect the

corridor, improve water retention, and strengthen human engagement through spatial design.

SQ2 – Design strategies & principles

Which strategies and design principles are suitable for regenerating the riparian corridor of the Yarra River while promoting human engagement with the river system?

The challenges and opportunities identified in Chapter 3 informed the desired outcome. Strategies and principles were developed using the project aims as design layers (riparian ecology, riparian hydrology, and human–river engagement). The strategies are defined as: (1) reclaiming the riparian zone and creating the conditions for functional riparian regeneration, (2) improving connections between the riparian corridor and surrounding habitats, (3) increasing riparian flooding frequency and water retention capacity, and (4) creating a visually and physically engaging riparian landscape and river dynamics. Design principles respond to these strategies and form the translation from framework to design. They were developed using knowledge from precedent studies with similar aims and approaches. The spatial implications of these principles depend on the specific site where they are applied, as they are shaped by site-specific conditions and characteristics.

SQ3 – Design exploration

How can the defined strategic framework and design principles be translated into spatial landscape architectural interventions at both regional and urban scales along the Yarra River corridor?

Applying the defined strategies along the Yarra River has resulted in a system-wide strategic vision that reflects the project's aim and serves as a framework for detailed spatial elaboration. As a linear system, interventions influence conditions both upstream and downstream. To explore local implementation, two downstream sites were selected for further design development. Design principles were tested through various spatial configurations. The urban floodplain, currently occupied by privatised golf courses, is transformed into a dynamic floodplain landscape with permanent wetlands. This renewed floodplain prioritises ecological restoration, enabling frequent inundation and riparian regeneration while offering low-impact public access through predefined routes. Seasonal changes in river levels are expected to gradually reshape the landscape over time, with the objective not to restore a past condition, but to regenerate a resilient and evolving riparian system. A second location in the urban context explores guiding visitors to the river via routes reaching the lower banks. Additionally, a concept for rural floodplain regeneration elaborates on the opportunity to combine agriculture with corridor regeneration and improved water buffering, by maintaining a 150-metre-wide riparian buffer and hybrid land use. Together, the detailed designs offer an initial exploration of how the strategic framework can be translated into local-scale interventions.

SQ4 – Synthesis

To what extent has the spatial strategic framework and adopted approach supported the regeneration of the riparian corridor, and what insights does this offer for future river regeneration projects with similar aims?

The project demonstrates that regenerating the Yarra River requires system-wide change to address the complexity of interrelated challenges. A transdisciplinary approach is essential, as the system demands ecological, hydrological, cultural, and social understanding to develop effective, site-sensitive responses. This approach proved useful in uncovering relationships between systems and identifying where interventions can have the most impact. The combination of strategies created a flexible and comprehensive framework that can respond to both river-wide processes and local conditions.

The design outcomes show the potential to combine riparian regeneration with meaningful human engagement, using spatial strategies that support ecological and hydrological function alongside human–river interaction. While the outcomes are promising, they remain conceptual and must be further tested through implementation or modelling to evaluate long-term effectiveness. The design principles developed in this thesis offer guidance for translating system-wide strategies to local interventions. However, they are not universally applicable and must be adapted to the specific conditions, needs, and opportunities of each site.

This research offers insights for future river regeneration projects by showing how regeneration can move beyond ecological restoration alone and instead be understood as a layered process that integrates natural systems with public engagement. The use of Research Through Design enabled iterative development between analysis and design, generating new spatial insight. While this thesis focuses on the Yarra River, the principles and methodology may inform similar projects elsewhere, provided that local cultural, ecological, and hydrological contexts are carefully considered.

This thesis proposes a spatial strategic vision and framework for Birrarung's regeneration, one that honours its natural dynamics and sees the riparian zone as a shared space of ecological function and human-nature connection. In doing so, it contributes to rethinking how we regenerate river systems: not by resisting their dynamics, but by (re)integrating them into spatial planning and design.

References

Atelier Descombes Rampini. (n.d.). *Office profile: Atelier Descombes Rampini* [Photograph]. Landezine. https://landezine.com/office-profile-atelier-descombes-rampini/

Bowler, J. (1972). F*looding of the Yarra River in Melbourne* [Photograph]. In The Age. (2020, February 13). *From the Archives, 1972: Chaos as floods batter Melbourne*. https://www.theage.com.au/national/victoria/from-the-archives-1972-chaos-as-floods-batter-melbourne-20200213-p5400i.html

Bureau of Meteorology. (2024). *Australia's changing climate: State of the climate 2024*. Australian Government. http://www.bom.gov.au/state-of-the-climate/australias-changing-climate.shtml

Bruin, D., Hamhuis, D., van Nieuwenhuize, L., Overmars, W., Sijmons, D., & Vera, F. (1987). *Ooievaar: De toekomst van het rivierengebied* (1e dr). Stichting Gelderse Milieufederatie.

Commissioner for Environmental Sustainability Victoria. (2023). *State of the Birrarung (Yarra) and its parklands: 2023 report.* State Government of Victoria. https://www.ces.vic.gov.au/reports/state-of-the-birrarung-2023

Cumpston, Z., Fletcher, M.S., & Head, L. (2022). *First Knowledges: Plants: Past, Present and Future.* Thames & Hudson Australia.

Davis, M. (n.d.). *The Whippet #96: The cat's judgement, the iron-eating mice. The Whippet* [Photograph]. https://thewhippet.org/1412432_the-whippet-96-the-cat-s-judgement-the-iron-eating-mice/

Davison, G. (2022, September 26). *Detoxing the Yarra River.* Foreground. https://www.foreground.com.au/agriculture-environment/detoxing-the-yarra-river/

Department of Environment, Land, Water and Planning; Bureau of Meteorology; Commonwealth Scientific and Industrial Research Organisation; & The University of Melbourne. (2020). *Victoria's water in a changing climate.* Victorian Government. https://www.water.vic.gov.au/__data/assets/pdf_file/0030/517400/Victorias-Water-in-a-Changing-Climate.pdf

Department of Sustainability and Environment. (2006). *Yarra River action plan: Securing water quality for a healthy future.* Victorian Government. https://www.melbournewater.com.au

Department of Sustainability and Environment. (2007). *Ecological vegetation class (EVC) bioregion benchmark for vegetation quality assessment: Gippsland Plain bioregion.* Victorian Government. https://www.environment.vic.gov.au/biodiversity/bioregions-and-evc-benchmarks

Descombes, G. (2018). *Aire: The river and its double = La rivière et son double = Der Fluss und sein Doppelgänger* (A. Viviani & C. Baker, Trans.). Superpositions; Park Books AG.

Environment Victoria. (2018, January 25). *Indigenous perspective: Birrarung – River of mists and shadows* [Photograph]. https://environmentvictoria.org.au/2018/01/25/indigenous-perspective-birrarung-river-mists-shadows/

FlyHigh Visuals. (2016, October 2022). *Melbourne Yarra River Flooding | 16th October 2022* [Video]. YouTube. https://www.youtube.com/watch?v=pV8QDYqEx_Q

Gummage, B., & Pascoe, B. (2021). *First Knowledges: Country: Future Fire, Future Farming*. Thames & Hudson Australia.

Greet, J., Lankri, R., Gaskill, S., Fischer, S., Freedman, D. L., Preston, T., & Narrap Unit Rangers. (2023). Urban billabong restoration benefits from Traditional Owner involvement and regular flooding. *Marine and Freshwater Research, 74*(4), 398–408. https://doi.org/10.1071/MF22195

Heard, S., Treadwell, S., & Gaskill, S. (2018). Environmental response of reconnecting billabongs along the Yarra River. In *Proceedings of the 9th Australian Stream Management Conference* (pp. 1-8). Hobart, Tasmania.

HNS. (2016). *Ruimte voor de Waal - HNS*. Available at: https://www.hnsland.nl/projecten/ruimte-voor-de-waal/ (Accessed: 27 June 2025).

Jackson, S., Anderson, E. P., Piland, N. C., Carriere, S., Java, L., & Jardine, T. D. (2022). River rhythmicity: A conceptual means of understanding and leveraging the relational values of rivers. *People and Nature, 4*(4), 949–962. https://doi.org/10.1002/pan3.10335

Kelly, A., & Miller, D. (2021). *Yarra River regeneration guide: Cremorne Railway*

Bridge to Westerfolds Park (Report). Yarra Riverkeeper Association. https://yarrariver.org.au/reports/

Kondolf, G. M., & Pinto, P. J. (2017). The social connectivity of urban rivers. *Geomorphology, 277*, 182–196. https://doi.org/10.1016/j.geomorph.2016.09.028

Lind, L., Hasselquist, E. M., & Laudon, H. (2019). Towards ecologically functional riparian zones: A meta-analysis to develop guidelines for protecting ecosystem functions and biodiversity in agricultural landscapes. *Journal of Environmental Management, 249*, 1–13. https://doi.org/10.1016/j.jenvman.2019.109391

Loidl, H., & Bernard, S. (2003). *Opening spaces: design as landscape architecture.* Birkhäuser.
lilkanyongmail. (n.d.). *Platypus* [Photograph]. DeviantArt. https://www.deviantart.com/lilkanyongmail/art/Platypus-1079573764

Melbourne Water. (2018). *Healthy waterways strategy 2018.* https://www.melbournewater.com.au/ media/6976/download

Melbourne Water. (2022). *Burndap Birrarung burndap umarkoo: The Yarra Strategic Plan – Part 2: Land use framework.* Victorian Government. https://www.water.vic.gov.au/planning-and-entitlements/yarra-river/yarra-strategic-plan

Melbourne Water. (n.d.-a). *Rainfall and river levels.* Retrieved April 26, 2025, from https://www.melbournewater.com.au/water-and-environment/water-management/rainfall-and-river-levels

Melbourne Water. (n.d.-b). *Water diversion management: Water trading fact sheet.* https:// www.melbournewater.com.au/sites/default/files/water_trading_-_fact_sheet.pdf

Nijhuis, S. (2022). Landscape-Based Urbanism: Cultivating Urban Landscapes Through Design. In R.
Roggema (Ed.), *Design for Regenerative Cities and Landscapes: Rebalancing Human Impact and Natural Environment* (pp. 249-277). (Contemporary Urban Design Thinking). Springer. https://doi.org /10.1007/978-3-030-97023-9_11

Nijhuis, S., & de Vries, J. (2020). Design as Research in Landscape Architecture. *Landscape Journal*, 38(1-2), 87-103. https://doi.org/10.3368/lj.38.1-2.87

Nijhuis, S., & Jauslin, D. (2015). Urban landscape infrastructures. Designing operative landscape structures for the built environment. *Research In Urbanism Series, 3*(1), 13-34. doi:10.7480/rius.3.874

Pinto, L. V., Inácio, M., & Pereira, P. (2023). Green and blue infrastructure (GBI) and urban nature-based solutions (NbS): Contribution to human and ecological well-being and health. *Oxford Open Infrastructure and Health, 1*(1), 1–14. https://doi.org/10.1093/ooih/ouad004

Poff, N. L., Allan, J. D., Bain, M. B., Karr, J. R., Prestegaard, K. L., Richter, B. D., Sparks, R. E., & Stromberg, J. C. (1997). The natural flow regime: A paradigm for river conservation and restoration. *BioScience, 47*(11), 769–784. https://doi.org/10.2307/1313099

Rose, D. B. (1996). *Nourishing terrains: Australian Aboriginal views of landscape and wilderness*. Australian Heritage Commission.

Rossano, F. (2016). Isar plan: The wild as the new urban. *Contour, 1*(2), 1-10.

State Government of Victoria. (2022). *Yarra River Protection (Wilip-gin Birrarung murron) Act 2017 (Authorised Version No. 008).* https://content.legislation.vic.gov.au/sites/default/files/2022-02/17-49aa008%20authorised.pdf

Yarra Ranges Council. (n.d.). *Yering Billabongs Project*. https://www.yarraranges.vic.gov.au/ Environment/Sustainable-communities/Healthy-Waterways/Yering-Billabongs-Project

Yarra Riverkeeper Association. (2021a). *Healthy waterways toolkit: The Yarra River.* https://yarrariver.org.au

Yarra Riverkeeper Association. (2021b). *Yarra River regeneration guide: Cremorne Railway Bridge to Westerfolds Park*. https://yarrariver.org.au/reports/:contentReference[oaicite:0]{index=0}

TreeProject. (n.d.). *River Red Gum (Eucalyptus camaldulensis)* [Photograph]. https://treeproject.org.au/river-red-gum-eucalyptus-camaldulensis/

Urban Waters. (n.d.). *Isar Plan – Urban river restoration in Munich* [Image]. https://urban-waters.org/en/projects/isar-plan

Victorian Aboriginal Heritage Council. (n.d.). *Wurundjeri Land and Compensation Cultural Heritage Council Aboriginal Corporation* [Photograph]. https://www.aboriginalheritagecouncil.vic.gov.au/ wurundjeri-land-and-

compensation-cultural-heritage-council-aboriginal-corporation

Victorian Government. (n.d.). *Growling Grass Frog: Habitat preferences* [PDF]. CCMa Knowledge Base. https://www.ccmaknowledgebase.vic.gov.au/resources/Growling_Grass_Frog_habitat_pref.pdf

Wantzen, K. M., Ballouche, A., Longuet, I., Bao, I., Bocoum, H., Cissé, L., Chauhan, M., Girard, P., Gopal, B., Kane, A., Marchese, M.R., Nautiyal, P., Teixeira, P., & Zalewski, M. (2016). River Culture: An eco-social approach to mitigate the biological and cultural diversity crisis in riverscapes. *Ecohydrology & Hydrobiology, 16*(1), 7–18. https://doi.org/10.1016/j.ecohyd.2015.12.003

Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation. (2020). T*owards cultural and environmental renewal of the Birrarung: Bulleen–Banyule Flats cultural values study.* Department of Environment, Land, Water and Planning.