Maribyrnong Waterfront Integrated Water Management Strategy

REALM studios alluvium VENANT SOLUTIONS

CITY OF MELBOURNE

Project: Maribyrnong Waterfront
Integrated Water Management Strategy

Report Title: **Strategic Development Report**

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Executive Summary

Overview

This report has been prepared by REALMstudios, Venant Solutions and Alluvium Consulting to provide direction for the future management of flood prone areas in Maribyrnong Waterfront.

Flooding affects the entirety of the site and it is a necessity that flooding is managed at a strategic level, rather than a lot by lot basis.

This strategy builds from existing work carried out by Melbourne Water to establish a blue-green solution to water management. This approach will improve the resilience and liveability of the site, and celebrates storm water in the public realm.

Flooding

There are two flows causing flooding on the Maribyrnong Waterfront.

1. Water travelling down the Maribyrnong River from upstream catchments and storm surges travelling up the Maribyrnong River from Port Phillip Bay. This is fluvial flooding.
2. Water falling directly in catchments that effect the site. This is pluvial flooding.

These floods can occasionally occur at the same time creating extreme flood events.

The Problem

Maribyrnong Waterfront has a past of flooding as a result to its close proximity to the Maribyrnong River and its low lying with ground levels generally between 1 m AHD and 3 m AHD.

There has been a number of significant floods at Maribyrnong Waterfront. Historically as a natural river floodplain and now as an area of urban development.

The current urban condition is made up of hard impermeable surfaces and underground pipe networks that give minimal consideration to natural flows or flood levels. As a result, the entire Maribyrnong Waterfront is at risk of flooding.

Flooding is expected to be exacerbated. Climate change which is predicted to increase rainfall intensity (and therefore runoff) and raise sea levels.

Current Flood Management

Flooding has traditionally been managed through a pit and pipe system that outlets into the Maribyrnong River.

When the river experiences high water levels in the river combined with insufficient pipe sizes have meant that flooding has not been effectively managed. Water from the river backs up the pipes causing localised flooding.

Melbourne Water have proposed a scheme that proposes floor levels set at 3 m AHD to mitigate flood risk to new mixed use property and 'humps' in the Kensington and Hobsons Road set at 2.4 m AHD. This approach does not however protect the public realm from flooding.

Reviewing The Approach

Much of the Maribyrnong Waterfront has been rezoned to mixed use and is therefore predicted to change extensively in future years. This coupled with the impacts of climate change mean that flooding is likely to intensify across the area.

Although Melbourne Waters approach does manage flood waters, there are concern that this requirement will have a negative impact on public realm interfaces, urban design outcomes, public space function, land values, rent returns and neighbourhood character.

Objective

The objectives of this project are:

- To develop creative, combined and integrated solutions to mitigate flooding and also drive the future identify of place and good urban design outcomes.
- To use systems that would occur naturally instead of hard engineering solutions to combine the public realm design with required flood management infrastructure and urban development.
- Integration of built form and flood management outcomes to increase resilience and apply best practice to unlock opportunities for high quality development, urban greening, celebrate water in the landscape, connection to the Maribyrnong River's waterfront and exceptional public realm outcomes.

The Strategy

The Maribyrnong Waterfront Integrated Water Management (IWM) Strategy recommends managing flooding through the integration of blue-green infrastructure into the public realm and private realm, providing an effective and integrated defence against fluvial and pluvial flooding.

Blue-green infrastructure is the reintroduction of a natural water cycle while creating multi-functional public realm and multiple benefits for the environment, community, and economy.

The blue-green infrastructure proposed includes:

An Integrated Dike - A dike or levee is an elongated artificially constructed fill embankment or wall, which regulates water levels. It is usually earth and often parallel to the course of a river in its floodplain.

Riparian Corridors - A riparian area is the interface between land and a river creating unique ecologies.

Tertiary Corridors - A hard or landscaped channel that conveys storm water to a desired location.

Detention Basins - A detention or retarding basin is an excavated area installed to store storm water for a set period of time before being released back into a river.

Blue-green Streets - A street that provides public thoroughfare whilst integrating garden beds, tree planting and water sensitive urban design (WSUD).

Green roofs - A roof of a building that is covered with vegetation and growing medium, planted over a waterproofing membrane.

Rainwater Tanks - A tank used to collect and store rain water runoff, typically from rooftops via pipes.

Improving Liveability

Flood management is an opportunity to improve liveability at Maribyrnong Waterfront. Blue-green infrastructure has been considered with a focus of incorporating additional uses and benefits other than just flood management.

For example, detention areas in the street and open spaces will increase the amount of urban greening. Urban greening and the presence of water can improve air quality, reduce the heat island effect, produce healthier micro-climates and create valuable habitat area for wildlife.

Multifaceted and Integrated Design

The focus is flood management, but a small consideration has been given to the water cycle, including grey water recycling.

Rainwater tanks within built form are currently a planning scheme requirement for all new development in Maribyrnong Waterfront, to act as detention for storm water falling on buildings. This provides opportunity to be recycled for non-potable demands.

The proposed streets have been carefully considered in the design of blue-green infrastructure replacing hard surfaces with porous surface and specialist rain gardens.

As suggested in the Maribrynong River Valley Design Guidelines, 2010 the dike along the river claims a 30m offset from the river banks as an open space contribution. An integrated dike can also provide community activation and pedestrian and cycle routes along the Maribyrnong River.

Conclusion

The primary objective of this strategy is to provide a conceptual plan to manage flooding at Maribyrnong Waterfront. This is achieved through an integrated approach that seeks to maximise the co-benefits of the design for the community.

The management of storm water in this way allows;

- floor levels in buildings to be better integrated, improving commercial value of these buildings and improved connections between the private and public realm
- no requirement for 'humps' in the Kensington and Hobsons Road
- reduced need for underground pipes and pumps
- addition of urban greening and open space provision
- better pedestrian and cycle access and connection, to the river, along the river and across the river
- Improved ecosystems and ecological connectivity

This concept demonstrates how Maribyrnong Waterfront can be an attractive and inviting new area of the City that is not constrained by its relationship with the Maribyrnong River and to storm water, but enhanced by it, defining its very character.

This Integrated Water Management Strategy is the first step in developing a holistic flood management approach. Further analysis is required to identify levels of contamination, implementation and funding approaches.

City of Melbourne practices IWM as a coordinated management of all components of the water cycle including water consumption, rainwater, stormwater, wastewater and groundwater, to secure a range of benefits for the wider catchment. Further work will be undertaken in future stages of the project to address the complete IWM approach outside and above of flood management.

0.0 Content

1.0 Introduction

Purpose

The City of Melbourne in consultation with Melbourne Water are seeking to develop creative solutions that integrate water management with the future identity of the Maribyrnong Waterfront.

This Integrated Water Management Strategy (IWM) aims to assist the future planning of the Maribyrnong Waterfront. This is seen as a technical strategy to inform the Maribyrnong Waterfront Opportunities Paper being produced by the City of Melbourne. This paper will present the key findings to land owners, the community and key stakeholders and later to inform the future strategic work in Dynon.

Focus

Although titled a Integrated Water Management Strategy, this report focuses on flooding of storm water only and does not consider potable water provision, grey or black water recycling or sewage treatment.

A focus is given to flooding due to the immediate pressures to unlock safe and viable mixed use development within a highly flood prone area.

This IWM strategy will answer the following questions:

1. How will drainage and flooding impact urban design and engineering outcomes and community perspective? This will include impact on streets, open spaces and built form
2. How will private ownership, limited control on sequencing, geotechnical conditions and ground contamination impact the approach towards flooding?
3. Are there alternative options to the proposed Hobsons Road Scheme and Melbourne Water flood level requirements (scheme outlined on page 9)?
4. If the Hobsons Road Scheme is required, how can this be designed to be multi-functional and achieve desirable public realm / connectivity outcomes?
5. How can the Maribyrnong Waterfront celebrate the management of water in the public realm?
6. How can design solutions both within the public realm and within built form be used to overcome the potential barrier of having raised floor level requirements which will impact upon active frontages and DDA requirements?

Background

The Maribyrnong Waterfront has a rich history and served many user groups in different capacities over the course of its existence. Pre-colonial indigenous communities revered the river and its rich flood plains for the abundance of resources it endowed them with, while colonial communities used the Maribyrnong as a mode of transport, source of water and as a waste disposal vehicle. The river was the lifeblood of western Melbourne and remained the industrial engine room of a growing city in later years.

During recent times, the majority of urban development sitting adjacent to the waterway has turned it's back on it, leaving the waterfront condition uncelebrated, underutilised and undervalued.

Future Development

Urban densification pressures and the ever-impending threat posed by climate change now present a new series of opportunities for all areas adjacent to the river and the site in question in particular.

Sections of the Maribyrnong Waterfront (Hobsons Road and Kensington Road) have recently been rezoned from commercial and industrial to mixed-use developable lots. These sites require an innovative, holistically considered and climate resilient series of interventions which unlock the inherent potential of the land. This will provide safety for users and inhabitants, habitat for fragile and threatened estuarine ecologies, well considered and connected movement networks and amenities for diverse user groups.

Overarching Proposal

The IWM Strategy 'blue-green' (water and landscape) water management strategy initiatives for the Maribyrnong Waterfront are multi-tiered in approach and outcomes. The overarching proposal is to:

- Prescribe a tool kit for pluvial and fluvial flood mitigation and storage
- Re-connect the Maribyrnong River with a new city narrative and context
- Increase areas for riparian ecologies to proliferate
- Identify new open space opportunities
- Retrofit existing streets for a new urban context
- Align sustainable transport networks with blue green infrastructure
- Use defunct infrastructure and heritage buildings as future assets
- Revitalise the environmental and recreation offering of the Dynon Road Tidal Canal
- Influence the future renewal of the wider Dynon area

Managing urban renewal, flood management and climate adaptation, while integrating social, cultural and ecological value to increase liveability for the growing community of the Maribyrnong Waterfront.

Guiding Policy and Strategies

This IWM Strategy is informed by and seen as an application of the City of Melbourne's guiding strategies, including:

- Climate Change Adaptation Strategy Refresh (2017)
- Total Watermark – City as a Catchment (2014)
- Nature in the City Strategy (2017)
- Open Space Strategy (2012) Technical report
- Urban Forest Precinct Plans Kensington and North-West Melbourne

State government strategies that have also informed the strategy include:

- Victorian Floodplain Management Strategy
- Maribyrnong River Valley Design Guidelines – State Gov. (2010)

Hydraulic Modelling Review

Two baseline flood models were available to inform the IWM Strategy as to flood extents, depths and levels. CoM supplied a model of the Hobsons Road local catchment (CoM Hobsons Road Flood Management Plan, Engeny 2017) and Melbourne Water supplied a model of the Maribyrnong River (model developed in-house by Melbourne Water). The Hobsons Road model provided flood mapping for the local catchment runoff (pluvial) only and the Maribyrnong River model provided flood mapping for runoff in the broader Maribyrnong River catchment (fluvial) only; the Maribyrnong River model did not extend into the floodplain and hence only provided flood levels along the river itself.

A review of the Hobsons Road model resulted in the following updates to the model:

- Minor corrections to the underground pipe network;
- Updating the rainfall inputs by 19.5 % to incorporate the future effects of climate change
- Modifications to the spatial distribution of the rainfall on the model;
- Update of the catchment outfall level in the Maribyrnong River for the following two cases:
  - A Port Phillip Bay storm tide level of the same probability as being assessed for the local catchment flooding, e.g. The 1% (1 in 100) AEP (annual exceedence probability) local catchment flood was paired with the 1% AEP storm tide level (1.4 m AHD) and similarly for the other events – Melbourne Water advised the storm tide levels;
  - The AEP storm tide level was increased to account for future sea level rise of 0.8 m associated with climate change;

In line with the above updates the Hobsons Road model was for two scenarios:

- Rainfall increased by 19.5% without sea level rise;
- Rainfall increased by 19.5% with sea level rise;

A technical review of the Maribyrnong River flood model supplied by Melbourne Water was not undertaken but the current climate Port Phillip Bay storm tide levels were updated as advised by Melbourne Water. At the time of preparing this report Melbourne Water has not assessed the future effects of climate change on the rainfall within the Maribyrnong River catchment. Therefore the following two scenarios were assessed:

- Current rainfall climate without sea level rise;
- Current rainfall climate with sea level rise.

The Hobsons Road flood model was developed using current best practice and is suitable for the purposes of this report. The City of Melbourne and Melbourne Water have been having ongoing discussions with regards to the most appropriate Maribyrnong River levels to use in combination with the local catchment flood event. The adopted approach of pairing even the small local catchment events with the 1% AEP tide level is conservative. Therefore it is recommended for future stages of this project that this aspect of the modelling be reviewed.

There are two major limitations with the Maribyrnong River modelling and it is recommended that these be addressed in future stages of this project. The first is the use of current climate rainfall which results in an inconsistency in approach with the Hobsons Road modelling. The second limitation is the modelling only provides levels within the river and does model the extent of backwater flooding into the Hobsons Road catchment during a river flood event. It is recommended that this be incorporated into the modelling for future stages of this project.

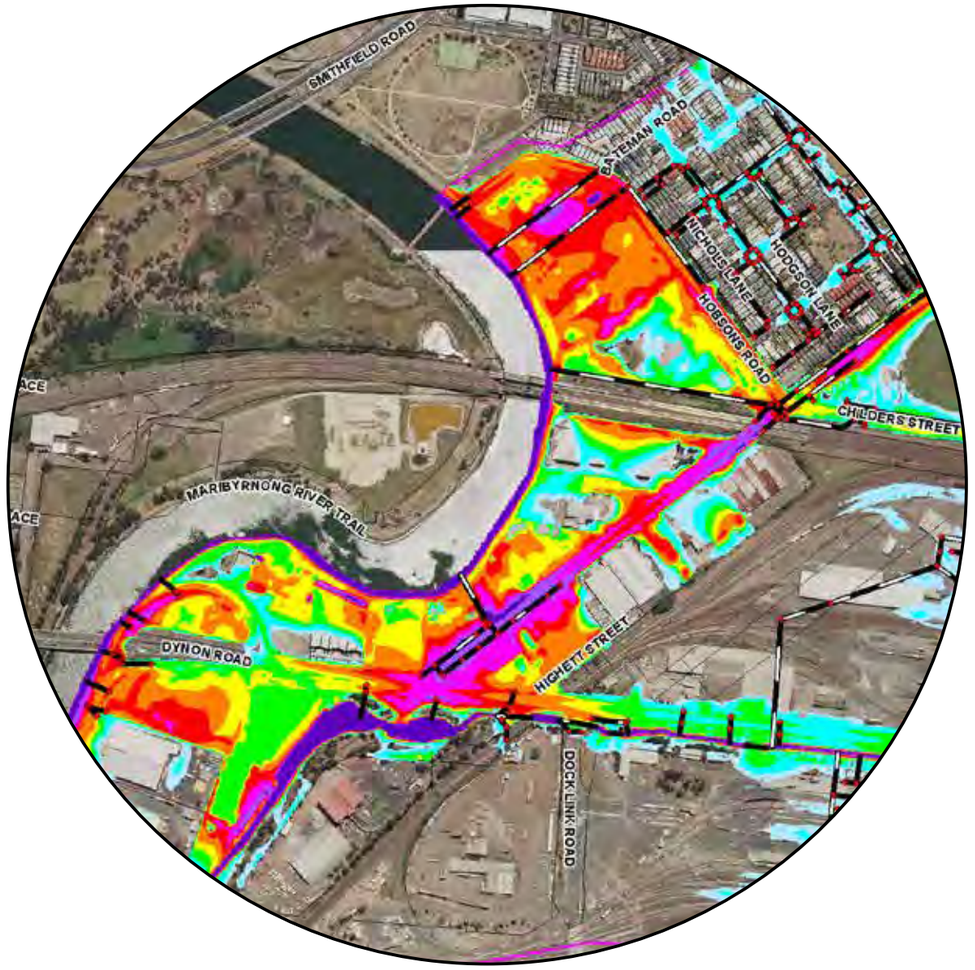


Figure 1: Hobsons Road Flood Management Plan, June 2017 - Existing 1% Annual Exceedance Probability with Climate Change and 2.4m AHD tailwater

Waterway Catchments

There are three major waterway catchments that effect the City of Melbourne - the Yarra River, Moonee Ponds Creek and Maribrynong River of which our study area is associated.

Site

The Maribyrnong Waterfront lies on the eastern banks, of the lower reaches of the Maribyrnong River. It has an area of approximately 485 hectares. The site sits across Kensington and West Melbourne - two west neighbourhoods within the City of Melbourne. The location of the Integrated Water Management Strategy study area is shown below. This is however different to the Maribyrnong Waterfront Discussion Paper study area.

Due to the low lying nature of the site and it's location on the Maribyrnong River, the site experiences significant flooding (illustrated in further detail on page 10).

Figure 2: Adapted from 'Melbourne's Water Story' City of Melbourne, 2018. – Waterway Catchments

Figure 3: Study Area

2.1 Melbourne's Water Story

A changing water landscape

Since the arrival of Europeans, Melbourne's water landscape has been changed dramatically.

Water Elements

Melbourne's water landscape once consisted of major waterways, including two major rivers, ephemeral sub waterways, such as the Williams Creek (Elizabeth Street), a swamp (source: www.emelbourne.net.au), extensive sponge like wetlands and floodplains, all feeding into a tidal bay.

Figure 4: Adapted from 'Melbourne's Water Story' City of Melbourne, 2018 - Pre 1835 Water Landscape

A Change in Course

The fresh water Yarra River made Melbourne a desirable location for settlement by early Europeans. The River was vastly different to what we see today. Its shores were lined with gums, wetlands and grasslands, with creeks and falls joining the river, and falls frequently breaking its flow.

As Melbourne grew its water landscape was changed dramatically.

- **Channelising the creeks and rivers** - increased the speed of water velocity into singular volumes.
- **Under grounding creeks and natural drains** - restricted drainage capacity to pipes and increased risk of failure.
- **Flood dike** - intended to increase the water holding capacity of rivers prevent flood waters from draining back into the rivers.

Figure 5: Adapted from 'Melbourne's Water Story' City of Melbourne, 2018. – Post 1835 Water Landscape

A Compromised Water Landscape

Increased population growth and urbanisation have created the water landscape we know today.

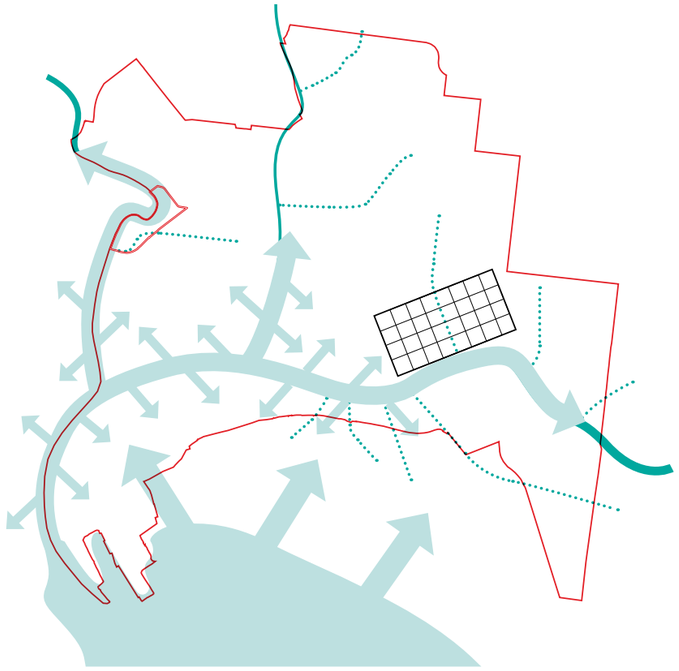
- **Development in 'wet' lands** - removed the natural resilience and sponge properties of these ecosystems.
- **Development further up the catchment** - increased the velocity and volume of water entering the waterways further up the catchment creating subsequent pressure on the lower parts of the catchment.
- **Increased amount of impermeable surfaces** - preventing water to permeate back into the soil and ground water table.
- **Deforestation** - removing vegetation that would naturally reduce surface water flow and soak up through precipitation.

Figure 6: Adapted from 'Melbourne's Water Story' City of Melbourne, 2018. – Today's Water Landscape

2.0 Context

Flooding in Melbourne

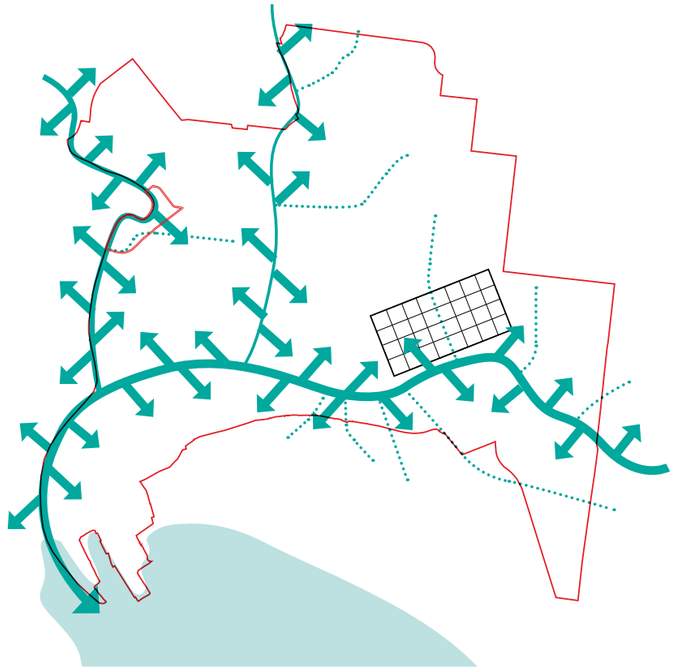
There are three main types of flooding significantly effecting the City of Melbourne.



Coastal Flooding

Flooding caused by extreme tidal conditions, including high tides and storm surges bring waters up from the bay, flooding the land. These also travel up the major waterways causing further inland flooding.

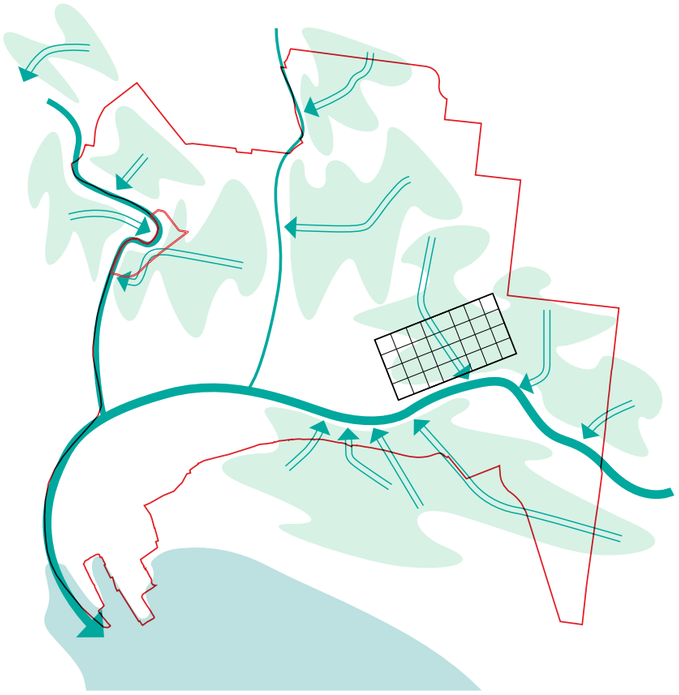
Figure 7: Adapted from 'Melbourne's Water Story' City of Melbourne, 2018. – Today's Water Landscape



Fluvial Flooding

Flooding caused when the rivers and creeks burst their banks as a result of sustained or intense rainfall.

Figure 8: Adapted from 'Melbourne's Water Story' City of Melbourne, 2018. – Today's Water Landscape



Pluvial Flooding

Flooding caused when a heavy downpour of rain saturates the ground water table and drainage systems, such as underground pipes. Excess water cannot be absorbed into the system and causes localised flooding within the catchment.

Figure 9: Adapted from 'Melbourne's Water Story' City of Melbourne, 2018. – Today's Water Landscape

Climate Change

The anticipated changes to our global climate will significantly effect water flows on our cities. In Melbourne, conservative projections indicate a **19.5% increase in precipitation intensities**[1] and **0.8m sea level rise**[2] by 2100.

Extreme precipitation and stormwater flooding - Increasingly frequent extreme precipitation events, combined with sea level rise, may overwhelm the existing stormwater management system, causing sewer backups into buildings and street flooding.

Tidal river inundation and high tide - Portions of the precincts edge are projected to be flooded on a regular basis due to tidal inundation.

Innovative management of flooding will be required at the building, street and precinct levels to minimise risk of flooding in the future.

1) Australian Rainfall and Runoff, 2016 - Australian Government Geoscience Australia

2) Victoria State Planning Policy Framework & Victoria Coastal Council, 2014

2.2 Pre-settlement Flooding

The Maribyrnong River - Historically a Place of Flood

Flooding has historically been part of the way the Maribyrnong Waterfront functions on an ecological and hydrological level. Originally flooding would occur as a natural process creating rich flood plains and swampy estuarine environments at the junction of the Maribyrnong and Yarra. The landscape Pre 1835 would have sustainably absorbed fluctuating water flows and levels.

Indigenous communities native to the region once harvested food and other resources from these waterways and flood plains, imbuing the waterway and it's surrounds with important cultural significance which endures to this day.

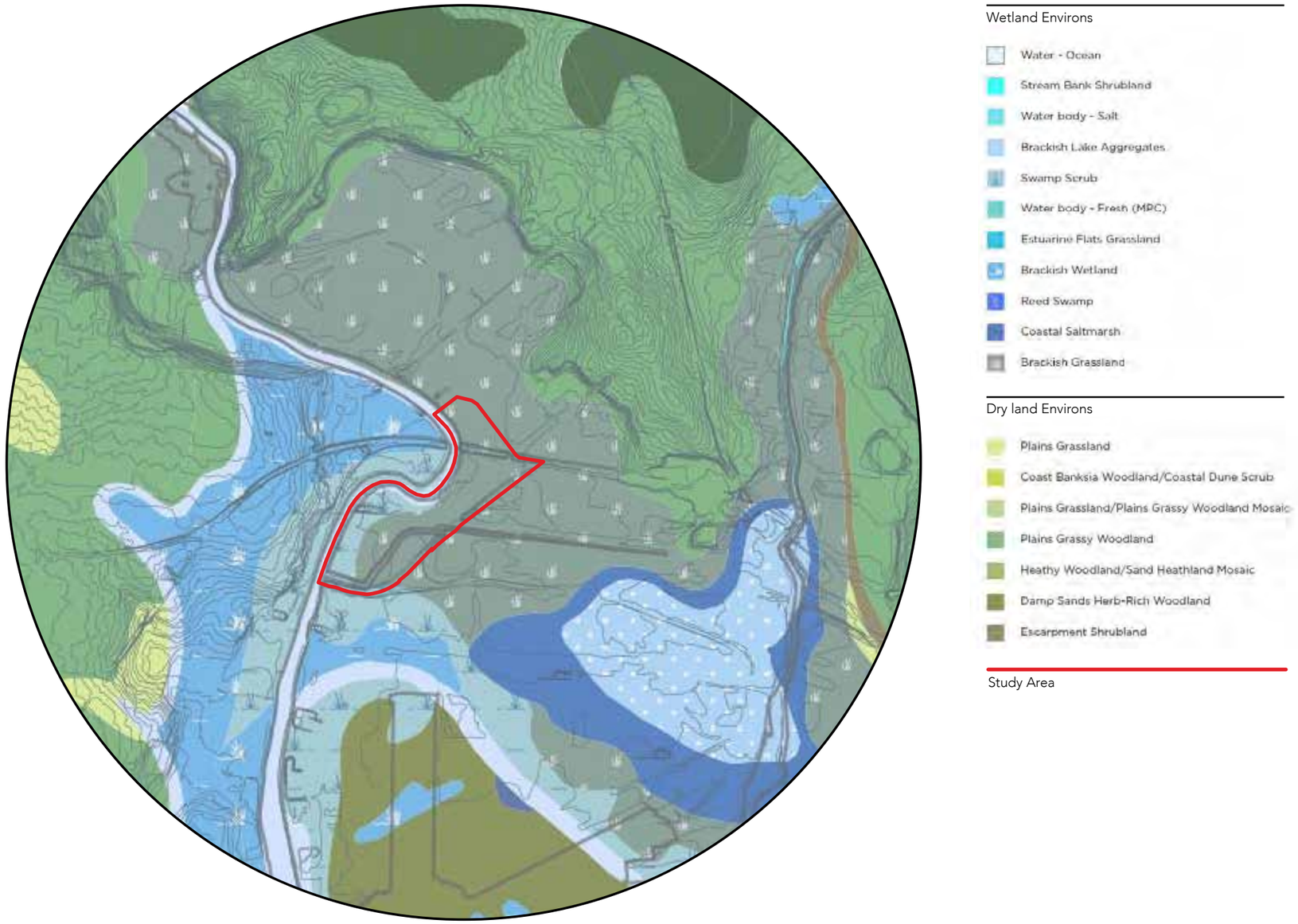


Figure 10: 'Maribyrnong Flood Story' City of Melbourne, 2018.
– 1750 Environmental Vegetation Class

2.3 Post Settlement Flooding

A Rising Problem

Since 1835 significant shifts have affected the way water moves through the Maribyrnong riverine environment. A once natural, unencumbered environment became a heavily urbanised and industrialised setting on the space of two centuries, changing the face of the Maribyrnong and its surrounds irrevocably. Industrial activity crowded the banks of the once pristine river, discharging untreated waste into the rivers and denuding and formalizing once thriving estuarine environments.

Interventions which have affected water flows include:

Waterway

- Bank alterations, channelizing the Maribyrnong River, and consolidating water velocity into a singular undispersed and undissipated volume
- Enclosing once natural surface drains into pipes, limiting their capacity and increasing risk of failure in extreme events
- The implementation of flood dikes, intended to protect certain zones from now prevent pluvial flood water from draining back into the river

Catchment

- Formalization and extensive development in what was previously swamp land, removing the natural resilience of these ecosystems
- Development further upstream in the catchment bottlenecking fluvial flows and applying increased pressure on the lower parts of the catchment
- Impermeable surfaces that do not allow water to permeate back into the subsurface flows
- Vegetation clearing reduces soil permeability, increases surface flow rate and increases erosion

Following built development, water now flows very differently through this new and extensively altered urban environment. These changes have increased flood risk, often with greater risk to the community, homes, businesses, infrastructure and natural environments. As a result, there have been 27 recorded floods on the Maribyrnong since 1871, with major floods occurring approximately every 10-20 years.

1887

1954

2011 - 2.21m Kensington Road

2018 - Flemington Racecourse Station

1906 - 4.50m

1974 - 4.20m

2017 Racecourse

Figure 11: Adapted from 'Maribyrnong Flood Story' City of Melbourne, 2018. – Graph showing flood levels since 1887

2.4 Flooding Today

Flood Types In Maribyrnong Waterfront

Flooding is expressed as an Annual Exceedence Probability (AEP), which shows the amount of times that the event is expected to occur on average in a given year.

Three types of flooding impact the Maribyrnong Waterfront:

Pluvial Flooding - when a heavy downpour of rain saturates the underground drainage system and excess water cannot be absorbed within the catchment.

Fluvial Flooding - when the Maribyrnong River exceed its capacity and bursts its banks as a result of sustained or intense rainfall.

Coastal Flooding - caused by extreme tidal conditions from Port Phillip Bay moving up the Maribyrnong Tidal River and bursting the river banks.

Flood risk is defined by factors of frequency, duration, extent, depth and velocity, as well as the danger to the occupants of development. A low level of residential occupants have made Maribyrnong Waterfront a low priority for flood protection investment. This is predicted to change due to an increase in population and flood levels due to predicted climate change.

Land Subject to Inundation

Currently a Land Subject to Inundation Overlay (LSIO) exists across the majority of the Maribyrnong Waterfront. Its purpose is to:

To implement the Municipal Planning Strategy and the Planning Policy Framework.

- To identify land in a flood fringe area affected by the 1 in 100 year AEP flood.
- To ensure that development maintains the free passage and temporary storage of flood waters, minimises flood damage, is compatible with the flood hazard and local drainage conditions and will not cause any significant rise in flood level or flow velocity.
- To reflect any declaration under Division 4 of Part 10 of the Water Act, 1989 where a declaration has been made.
- To protect water quality in accordance with the provisions of relevant State Environment Protection Policies.
- To ensure that development maintains or improves river and wetland health, waterway protection and flood plain health.

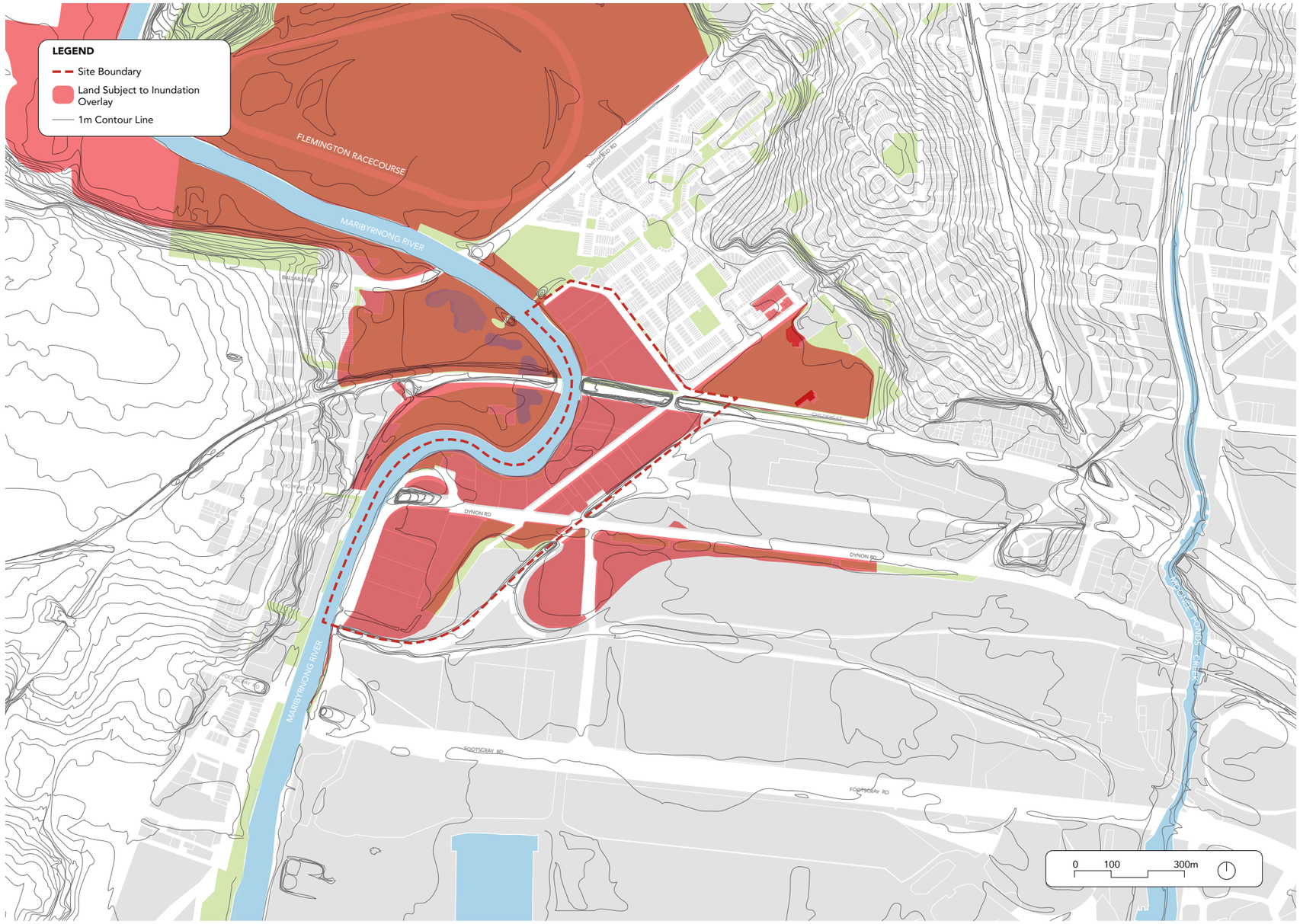


Figure 12: LSIO overlay, data source City of Melbourne.

Catchments

Catchments are areas from which rainfall lands and flows through underground storm water pipes and overland flows into the river. Two predominate catchment areas effect Maribyrnong Waterfront.

1. JJ Holland Park catchment
2. Dynon Tidal Canal catchment

These are both low lying and relatively flat in land form and subject to both pluvial and fluvial flooding.

Kensington Banks catchment to the north is set at a higher level resulting in reduced fluvial flooding. Pluvial flows in this catchment are directed to a wetlands in Riverside Park before being realised into the river.

Current Infrastructure

Pluvial Drainage Infrastructure

Maribyrnong Waterfront's current flood water management comprises of a singular conventional pit and pipe drainage solution. The majority of the site is covered by impermeable surface that shed overland flows directly into the river. Where overland flows can't access the river underground storm water pipes are used to provide free drainage. The existing storm water pipe system quickly reaches capacity in storm events resulting in frequent local flooding.

Fluvial Drainage Infrastructure

Fluvial flooding creates conditions that put Maribyrnong Waterfront at high risk of flooding. Currently no infrastructure is in place to protect the Maribyrnong Waterfront from fluvial flooding. Immediately north of the site Riverside Park integrates a dike that protects the park and residential area of Kensington Banks and Flemington Racecourse is protected by a flood wall.

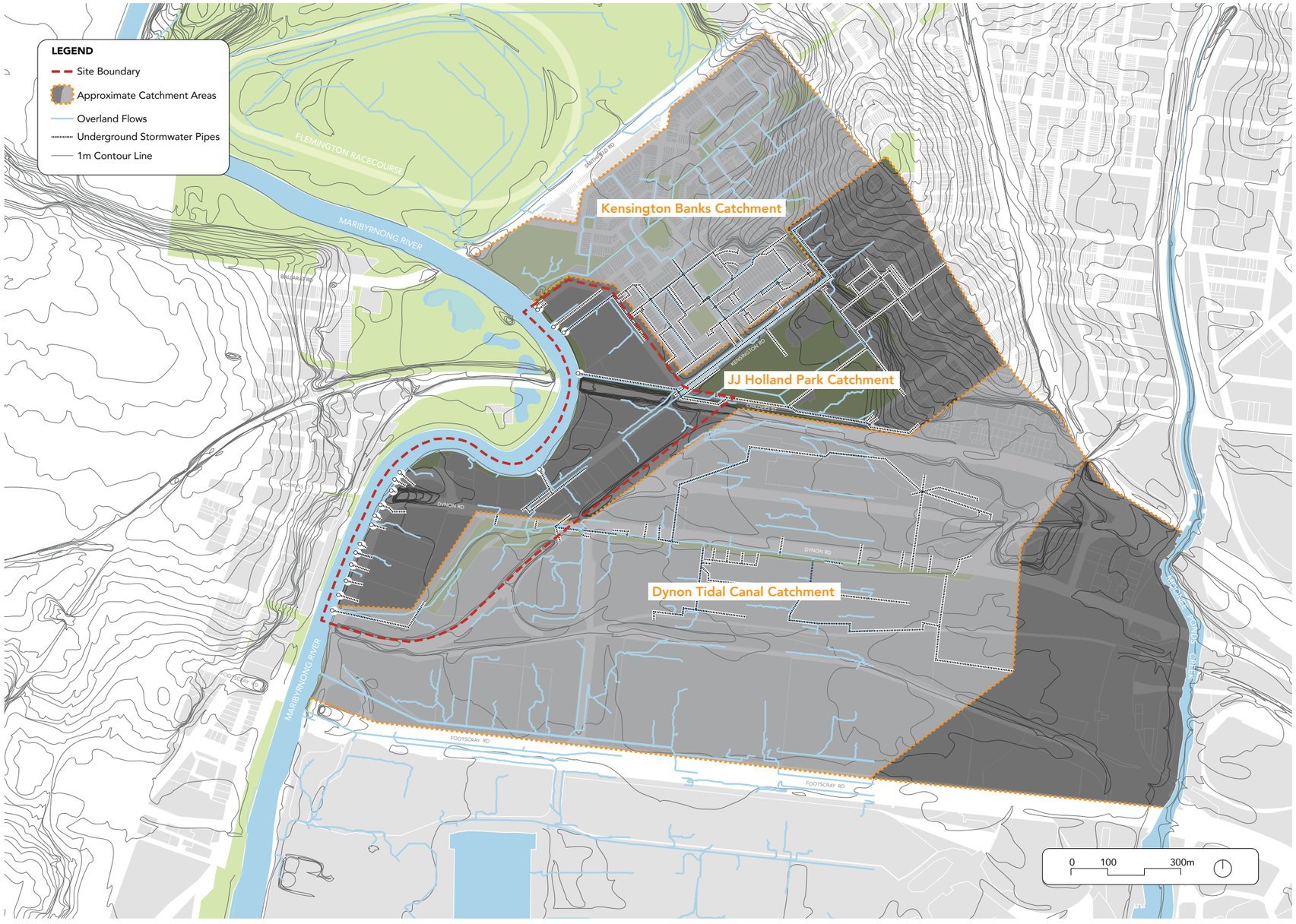


Figure 13: Extent of Land Subject to Inundation Overlay, data source City of Melbourne.

2.5 Development

Growing Population

City of Melbourne is predicted to increase in population from 162,668 people in 2017 to 386,029 in 2041. A huge proportion of this growing population will find home in the city's urban renewal areas, such as Arden, Macaulay, Lorimer and Maribyrnong Waterfront. All of these areas are significantly affected by flooding.

To accommodate a mix of uses, particularly residential, the impact of flooding needs to be managed appropriately and sustainably prior to the rolling out of development.

Plan Melbourne 2017-2050

Plan Melbourne identifies Dynon of which the Maribyrnong Waterfront is part of as a urban renewal area of state significance.

The Dynon urban renewal area will take advantage of underutilised land close to jobs, services and public transport. It will accommodate future housing and employment growth and make use of existing infrastructure.

Policies that affect Maribyrnong Waterfront include:

Policy 6.5.2 Protect and enhance the health of urban waterways

> The impacts of climate change—combined with urban development from Melbourne's growing population— influence the quantity, velocity and quality of urban stormwater run-off and pose a number of challenges for the health of Melbourne's waterways. Objectives and performance standards within planning schemes must be strengthened to minimise the impacts of stormwater.

Policy 4.1.4 Protect and enhance the metropolitan water's edge parklands

> Significant water's edge parklands such as Maribyrnong river are essential to the health and well-being of local communities. They also attract tourists and events that generate significant revenue streams for businesses and are the source of considerable historical and cultural importance to Aboriginal Victorians.

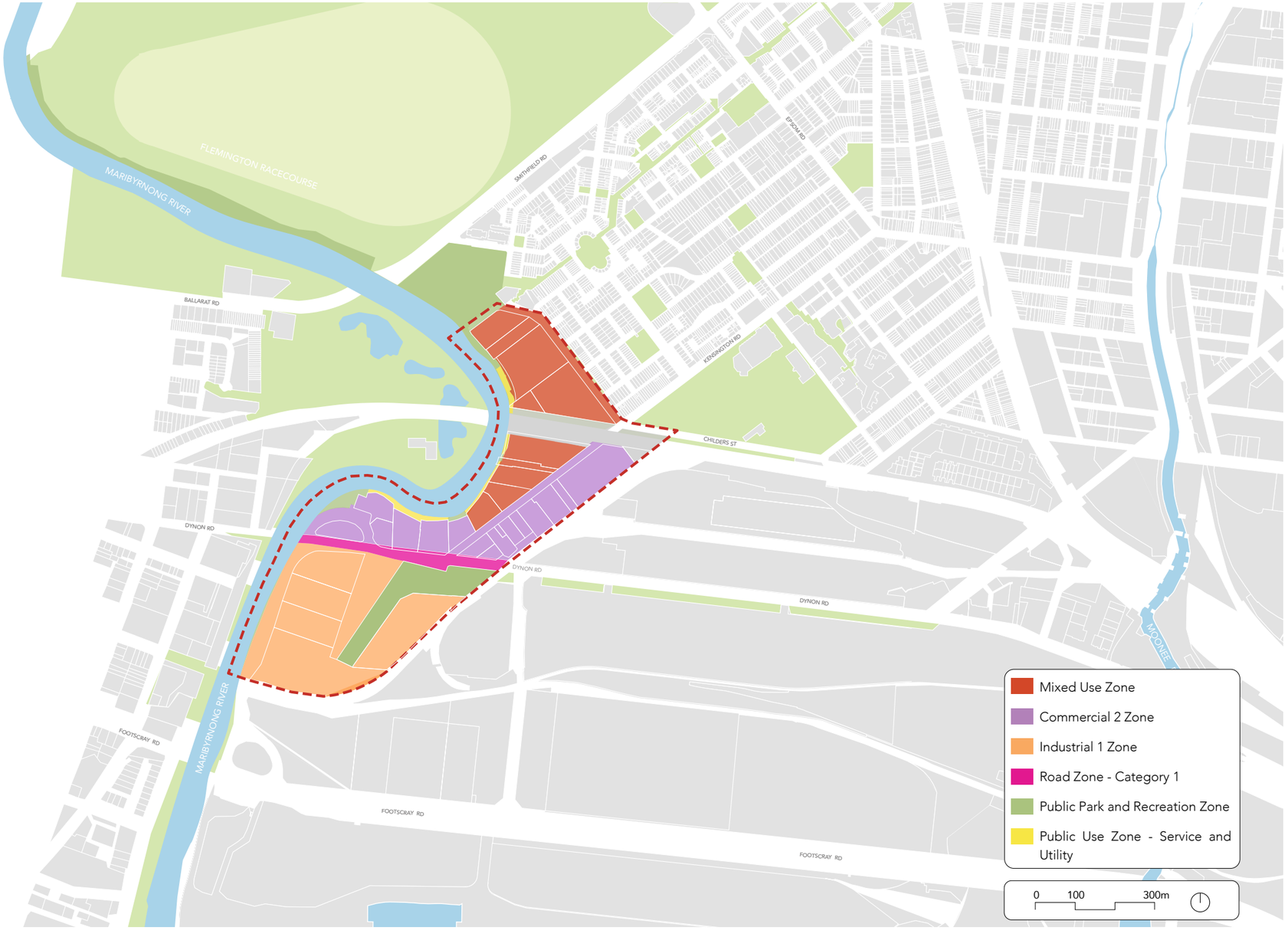


Figure 14: Sourced, Melbourne Planning Scheme – 04 Zone Overlays (planningschemes.dpcd.vic.gov.au). Existing planning zones clipped to study area.

Urban Development

Amendment C124 (Sep 2010) and Amendment C221 (April 2017) have facilitated future development potential on a series of land parcels for a mix of uses including residential.

To allow mixed use development, Melbourne Water are required to approve a suitable flood management strategy with a 1 in 100 year AEP flood protection drainage standard, as illustrated opposite. The current strategy proposes:

1. A raised section in Hobsons Road to 2.45m AHD
2. A raised section in Kensington Road to 2.45m AHD
3. A continuous barrier along the Maribyrnong River being formed once all properties fill for mixed use development. Floor height for development will be
4. A minimum lot level of 3.0m AHD
5. A pump at the junction of Hobsons and Kensington Road. This will pump catchment flood waters back into the Maribyrnong

The Melbourne Water strategy is funded by drainage contributions paid when development occurs. All developable properties pay a drainage contribution on the basis of the development size and the development type. Contributions include a hydraulic component which funds the flood protection works.

Contributions for each scheme are calculated so the income derived from contributions is designed to equal the planned expenditure over the expected life of a scheme, using a discounted cash flow methodology.

Although this strategy will unlock land for safe and economically viable development, it does however pose several disadvantages including:

- Poor activation at the street interface due to increased floor heights
- A system reliant on a fully functioning pump
- Underground pipes with a fixed drainage capacity
- Sequential development will not deliver a fully functioning strategy until all development is complete
- Loss of mature street trees to implement raised sections of Kensington Road
- Broken view corridors along Kensington Road and Hobsons Road due to raised street sections
- Poor interface and connection between the river and new development
- No consideration of future renewal or land use change in the immediate area

First mixed use development on Hobsons Road

Figure 15: Melbourne Water – Hobsons Road Scheme, 2018

2.6 Future Flooding

Fluvial Flood Patterns - Year 2100

To understand the effects of the river on the Maribyrnong Waterfront, fluvial flooding has been mapped independently to pluvial flooding. This will inform appropriate mitigation approaches that manage fluvial flooding in the study area and wider catchment.

Points A to G on the plan opposite indicate varying ground levels along the banks of the river. Fluvial flooding occurs when these levels are breached.

In the year 2100 the Maribyrnong River will break its banks in all flood events flooding the Maribyrnong Waterfront. Water will also backup through the storm water pipe network via the river outlets creating local flooding. In addition anticipated sea level rise will significantly increase fluvial flooding levels.

Long duration storms are required to cause this type of flooding. It is estimated that with half a day of downpour the river could start flooding into the over bank areas and a day or more would reach peak flood levels. In these events flooding may remain for 2 to 3 days after the event.

To mitigate fluvial flooding the river bank levels must be raised to an appropriate level to prevent breaching in a 1 in 100 AEP event with sea level rise. Drains must also be modified to prevent backup.

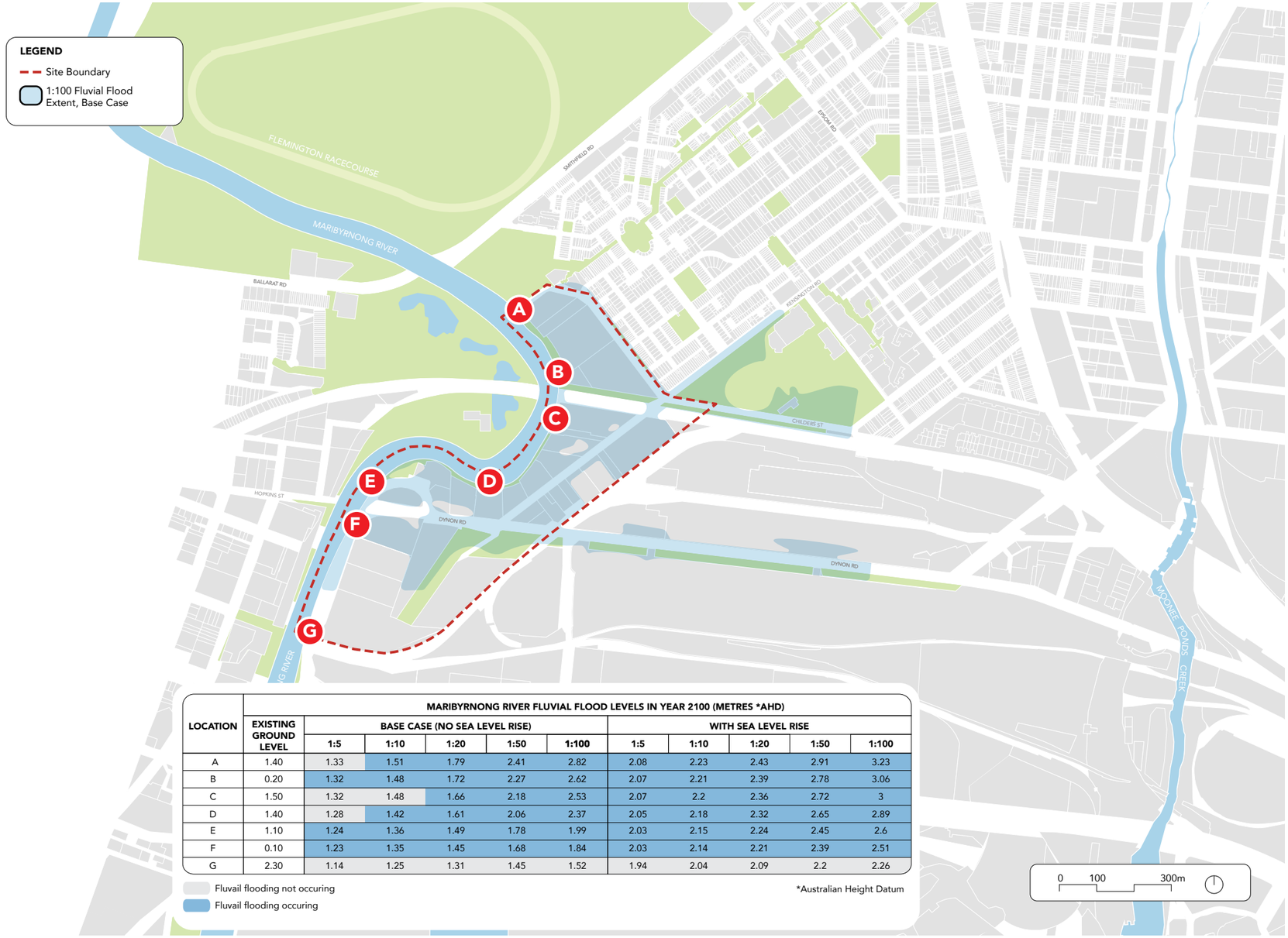
Modelling Parameters

The fluvial flood modelling used a one-dimensional model based on the HEC-RAS software platform. Being of the river channel only, it does not provide flood levels in the floodplain areas. Catchment flows from a hydrological model were provided by Melbourne Water. At the time of preparing this report flows were not available for 2100 year 19.5% increase in rainfall intensity and is not included in the modelling opposite.

The hydraulic model extends upstream from the investigation area as well as downstream to the confluence with the Yarra River and Port Phillip Bay. At the downstream end the water level in the model is fixed using Port Phillip Bay storm tide levels provided by Melbourne Water.

The model was run for a range of catchment inflow events. These were paired with the same probability storm tide. For example a 1 in 100 (1% AEP -annual exceedance probability) catchment inflow was paired with a 1 in 100 storm tide level. A 1% AEP flood equates to a flow which has a 1% chance of occurring or being exceeded in any year. It is more likely that these events would occur independently. For the sea level rise scenario the storm tide levels were increased by 0.8 m.

The table right show the estimated 1% AEP fluvial flood extent for existing conditions, i.e., without sea level rise.



LOCATION	EXISTING GROUND LEVEL	MARIBYRNONG RIVER FLUVIAL FLOOD LEVELS IN YEAR 2100 (METRES *AHD)									
		BASE CASE (NO SEA LEVEL RISE)					WITH SEA LEVEL RISE				
		1:5	1:10	1:20	1:50	1:100	1:5	1:10	1:20	1:50	1:100
A	1.40	1.33	1.51	1.79	2.41	2.82	2.08	2.23	2.43	2.91	3.23
B	0.20	1.32	1.48	1.72	2.27	2.62	2.07	2.21	2.39	2.78	3.06
C	1.50	1.32	1.48	1.66	2.18	2.53	2.07	2.2	2.36	2.72	3
D	1.40	1.28	1.42	1.61	2.06	2.37	2.05	2.18	2.32	2.65	2.89
E	1.10	1.24	1.36	1.49	1.78	1.99	2.03	2.15	2.24	2.45	2.6
F	0.10	1.23	1.35	1.45	1.68	1.84	2.03	2.14	2.21	2.39	2.51
G	2.30	1.14	1.25	1.31	1.45	1.52	1.94	2.04	2.09	2.2	2.26

Fluvail flooding not occuring
Fluvail flooding occuring

*Australian Height Datum

Figure 16: Indicative extent of 1 in 100 AEP fluvial flooding within the Maribyrnong Waterfront catchments. Refer to appendix for detailed mapping.

Pluvial Flood Patterns - Year 2100

Pluvial flows often move independently to fluvial. Understanding pluvial flooding will ensures pluvial storm water can be appropriately detained whilst fluvial river levels return to base flow. The detained pluvial storm water can then be purified and slowly released back into the river or recycled within the catchment. Understanding pluvial flooding will determine appropriate detention volumes required across study area and wider catchment.

An approximately 180 ha urban catchment drains to the Maribyrnong Waterfront area and before flowing into the Maribyrnong River either as channel flow, overland flow or through the stormwater pipe network.

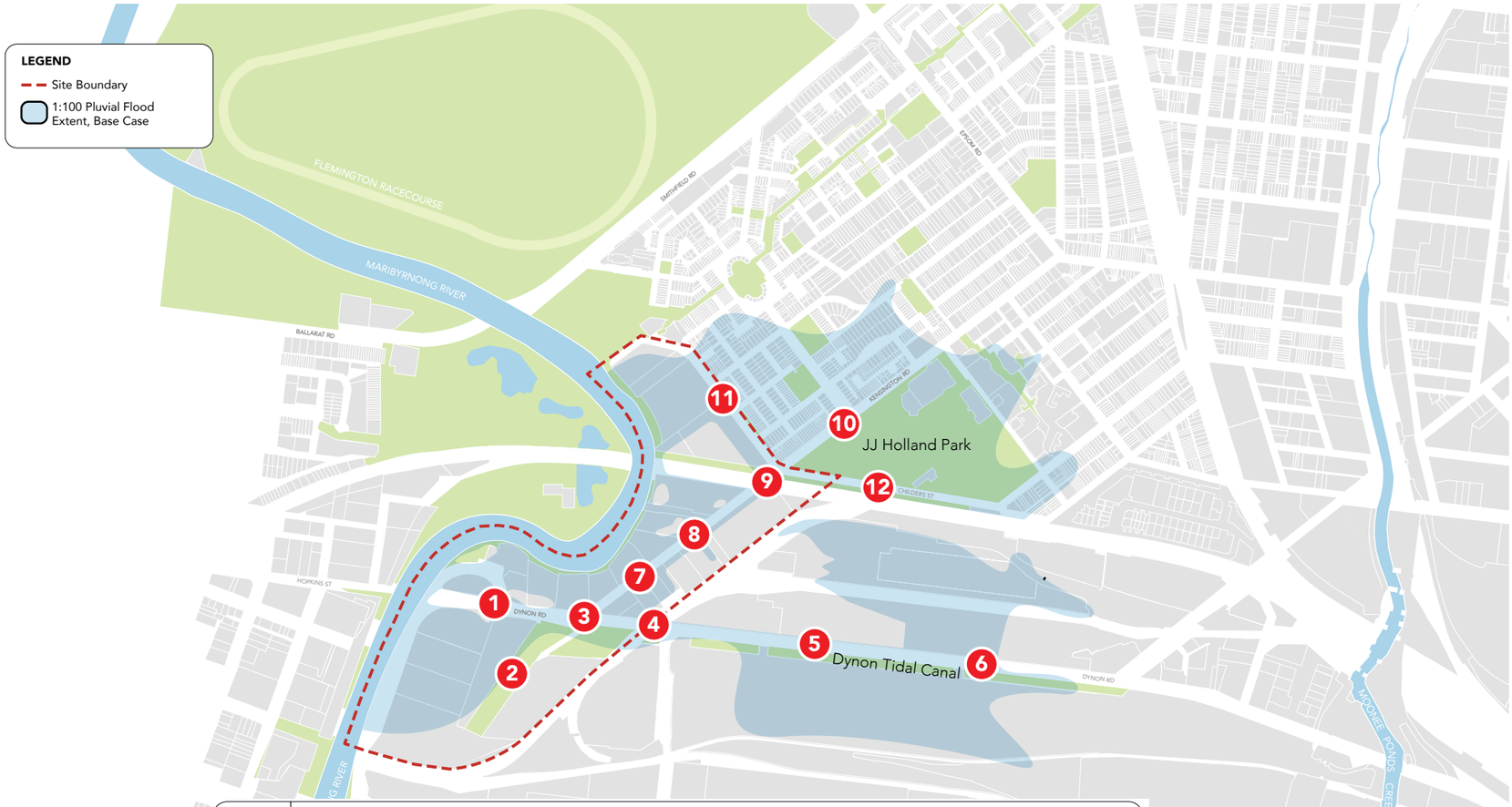
There are two main drainage areas within this catchment; one that drains to the Dynon Tidal Canal and the other to the JJ Holland Park. In larger events there can be break out flow from the JJ Holland Park catchment into the Dynon Tidal Canal catchment. Compared with the fluvial flooding of the Maribyrnong River it result from relatively short and intense storms, typically one to two hours, and the flooding may only remain for several hours rather than days.

Points 1 to 12 indicate existing ground levels and depth of pluvial flood waters in any given event. Any water level deeper than 50mm is considered pluvial flood. These volumes of water need to be conveyed to a suitable detention area for safe storage.

Modelling Parameters

The Pluvial flood modelling used a RORB hydrological catchment model and a two-dimensional TUFLOW hydraulic model. The RORB model calculates the stormwater runoff which is fed into the hydraulic model. The RORB model was run with 19.5% rainfall intensity increase by 2100. The hydraulic model established the flood extent, height, depth and velocity based on ground levels and stormwater pipe network. It is unlikely that a river flood event will occur at the same time as a short duration intense local storm, river tide levels were adopted for the Maribyrnong River. As with the fluvial flooding the 1% AEP pluvial storm event was paired with the 1% AEP storm tide level in Port Phillip Bay; it was assumed the same tide level would occur in the river at the location of the precinct as occurs in Port Phillip Bay. Whilst it is unlikely that the pluvial storm event and tide event would occur simultaneously, it provides a slightly conservative analysis but also accounts for storm tide inundation which could occur independently from the pluvial flooding. The model was run with 0.8m sea level rise using the same Port Phillip Bay storm tide levels as documented for the Maribyrnong River flood assessment.

The figure right shows 1% AEP pluvial flood extent and lists flood levels at selected locations. An indicative depth of flooding can be calculated for each location by subtracting the ground level (provided in the table) from the flood level.



LOCATION	EXISTING LEVEL	CATCHMENT PLUVIAL FLOOD LEVELS IN YEAR 2100 (METRES *AHD)									
		BASE CASE (NO SEA LEVEL RISE)					WITH SEA LEVEL RISE				
		1:5	1:10	1:20	1:50	1:100	1:5	1:10	1:20	1:50	1:100
1	1.70	N/A	N/A	N/A	N/A	1.80	2.20	2.20	2.20	2.20	2.24
2	1.00	1.43	1.52	1.61	1.74	1.79	2.20	2.20	2.20	2.20	2.24
3	1.11	1.52	1.57	1.64	1.75	1.80	2.20	2.20	2.20	2.20	2.24
4	1.40	1.58	1.59	1.64	1.75	1.81	2.21	2.21	2.21	2.21	2.24
5	0.80	2.00	2.09	2.18	2.24	2.28	2.24	2.26	2.28	2.31	2.36
6	1.20	2.03	2.11	2.20	2.26	2.30	2.25	2.27	2.29	2.33	2.38
7	0.80	1.52	1.57	1.64	1.75	1.80	2.20	2.20	2.21	2.21	2.24
8	1.30	1.52	1.57	1.64	1.74	1.80	2.20	2.20	2.20	2.20	2.24
9	1.10	1.52	1.57	1.63	1.74	1.80	2.20	2.20	2.20	2.20	2.24
10	1.50	1.63	1.71	1.78	1.84	1.88	2.20	2.20	2.20	2.21	2.25
11	1.20	1.42	1.45	1.50	1.62	1.68	2.20	2.20	2.20	2.20	2.22
12	1.50	1.90	2.01	2.08	2.16	2.22	2.20	2.22	2.26	2.32	2.36

Pluvail flooding not occuring
Pluvail flooding occuring

*Australian Height Datum

Figure 17: Indicative extent of pluvial flooding within the Maribyrnong Waterfront catchment. Refer to appendix for detailed mapping.

2.7 Study Site

A contextual photographic study reveals potential public realm opportunities within the site. This will ensure water management is integrated appropriately within its context and inform a conceptual framework built on the existing characters of place not just flood modelling.

1. Pedestrian and cycle pathway adjacent to the Maribyrnong River looking north
2. View north towards Stock Bridge
3. Northern entry to site at end of Hobsons Road looking towards existing residential building
4. Tidal Canal adjacent to Dynon Road. Current condition of the canal is polluted however holds significant ecological value in its urban context
5. Landscaped and road level change between Hobsons Road and Kensington Estate
6. View of Maribyrnong River and study site from Western side of the river
7. Newells Paddock Wetlands Reserve a significant ecological asset in the region-.
8. Historical buildings and parking lot adjacent to railway corridor
9. Pedestrian and cycle pathway adjacent to the Maribyrnong River north of railway corridor
10. Dynon Rd Tidal Canal outlet culvert
11. Kensington Road railway bridge underpass
12. View towards northern aspect of Hopkins Street/ Dynon Road Bridge from Maribyrnong River
13. Heavenly Queen Temple - view from study site

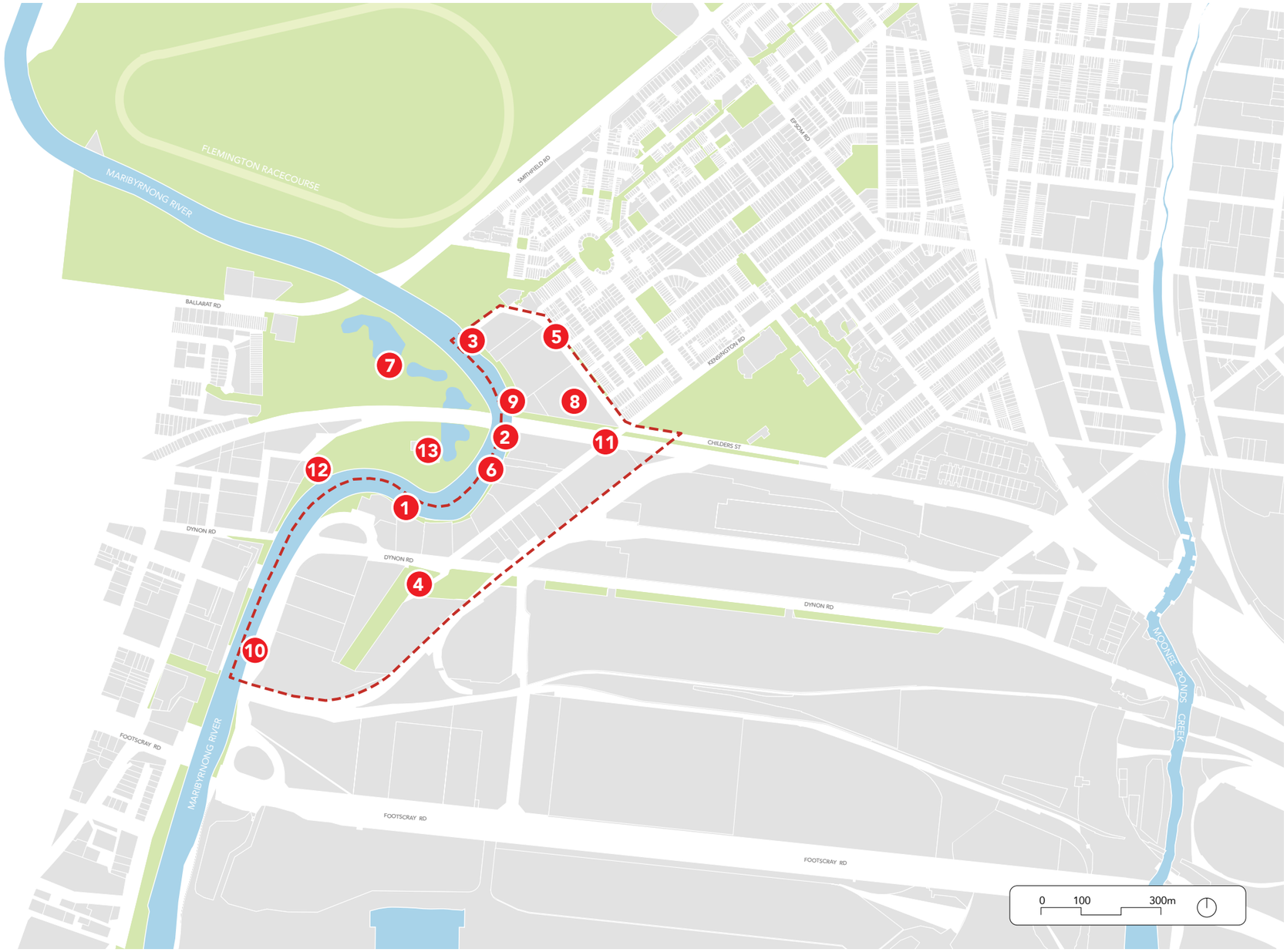
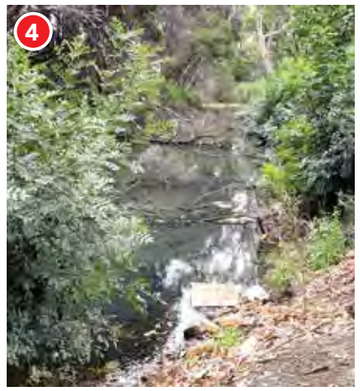
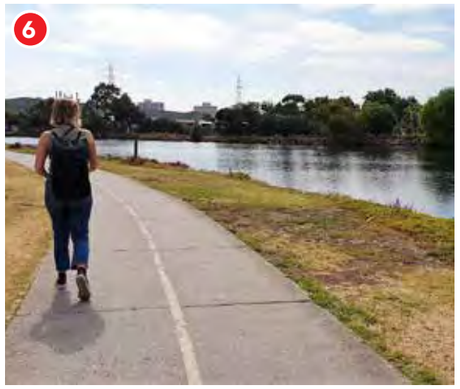


Figure 18: Site photo location reference plan





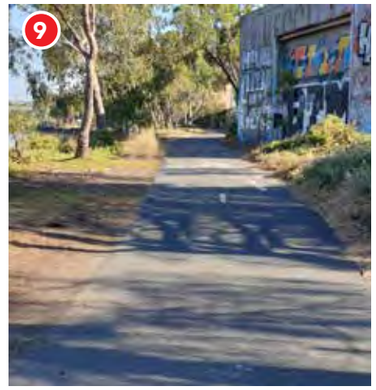





Figure 19: Site photos, February 2019

3.1 A Blue-Green Future

Liveability

Identifying Maribyrnong Waterfront's potential public realm opportunities ensures the successful integration of blue-green infrastructure. This will provide greater urban value and liveability, creating co-benefits for capital investments. Within the study area these include;

- The pedestrian and cycle network that could take advantage of unbroken, elevated levee and conveyance paths
- Open spaces that could provide multifunctional recreation and detention areas such as water plazas
- Community assets that could positivity demonstrate and celebrate water in the landscape
- Landforms and infrastructure that could control storm water flows whilst provide safe passage for inhabitants
- River pedestrian and cycle crossings that could better connect communities
- The tidal canal that could improve degraded ecosystems, ecological connectivity and establish blue-green infrastructure for future renewal
- Hard infrastructure such as rail lines and electrical pylon easements that could establish linear blue-green parks

Utilising these opportunities will ensure water management is integrated within its context to increase recreation and social value, improve micro climates, provide synergy with traffic planning and facilitate economic and development growth.

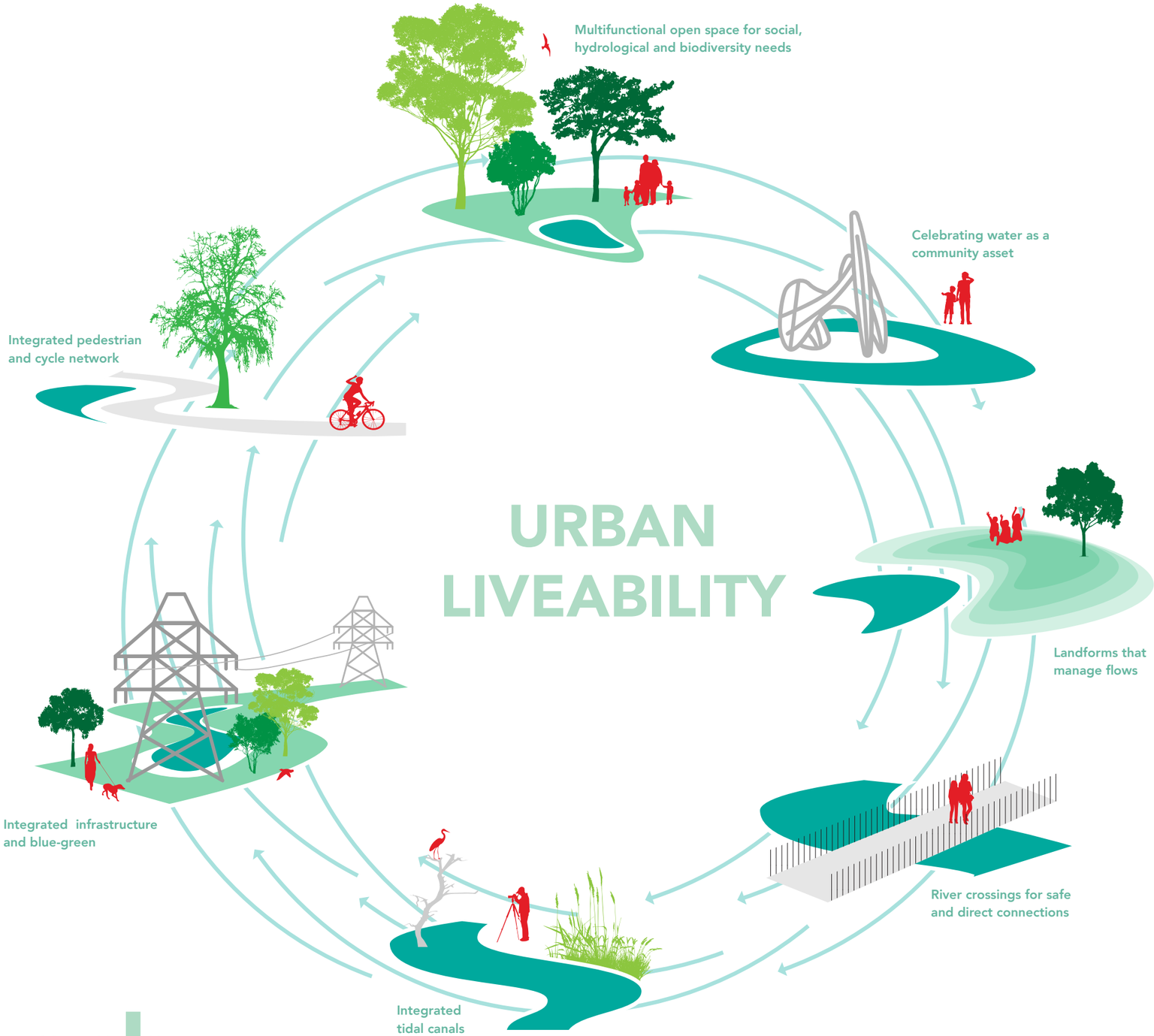


Figure 21: Urban Liveability

3.0 Approach

Multifaceted Approach

The increased pressures posed by flooding require innovative methods in storm water management over and above the singular conventional infrastructural solutions. The blue-green infrastructural solution integrates a multi faceted approach to storm water management within the public and private realm. Blue-green aims to go beyond the narrow focus of a single problem, to not only manage flood waters, but offer greater value to community and environmental health and liveability, including:

1. Increased green space offering
2. Improved micro-climates, such as reduced urban heat island effect
3. Improved water quality through natural filtration
4. Wider opportunities for urban forestry and biodiversity
5. Greater adaptive capacity for a fluctuating climate

Applying this approach in Maribyrnong Waterfront will provide an effective flood management solution providing:

6. A safe living environment, with protection to habitat, life and property
7. Aesthetically desirable urban design outcomes
8. Greater drainage system capacity
9. Resilient community living, that embraces flood water as a visible part of the landscape character
10. Reduced long term maintenance and upgrade costs

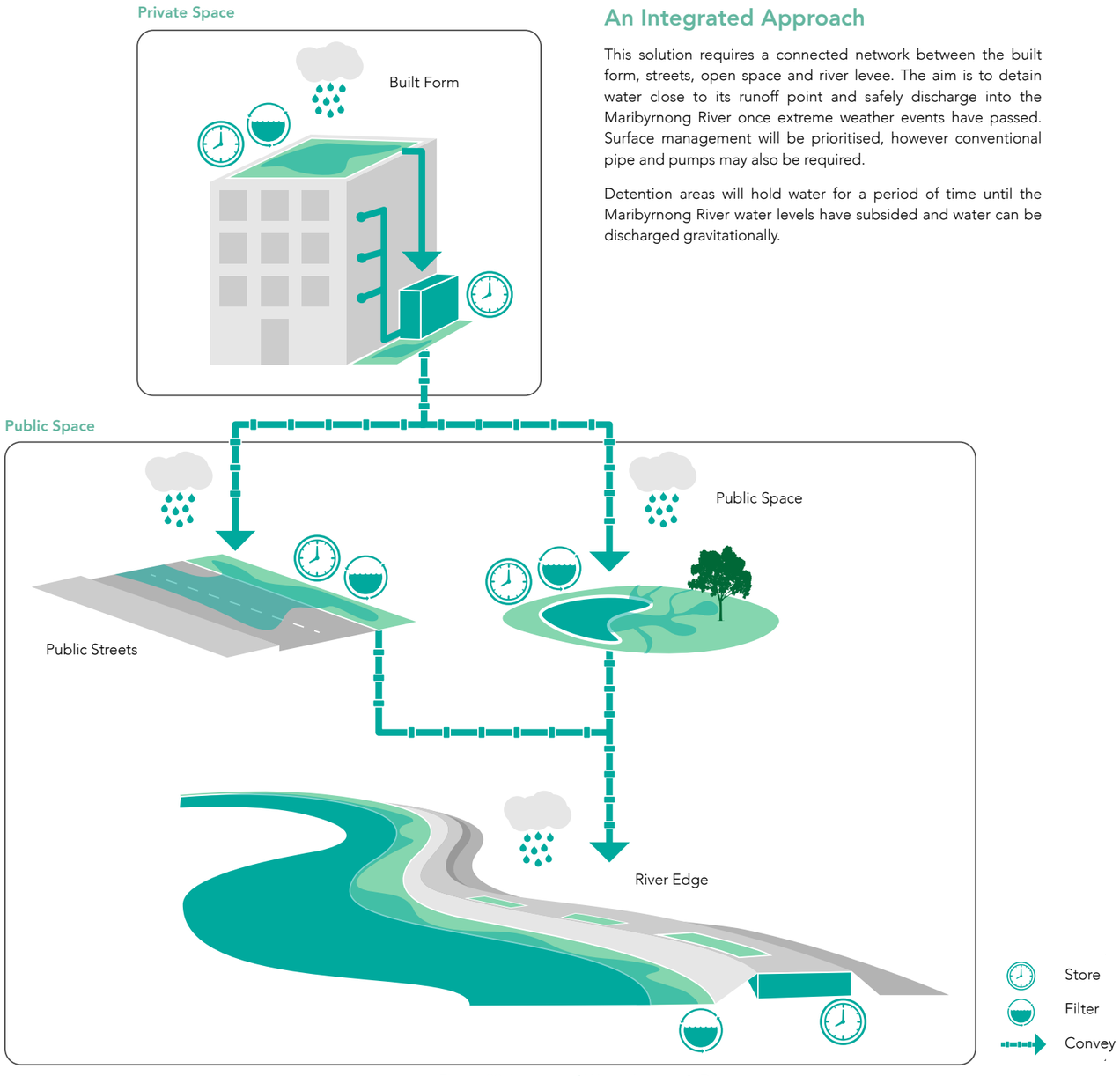


Figure 20: Integrated Water Approach Diagram

An Integrated Approach

This solution requires a connected network between the built form, streets, open space and river levee. The aim is to detain water close to its runoff point and safely discharge into the Maribyrnong River once extreme weather events have passed. Surface management will be prioritised, however conventional pipe and pumps may also be required.

Detention areas will hold water for a period of time until the Maribyrnong River water levels have subsided and water can be discharged gravitationally.

4.1 Pedestrian + Cycle Network

There are a number of particular challenges surrounding safety and accessibility for pedestrians and cyclists. The area's industrial history has resulted in large block sizes and wide streets that prioritise cars and trucks instead of pedestrians and cyclists. Whilst there are cycling trails along the river's edge, there are limited opportunities to safely access these trails from the surrounding context.

This strategy provides the opportunity to integrate new and improved pedestrian and cycle connections with proposed water management infrastructure.

Opportunities

1. Second access route through Kensington Banks, crossing the rail corridor at Bellair Street through the existing pedestrian underpass and linking parkland along the journey. Access through the site to the river would provide a new blue-green street.
2. A continuation of pedestrian/cycle movement from Childers Street, through an improved Kensington Road crossing provides a river connection and blue-green corridor.
3. A reconfiguration of the existing river edge pedestrian/ cycle path provides multi-level paths connecting to the rivers edge and safe access during flood events.
4. Extending the pedestrian/cycle route over Dynon Road bridge on the north and south side and into Footscray provides safe access over the river.
5. Pedestrian/cycle connection through the Dynon Wildlife Reserve connects the reserve back to the river.
6. A new trail to the south of the tidal canal, as part of a widening of the ecological corridor, links back to the river. Further work will be required to understand the impacts on the existing biodiversity corridor and wildlife.
7. A underpass connection provides improved north south permeability.
8. The future renewal of Dynon gives potential to connect, through a new rail corridor underpass, to Kensington Road and the river.
9. Using the existing rail corridor provides a long term vision of creating a high line across the existing rail bridges at Dynon Road and the river and linking in with Footscray Arts Centre.
10. Future renewal of Dynon provides opportunity for further pedestrian/cycle connections, linking in with South Kensington Station underpass and connections to the north.

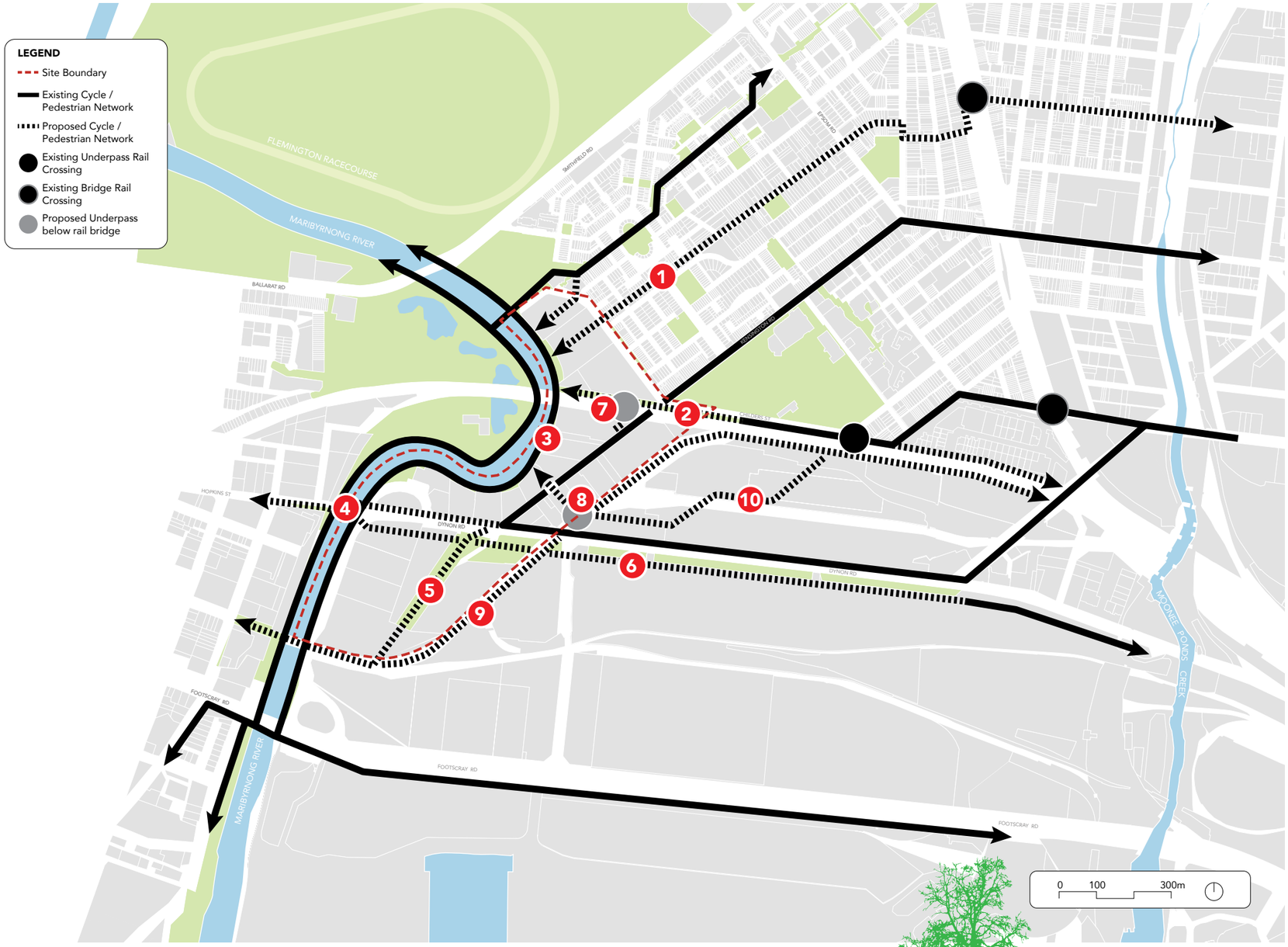


Figure 22: Existing and proposed pedestrian and cycle networks

4.0 Synthesis

4.2 Open Space

The current open space offering services the existing community, however a large proportion has reached user capacity and is at risk of regular flooding reducing the usable user time.

Aligning blue-green water management alongside new and existing open spaces provides a greater open space offering to the community.

Opportunities

1. Blue-green corridor through Kensington Banks connects existing parklands.
2. A multi-use community precinct with an array of blue-green initiatives and water retention opportunities.
3. The Maribyrnong River Valley Design Guidelines, 2010, suggest a 30m public access along the river's edge. This allows for a range of access requirements for river activities,access to property frontages, flood mitigation initiatives and a range and intensity of urban activity. The nominated land widths are based on 30 metres for riparian vegetation corridor (SPPF clause 15).
4. Indicative community open space connecting the Dynon/ Kensington Roads intersection and Dynon Wildlife Reserve with the river and through to Dynon urban renewal area.
5. The extension of the Dynon Wildlife Reserve with the relocation of Citywide Waste Management provides additional habitat area and water retention opportunities.
6. Potential for a high line corridor over the river once rail infrastructure becomes redundant.
7. Future extension of the river frontage corridor and flood mitigation initiatives.
8. Blue-green corridor along Childers Street and link across rail corridor to Arden St.
9. Blue-green corridor along Lloyd Street to Arden urban renewal area.
10. Future blue-green corridor with the renewal of Dynon below the existing electrical pylons.
11. Future widening of the tidal canal ecological corridor would provide extensive blue-green opportunities. Further work will be required to understand the impacts on the existing biodiversity corridor and wildlife.
12. Future blue-green spine as part of Dynon's renewal.
13. Future opportunities for a municipal open space as part of Dynon's renewal.
14. Significant open space is provided on the opposite banks of the river, which could be leveraged off with better river connections.

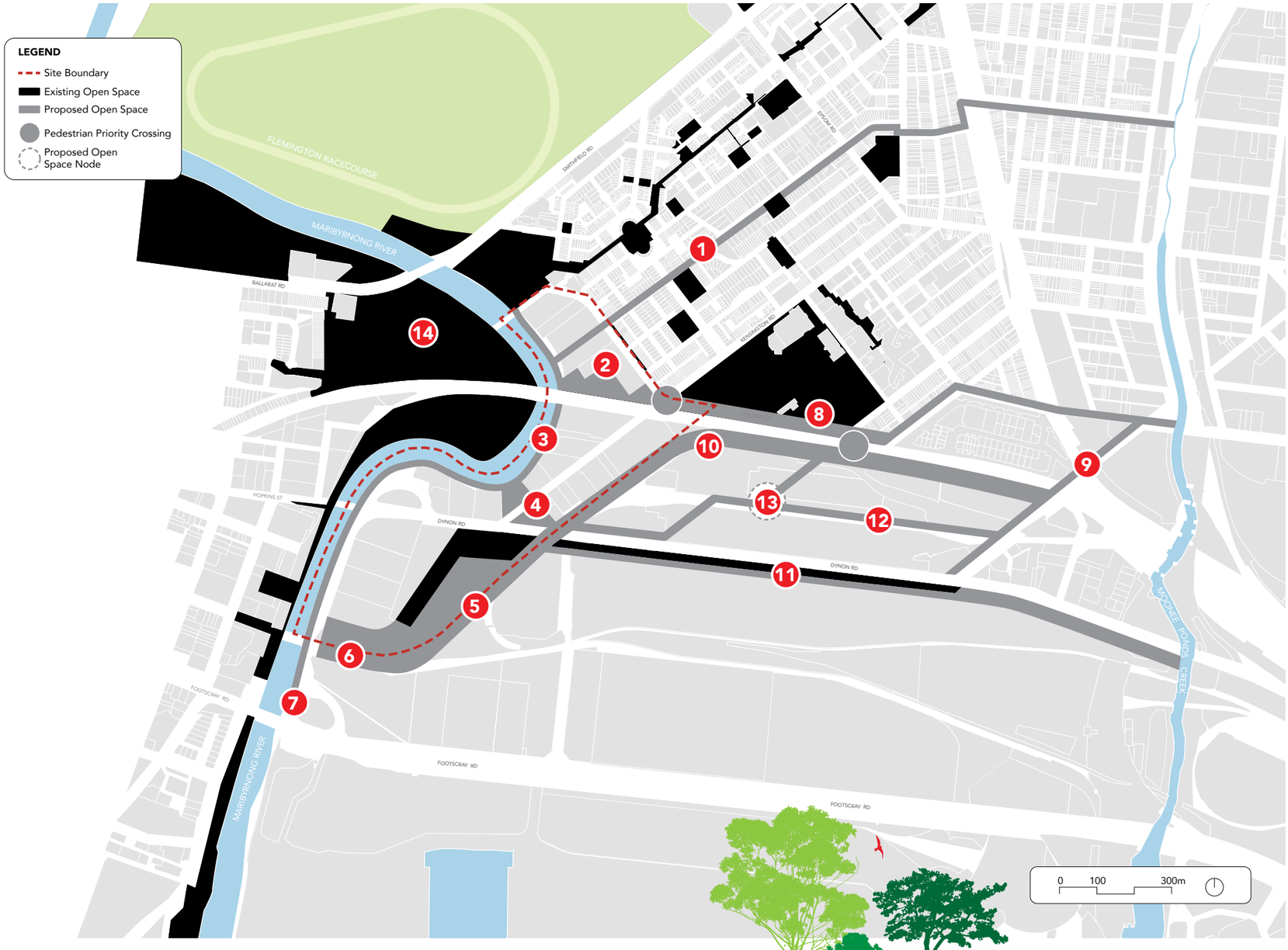


Figure 23: Existing and proposed open space

4.3 Community Assets

Creative spaces populate the footscray side of the river and south of the study area. Active recreation is provide north and east, where as the iconic Heavenly Queen Temple sits centrally to all these on the S-bend of the river.

1. Kensington Tennis Courts
2. Kensington Community Recreation Centre YMCA
3. Kensington Community Children's Co-Operative
4. South Kensington Station
5. Heavenly Queen Temple
6. River Studios
7. Footscray Community Arts Centre
8. Waterside Metal Art Studio
9. Big fish Workshop

Linking these assets and providing additional amenities for the growing community will strengthen the social infrastructure provision through creativity and recreation. Positioning these with blue-green infrastructure celebrates flooding as part of the identity of place.

Opportunities

10. The only heritage buildings in the site offer an ideal opportunity to provide a community hub. A youth and arts focus leverages off the proposed youth recreation and existing creative facilities.
11. Transition structures designed to manage fluvial flood waters double up as art opportunities.
12. Linking views and connections to the Heavenly Queen will reveal this as a place making opportunity.

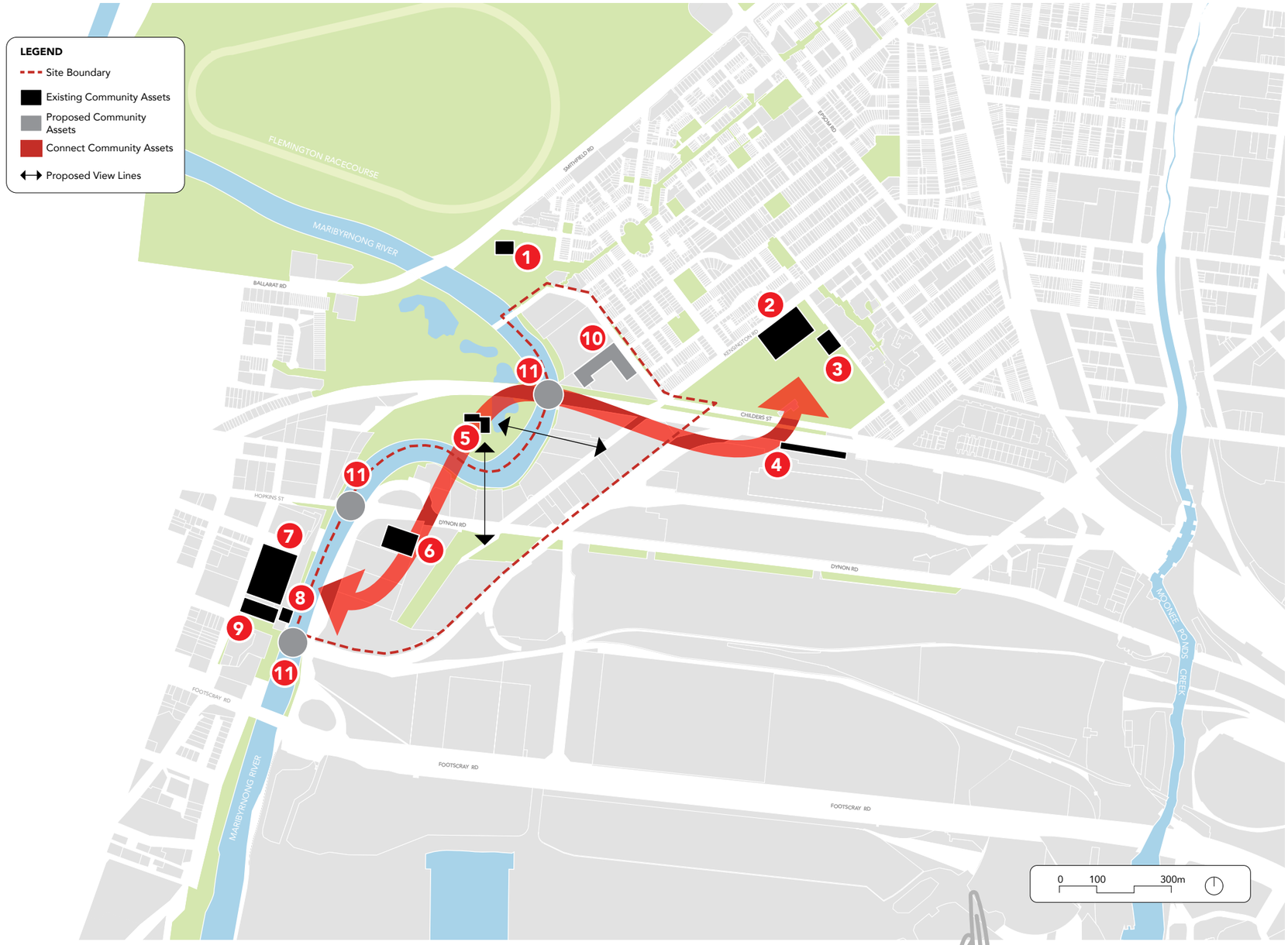


Figure 24: Existing and proposed community assets

4.4 Landforms

The levels across the site create flood hotspots, particularly at key movement junctions. Low road areas below bridges would need to be maintained for large vehicle access, even if adjacent road levels are raised in the future.

Existing rail infrastructure provides the greatest elevation to the area and future potential re-appropriation for viewing and safe passage.

Taking advantage of the existing land form to control and convey flows will manage storm water on the surface and create safe passage at times of flood.

Opportunities

1. A new terraced landscape with dedicated upper and lower paths and link to existing pedestrian bridge will provide a flood barrier and protection of Hobsons Road
2. Sculptural pedestrian/cycle 'tube' structure allowing for access below the rail corridor during times of river flooding
3. Transitional art wall from terraced 30 metre wide landscape corridor to Sims Street provides a flood barrier to Sims Street and Dynon Road
4. Associate flood detention areas with low lying roads subject to flooding
5. Existing elevated rail corridors with grassed embankments provide a barrier to water inundation whilst creating an opportunity to reinterpret as a high line connection
6. Extension of river dike to mitigate fluvial flooding

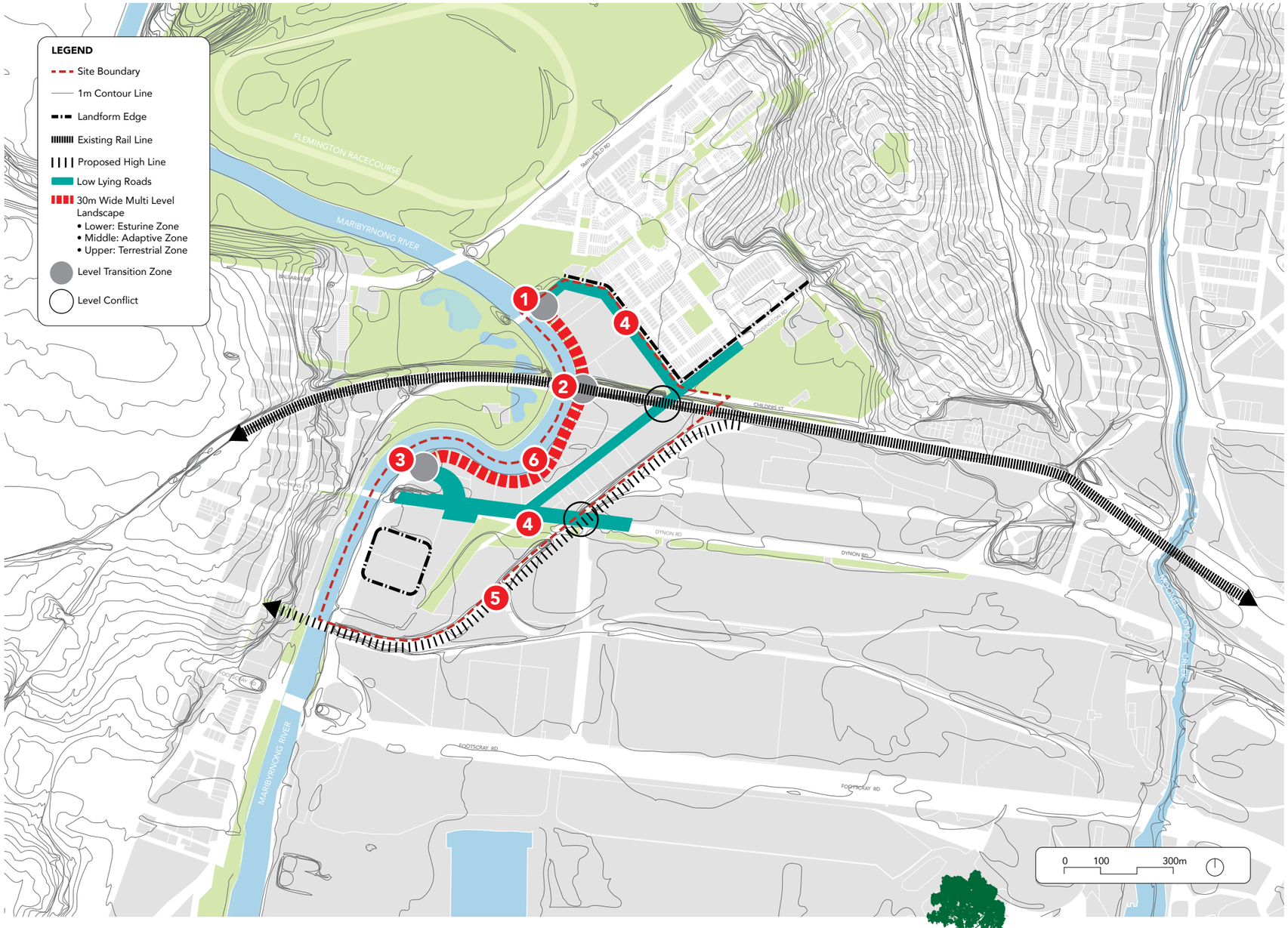


Figure 25: Existing and proposed landforms

4.5 River Crossings

Currently pedestrian and cycle bridge connections are limited along the Maribyrnong River. Crossing opportunities are often shared with high traffic bridges where all users are bottlenecked. This creates indirect and dangerous connections, particularly for more vulnerable users. These include:

Opportunities:

1. Improved connection to existing pedestrian and cycle bridge from river-front path and Hobsons Road.
2. Using the existing northern rail bridge to cantilever a pedestrian and cycle bridge as an extension of Childers Street east/west connection.
3. Using the existing southern rail bridge to cantilever a pedestrian and cycle bridge connection to the Heavenly Queen Temple and Joseph Road Precinct.
4. Connection from Kensington Road north, maximising views to the Heavenly Queen Temple.
5. Connection from Dynon Wildlife Reserve to the Heavenly Queen Temple.
6. Reconfigure Dynon Road and bridge to provide separated bike lanes.
7. Using the existing rail bridge to cantilever a pedestrian and cycle bridge as an extension of Dynon Wildlife Reserve connection to Footscray River Edge. Optionally if the rail lines become redundant in the future they could be re-appropriated to provide a pedestrian and cycle connection.

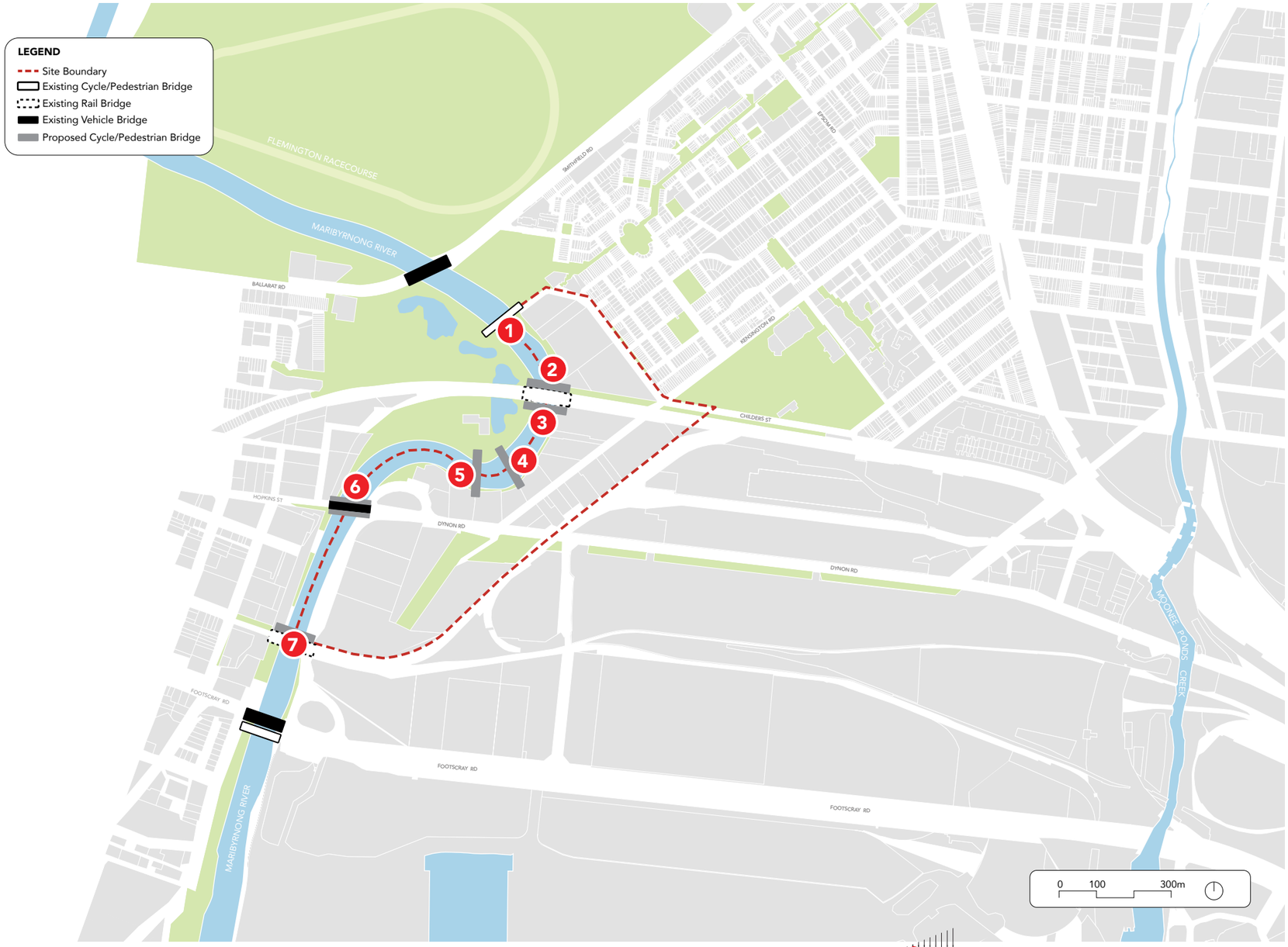
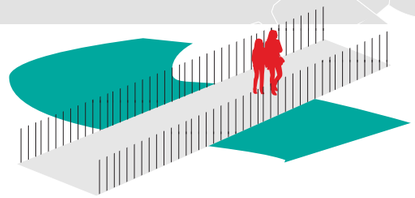


Figure 26: Existing and proposed river crossings



4.6 Tidal Canal

A drainage system in this area was constructed by the Low Lying Lands Commission in 1879 to drain the West Melbourne Lake and swamp lands.

The land was reclaimed by cut and fill, including excavation of the Coal Canal which allowed barges to deliver coal to the railways depot. This created an artificial outlet for the Moonee Ponds Creek and raised the level of the ground making it suitable for industrial uses.

The Dynon Road Canal is linked to tidal flows. The catchment north and south of Dynon Road currently feed water into the canal and an underground pipe adjacent to Dynon Road.

The canal is a biodiversity hotspot and supports varying flora and fauna. Water quality is poor and canal embankments are full of rubbish with an assortment of flora in varying states.

Opportunities

1. The canal has a drainage catchment from industrial land both north and south of Dynon Rd. This provides opportunity to treat polluted catchment run-off water before it reaches the canal, subsequently improving the canal's water quality.
2. Connect the canal to Moonee Ponds Creek by daylighting the underground stormwater pipes into a exposed blue and green canal.
3. The canal could be more visible and a significant ecological corridor in Dynon urban renewal area. In time the canal corridor could be widened to accommodate a designated people movement corridor away from the heavily trafficked Dynon Road.

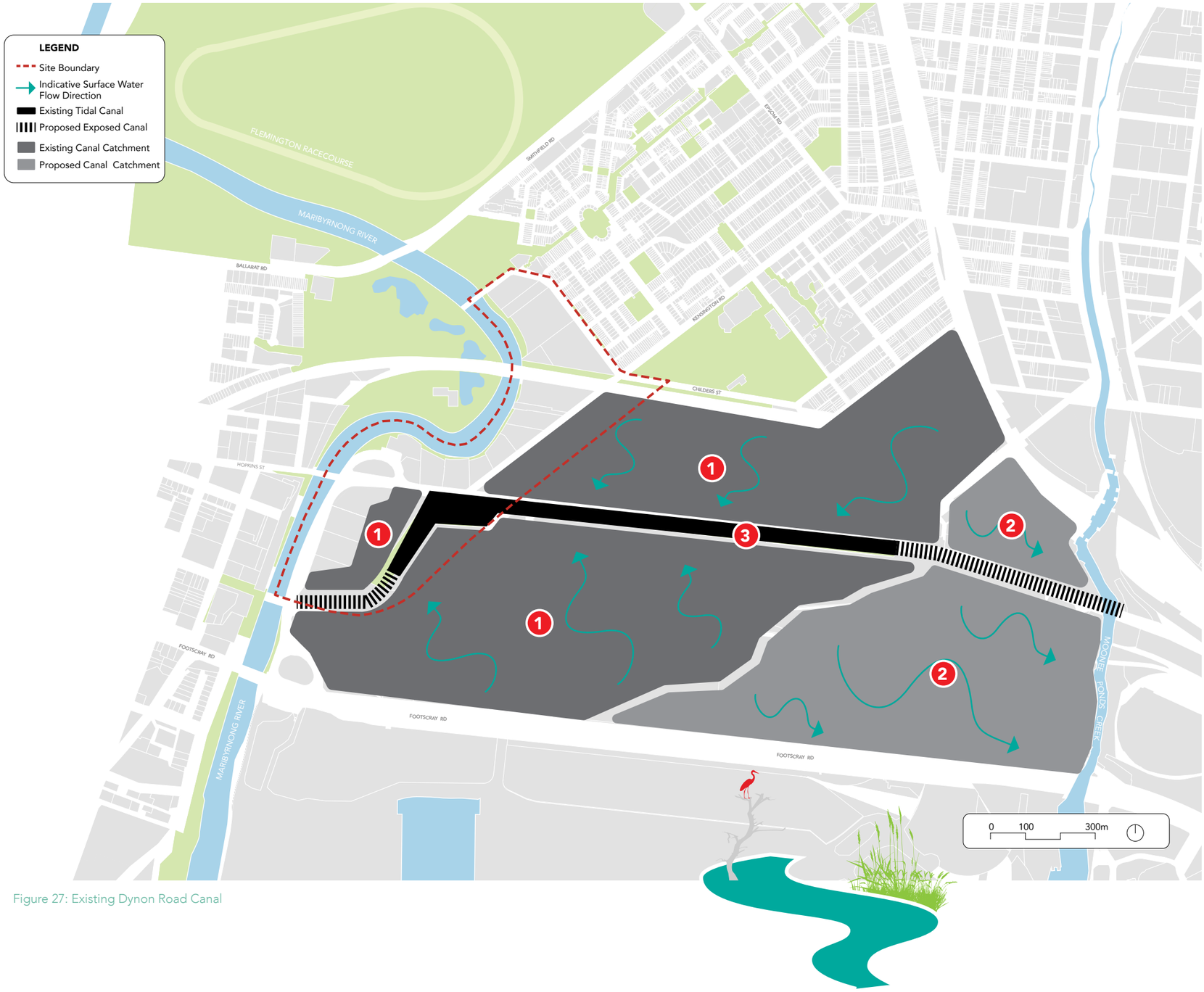


Figure 27: Existing Dynon Road Canal

4.7 Hard Infrastructure

Existing transport and servicing infrastructure currently run east/ west through the site. High power electrical pylons require a 60m easement. This restricts development opportunities within the easement. Rail lines service the industrial area of Dynon from the south of the site.

Opportunities

1. Utilise the easement alignment to deliver linear blue-green connections in the form of encumbered open space.
2. The renewal of Dynon could offer opportunity to reconfigure the rail lines as a linear high line park.

Land associated with these existing infrastructures are considered encumbered and will continue to be even if converted to open space.

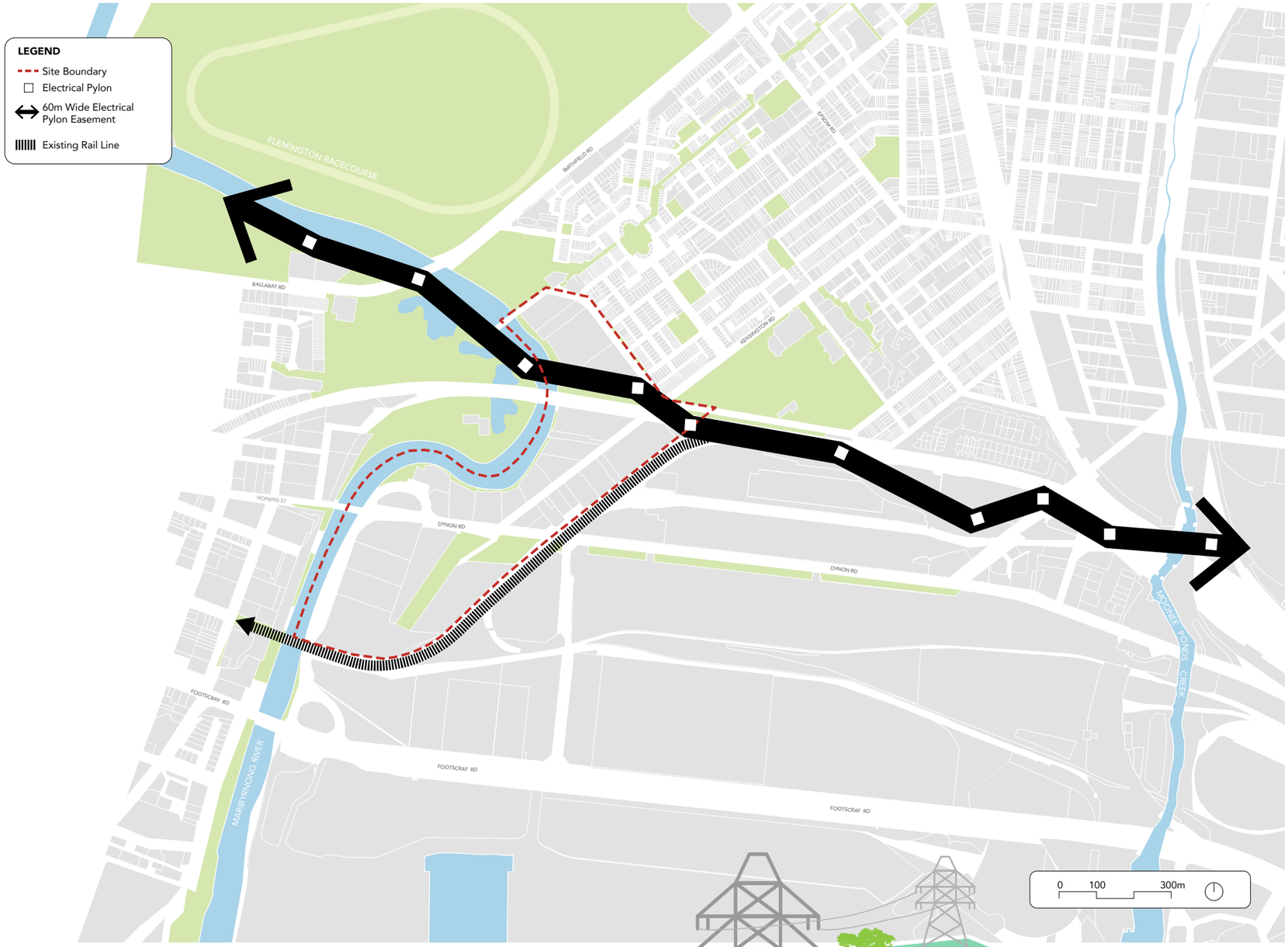


Figure 28: Existing hard infrastructure

Figure 29: Tanner Springs Park, Portland

5.1 Fluvial Approach

Fluvial flooding refers to flood waters that come from the Maribyrnong River when it bursts its banks. The approach outlined advocates an adaptive built form that leaves room for the river to swell during flood events. At the same time this built form protects infrastructure and maintains public access and safety.

Status quo:

1. Current proposed flood mitigation method is to build walls and raise buildings to protect infrastructure. This approach results in a dead street level interface and adds little urban value. Walls also act to sever connections with the waterfront.
2. Any waterfront amenity is inundated, dangerous and inaccessible during flood events.

Proposed:

3. Changing topography to raise buildings out of flood zone and adding canal intrusions into development precinct to increase waterfront length. Value adding intervention on an urban, ecological and flood mitigation level
4. Inundation allowed to occur without damaging infrastructure and allowing adjacent urban activities to continue as usual including pedestrian and cycle networks and other recreational value adding programs and activities

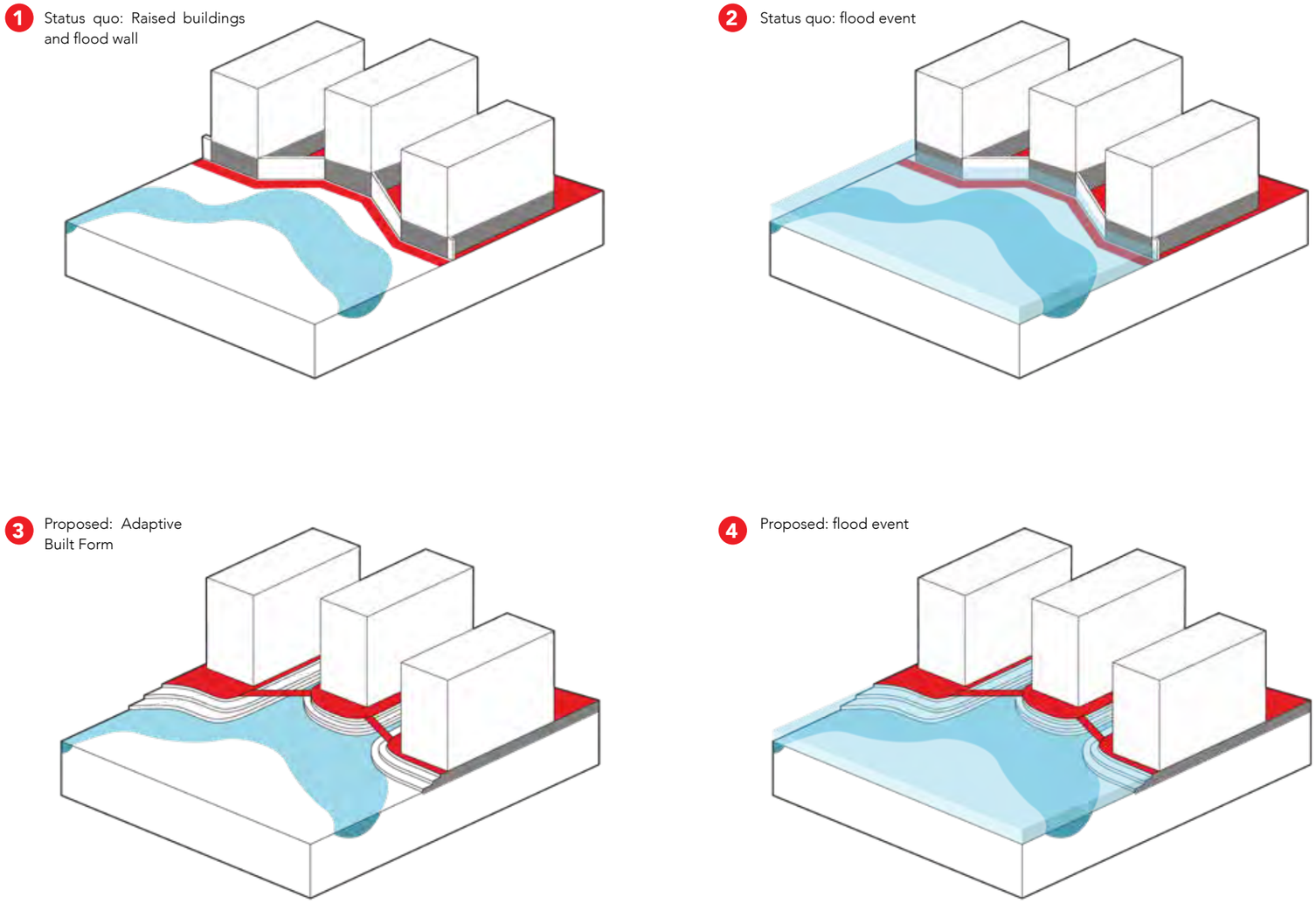


Figure 30: Indicative Fluvial Approach

5.0 Fluvial Strategy

5.2 Fluvial Arrangement

The fluvial arrangement will celebrate the fluctuating water levels whilst also treating and celebrating the water for a healthy river environment. Experiencing the river landscape and incorporating river dynamics into new urban development become a key part of place making.

Increased accessibility to, across and along the river will be improved. Paths will sit at varying levels along the river banks. Occasionally some will be flooded in the event of high water levels. A higher path will always remain accessible in a 1 in 100 year event.

Managing fluvial flows and flooding for future climate conditions will additionally create:

1. A 30m wide public open space along the banks of the Maribyrnong River with;
    - Integrated landscape flood levee
    - Social and recreation uses
    - Increased tree canopy
    - Riparian habitat and
    - Safe active transport connections
2. Sims Street dike wall (refer to page opposite)
3. Sunbury Line Railway corridor underpass tunnel (refer to page opposite)
4. Hobsons Road/ Stock bridge dike intersection (refer to page opposite)
5. Riparian (riverbank wetlands) corridors provide room for the river to fluctuate, echoing the natural processes of river floodplains in an urban structure. They not only manage both fluvial and pluvial flows, but provide increased pedestrian permeability, riparian habitat and aesthetic values. They allow the rivers inherent properties to define the future character of place
6. Tertiary corridors provide healthy water circulation between the riparian corridors and ensure water does not sit stagnant. Future development will be able to discharge excess storm water into the tertiary corridors, before being released into the riparian corridors. These will be a mix of open air or piped corridors.

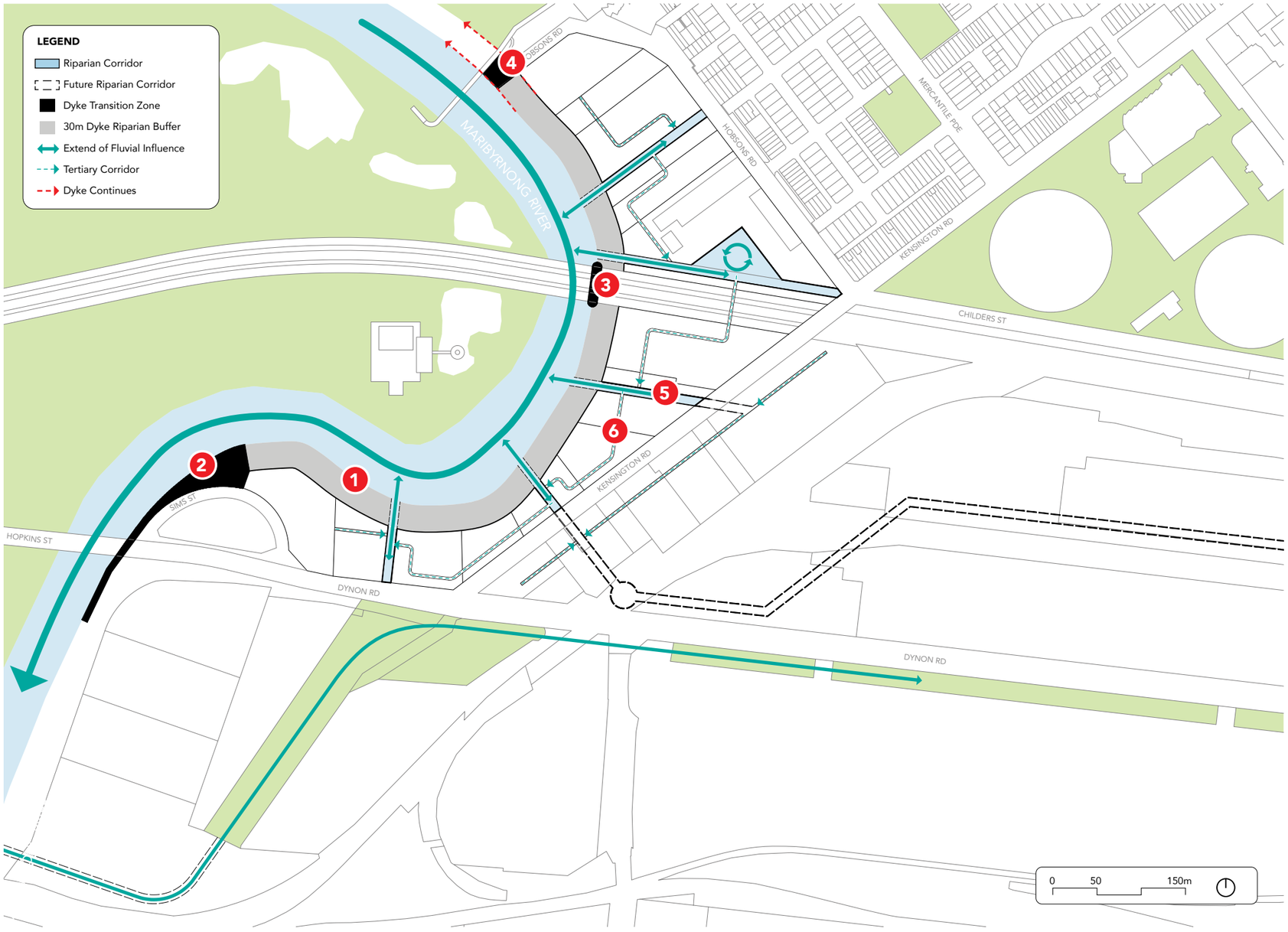


Figure 31:Indicative fluvial arrangement and flood flows

5.3 Fluvial Transition Zones

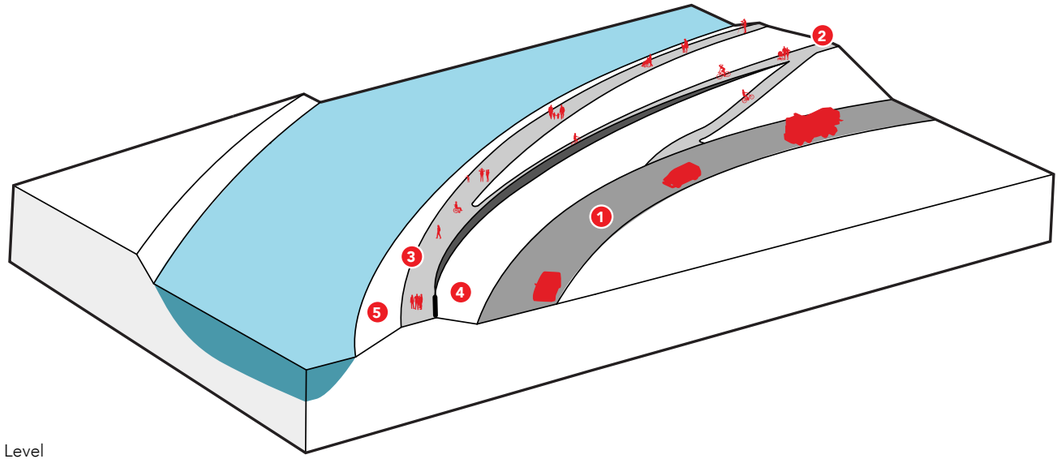
Three transition zones require special treatment to ensure fluvial flooding is appropriately managed. These include:

1. Sims Street dike wall looks to seamlessly integrate the new dike level into the adjacent existing ground levels
2. Sunbury Line Railway corridor underpass provides safe passage for cyclists and pedestrians during 1 in 100 AEP flood events in an area constrained by the existing levels of the rail infrastructure.
3. Hobsons Road/ Stock bridge dike intersection looks to integrate the new dike levels into the existing Riverside Park dike whilst creating strong access and connections for cyclists and pedestrains.

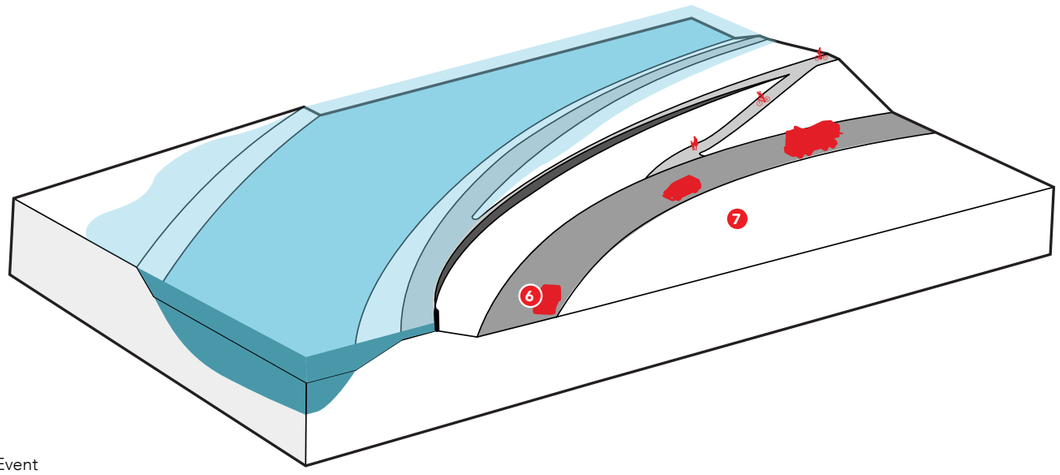
2 Sims Street Dike Wall

- Diagram two shows the introduction of a berm which meets with an existing topographical mound and extends to form a defensive dike along Sims Street.
- Where the dike meanders down to the natural ground level, a defensive wall continues at the necessary height to maintain the required defences against flooding.
- During flood events, the outer dike zones flood in a controlled manner and leave inner dike zones undisturbed, allowing movement patterns to continue as usual.

1. Sim Street
2. Upper dike path
3. River edge path
4. Outer dike
5. Inner dike
6. Defensive dike wall
7. Flood event access path



Everyday River Level



1 in 100 Flood Event

Figure 32: Sims Street Dike Wall Conceptual Diagram

3 Sunbury Line Railway Corridor Underpass Tunnel

- Diagram three shows how the existing cycle and pedestrian networks will be altered and appropriated to deal with 1 in 100 flood events.
- The path will meander down under the bridge and be partially encased in a tunnel like shell which prevents water from running down into the bottom of the 'tunnel'.
- During flood events, the fluvial water level can rise uninhibited while egress and general circulation can continue in safety.

1. Existing rail bridge
2. 30m river setback
3. River edge path
4. Upper dike path
5. Tunnel underpass

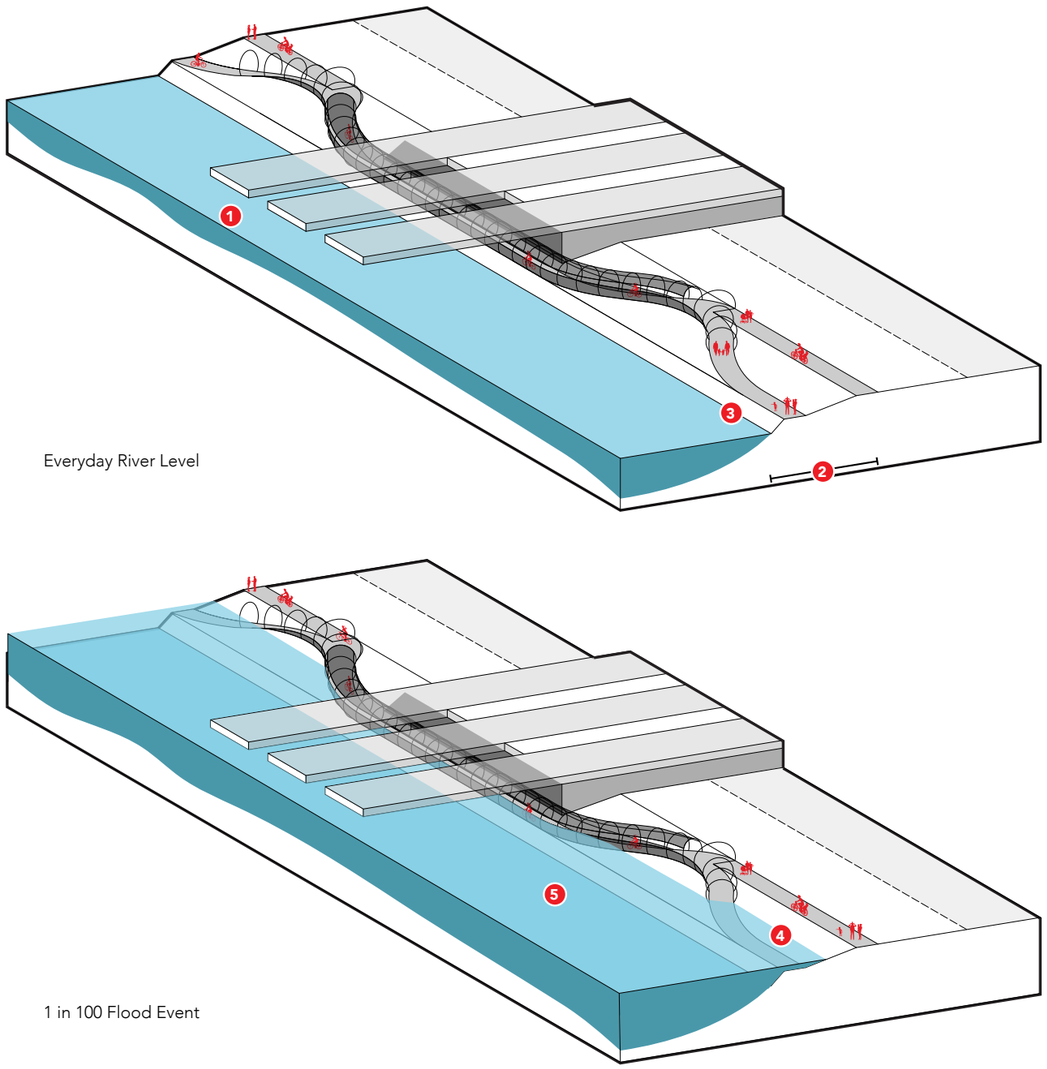


Figure 33: Sunbury Line Railway Corridor Underpass Tunnel Conceptual Diagram

4 Hobsons Road/ Stock bridge Dike Intersection

- The levee of the Riverside Park detention basin is extended to meet the raised and terraced 30m riverside corridor landscape.
- The upper most path sits outside the inundation zone, providing circulation and egress options for people during periods of flooding.

1. Existing pedestrian/cycle bridge
2. Hobsons Road
3. Existing Hobsons Road residential development
4. Riverside Park
5. 30m river setback
6. Reconfigured river edge path
7. Proposed upper dike path
8. Proposed ramp connections

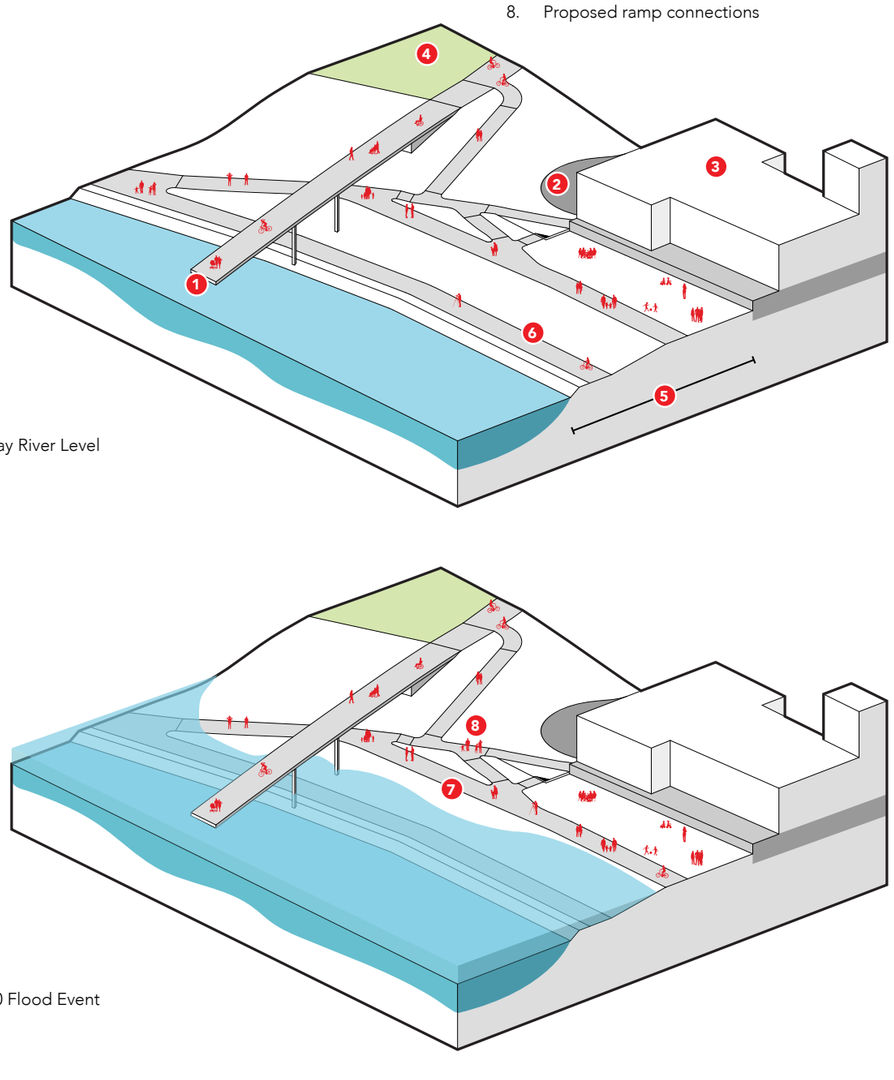


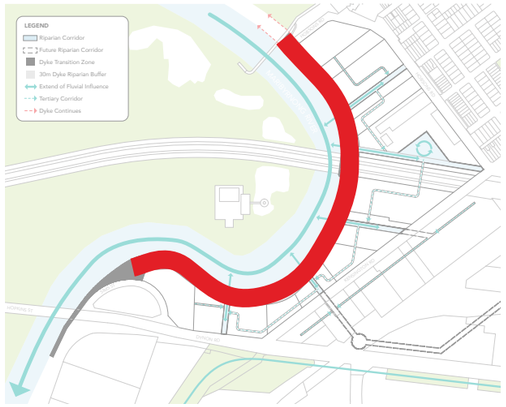
Figure 34: Hobsons Road/ Stock bridge Dike Intersection Conceptual Diagram

5.4 River Corridor

River Corridor - Typical Flow Condition

The adjacent axonometric diagram shows the proposed waterfront condition which introduces a terraced landscape. This not only elevates buildings out of the flood zone, but also creates a series of pedestrian and cycle networks, habitat for vital river ecologies and seeks to activate the waterfront with a series of programs and activities.

1. Indigenous riparian wetlands and board walk
2. River edge pedestrian path - Min. 3m wide
3. Dike wall with access steps
4. Upper pedestrian and cycle path - Min. 4m wide
5. Linear active/passive open space
6. Potential development
7. Rainwater tanks in private development



River Corridor location in red

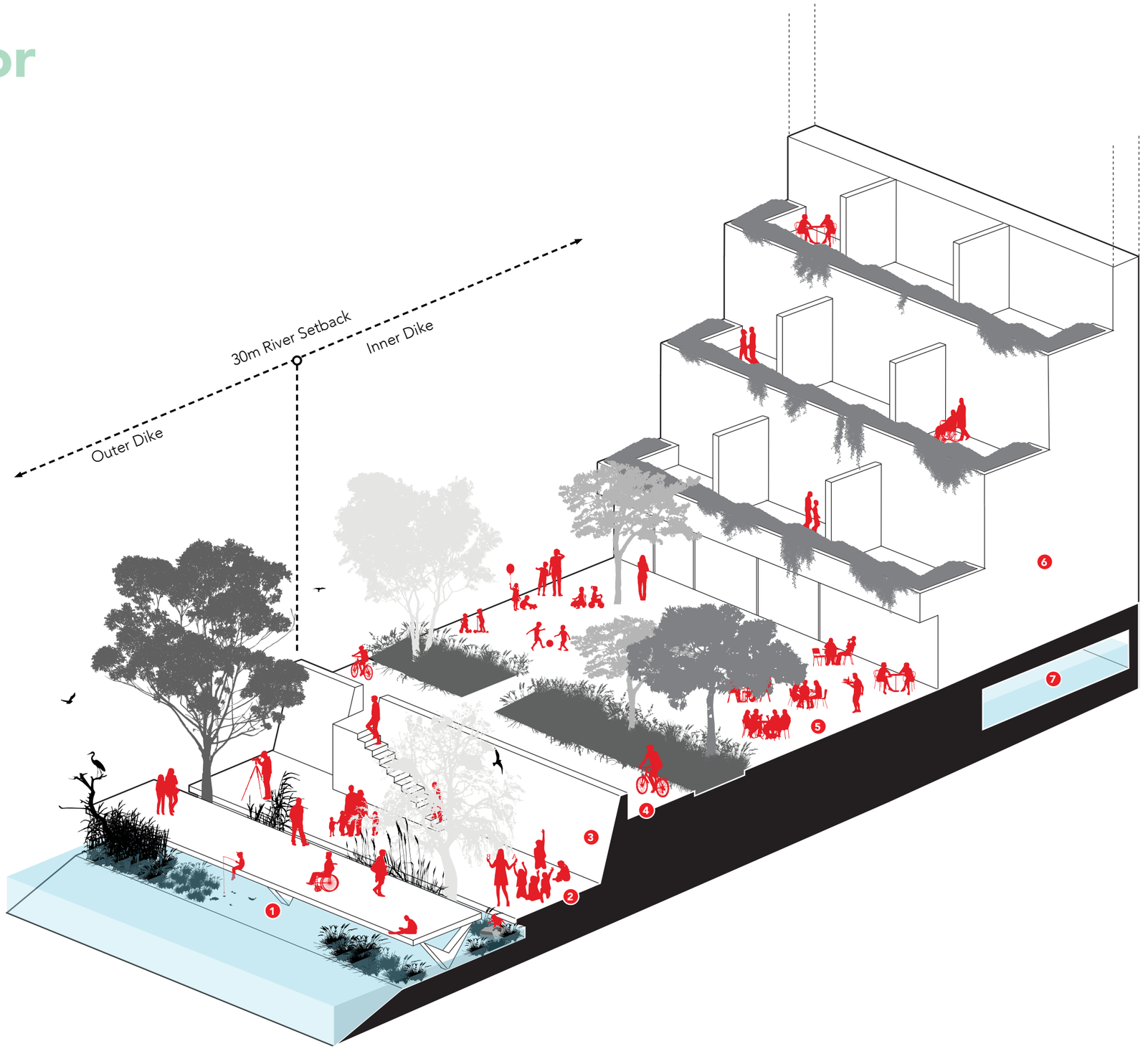


Figure 34: Indicative River Corridor in typical flow conditions

River Corridor - 1 in 100 Year Flood

A 30m river setback provides the space for the river to expand and contract. The adjacent axonometric diagram shows how, during times of fluvial inundation the outer dike zones are allowed to and designed to accommodate fluvial flooding. A dike wall protects the inner dike zones that remain habitable in spite of fluvial flooding.

Managing fluvial flooding in this way creates a safe environment for the community, reduces damage to adjacent properties and infrastructure and subsequently reduces the economic cost of flooding. Fluvial flooding becomes a valued part of the urban waterfront environment and by the community that inhabit it.

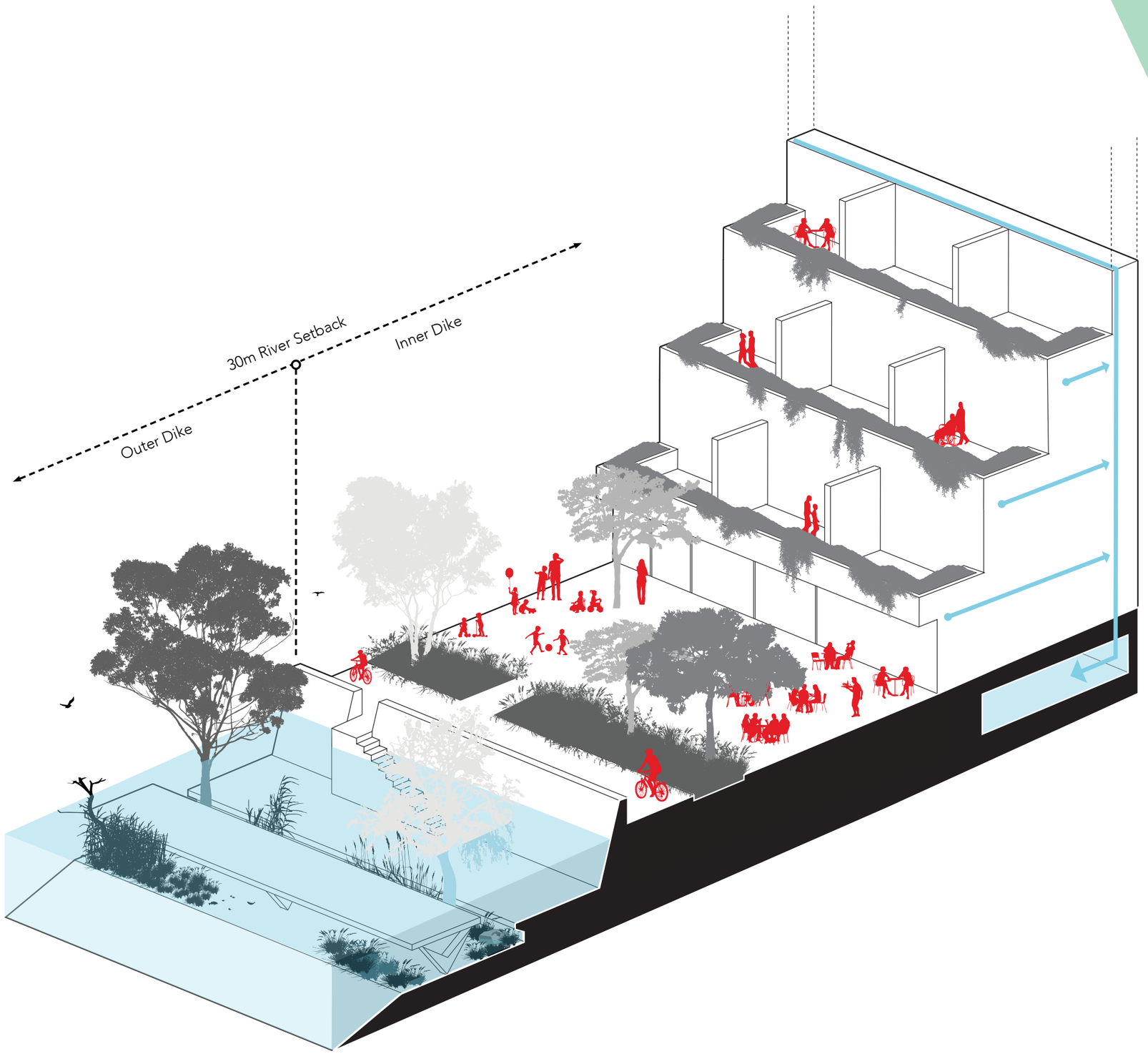


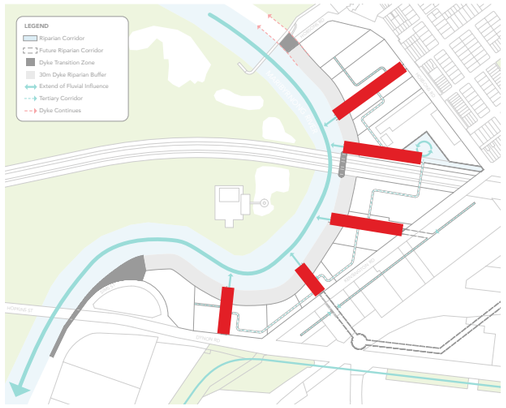
Figure 35: Indicative River corridor in a 1 in 100 year flood scenario

5.5 Riparian Corridor

Riparian Corridor - Typical Flow Condition

The adjacent diagram shows the proposed canal intrusions within development zones. These waterfront zones introduce terracing on both sides of the canals. The landscape not only elevates buildings out of the flood zone, but also creates a series of pedestrian and cycle networks and linkages and seeks to activate the waterfront with a series of programs and activities and increase riparian habitat. These corridors and bridges will fully accessible for pedestrians, cyclists and emergency vehicles.

1. Indigenous riparian wetlands
2. Waters edge pedestrian path - Min. 3m wide
3. Dike wall with access steps
4. Upper pedestrian and cycle path - Min. 4m wide
5. Addressed development
6. Rainwater tanks in private development



Riparian Corridor location in red

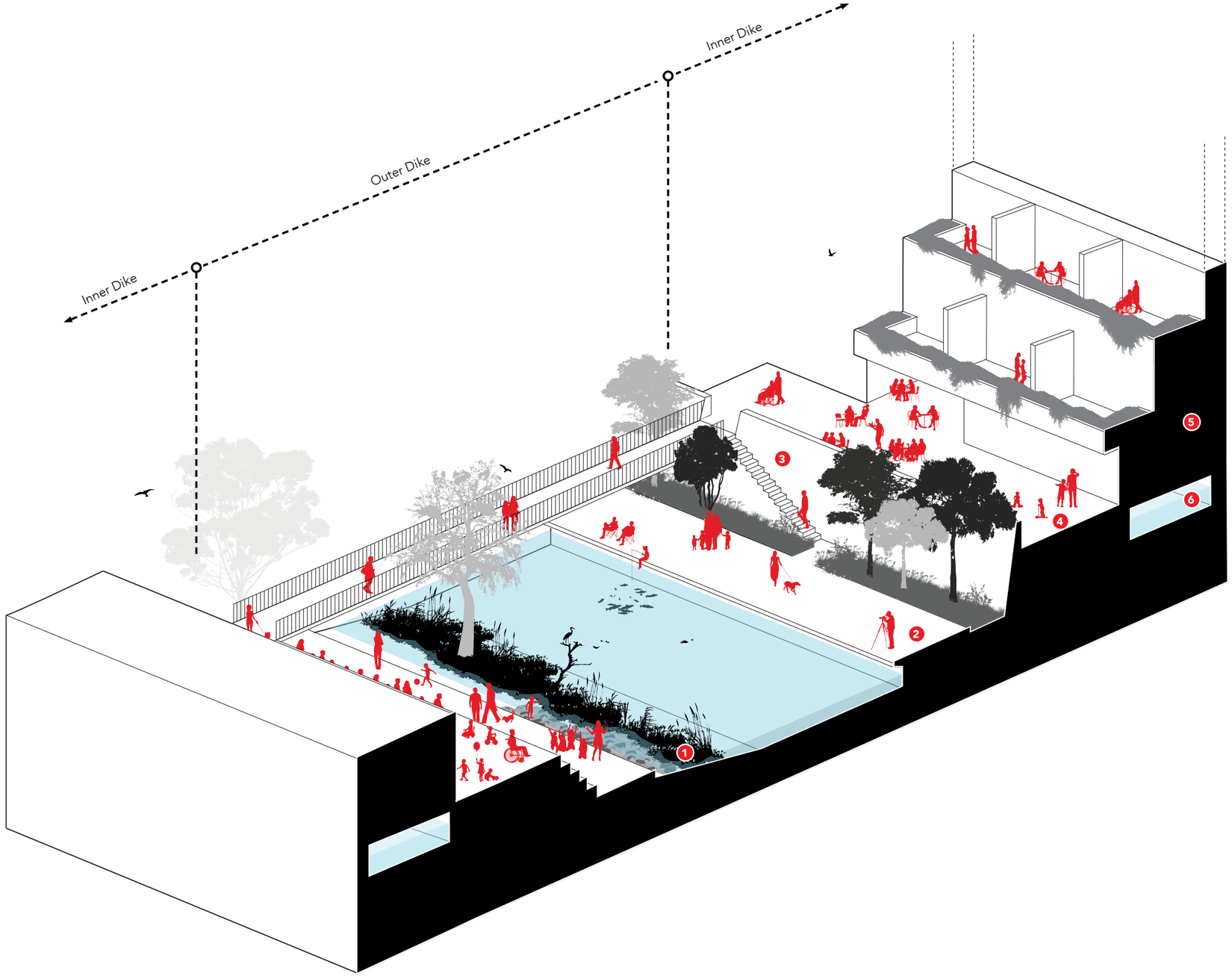


Figure 36: Indicative Riparian Corridor in typical flow conditions

Riparian Corridor - Flood Scenario

The adjacent diagram shows how, during times of inundation, outer dike zones are allowed to and designed for inundation while inner dike zones remain protected and habitable in spite of both fluvial and pluvial flooding.

Bridge connections across canals link banks and allow people to continue moving around despite flooding.

Infrastructure and people are safeguarded through the implementation of climate-adaptive, value adding urban and landscape design initiatives.

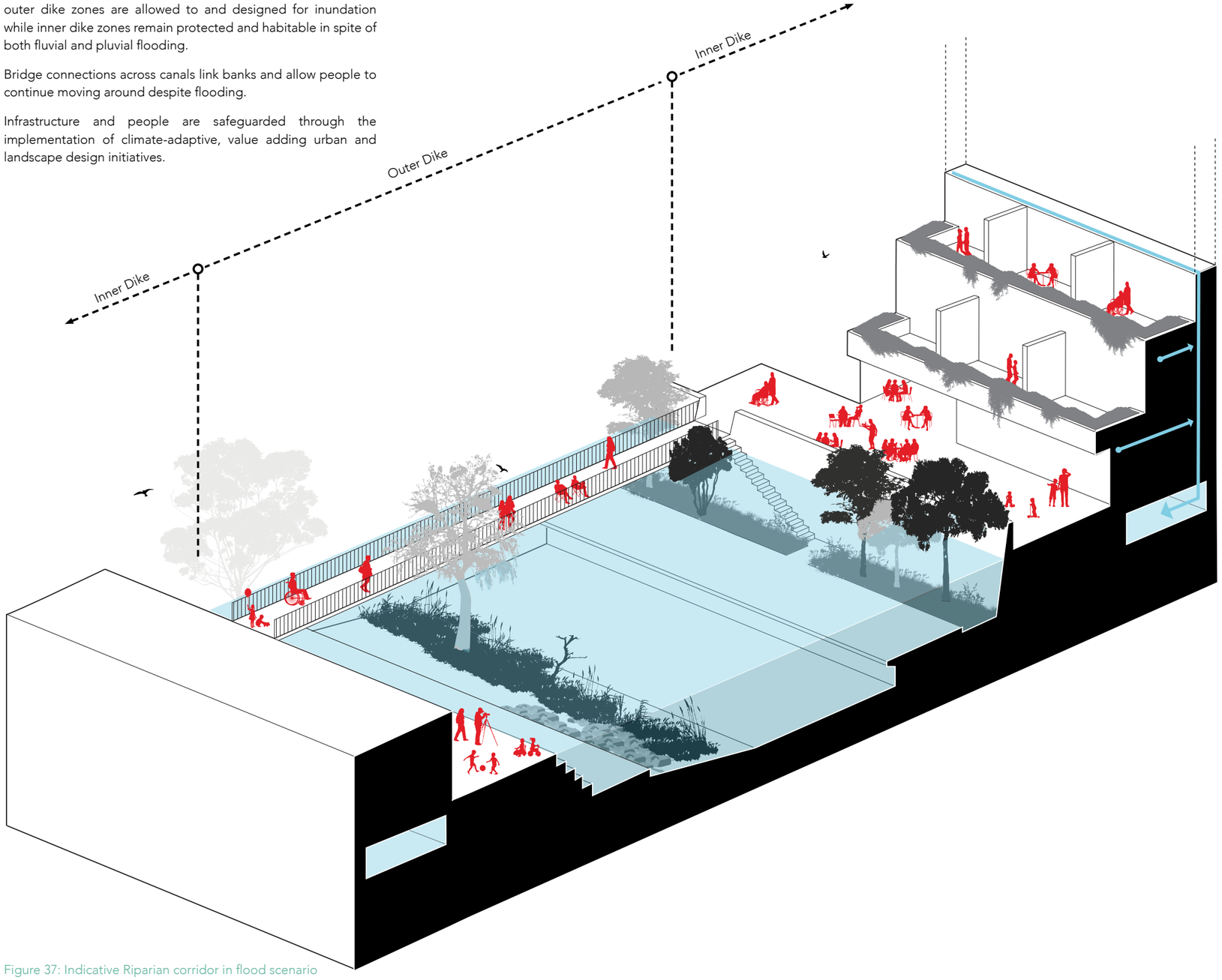


Figure 37: Indicative Riparian corridor in flood scenario

Shadow analysis

To ensure adequate levels of sunlight reach the riparian corridors a respectful relationship between built form and public space is required. This should align with 22.02 Sunlight To Public Spaces as outlined in the Melbourne Planning Scheme.

The spacing and shape of taller buildings should maximise sunlight penetration at the riparian corridor level and floor plates should maximise views toward the riparian and river corridor.

Massing of built form should be broken down and adopt lower street wall heights to respond to the riparian corridor's narrow profile and reduced shadowing conditions.

Contamination analysis

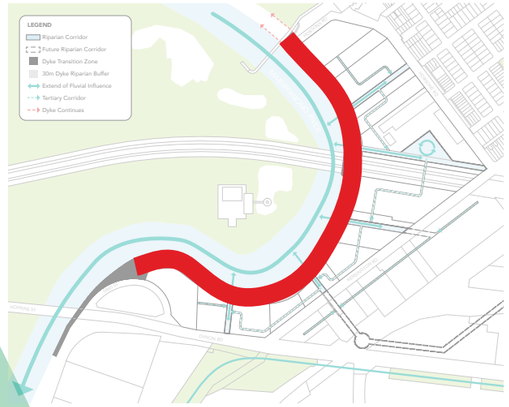
Further analysis is required to determine widths, locations and potential remediation requirements to deal with any ground contamination.

5.6 River Corridor Sections

The following sections show possible configuration options that could appear at any given point along the 30m river corridor. They provide the same level of fluvial flood mitigation in varying arrangements and programming.

Section A

- Estuarine zone is limited to maximize adaptive and terrestrial zones and comprises of a stone wall river bank edge
- A river side footpath sits between two planting strips for thermal comfort in adaptive zone
- The adaptive zone terraces up to building level with varying edge conditions
- Open unprogrammed plaza space provide opportunity for a plethora of activities for a variety of user groups
- Informal seating is integrated into terracing between the plaza space and cycle route
- Safe bicycle movement is integrated into the space by way of a dedicated bike lane in the terrestrial zone. This also provides safe pedestrian movement in 1:100 flood conditions.
- Extensive strip planting creates terrestrial habitat, provides infiltration benefits, contributes to the space on an aesthetic level and passively provides thermal comfort for users



River Corridor location in red

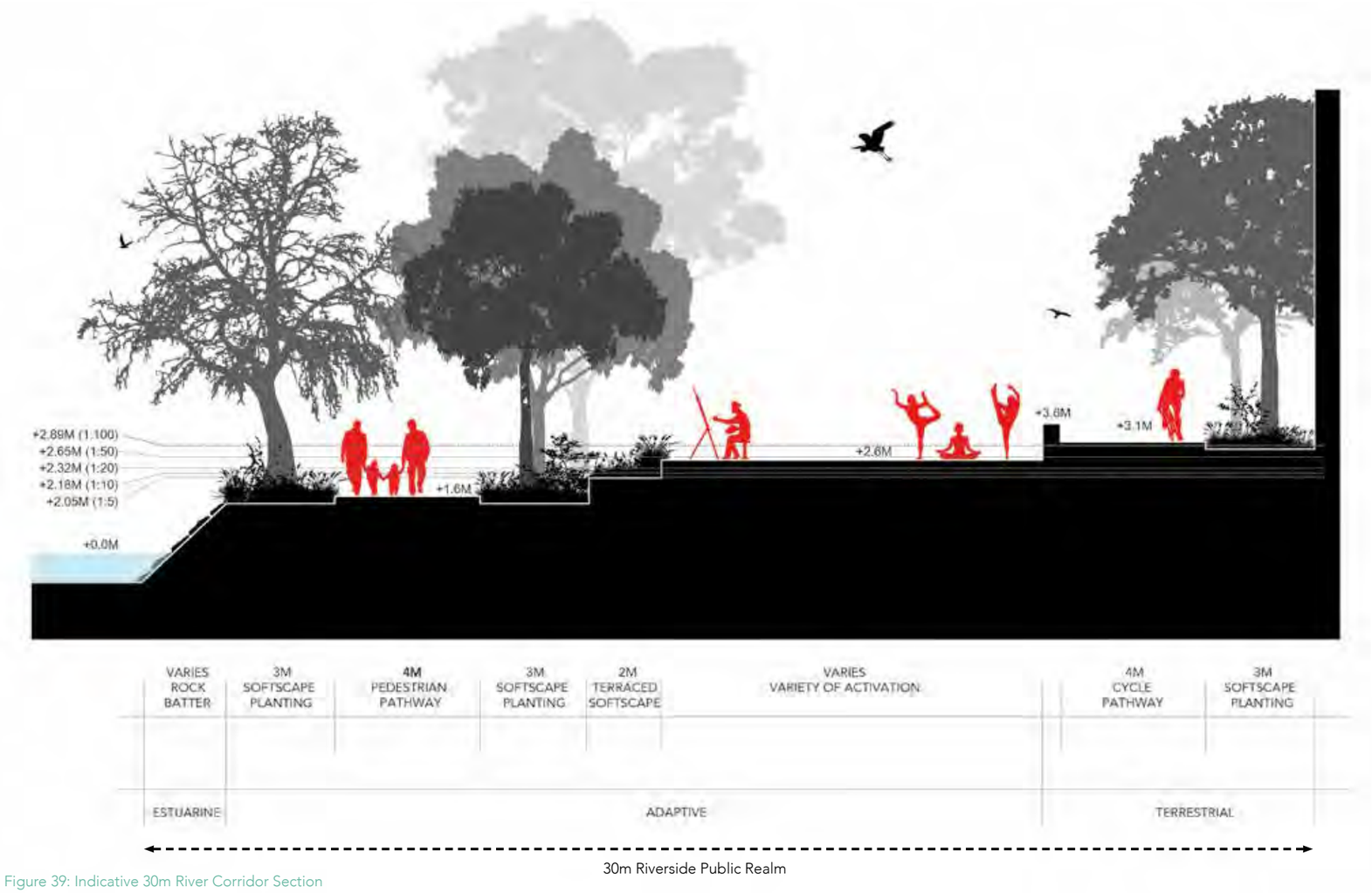


Figure 39: Indicative 30m River Corridor Section

Section B

- A more generous estuarine zone creates habitat and shades the adjacent path
- A river side footpath with terraced edge provide opportunity to enjoy the immediate river environment
- Adaptive zone encompasses an unprogrammed interstitial zone for various activities
- Safe bicycle movement is integrated into the space by way of a dedicated bike lane in the adaptive zone. This also provides safe pedestrian movement in 1:100 flood conditions.
- Terrestrial zone drops down behind a dike into an unprogrammed shaded spill out space for activation by adjacent buildings

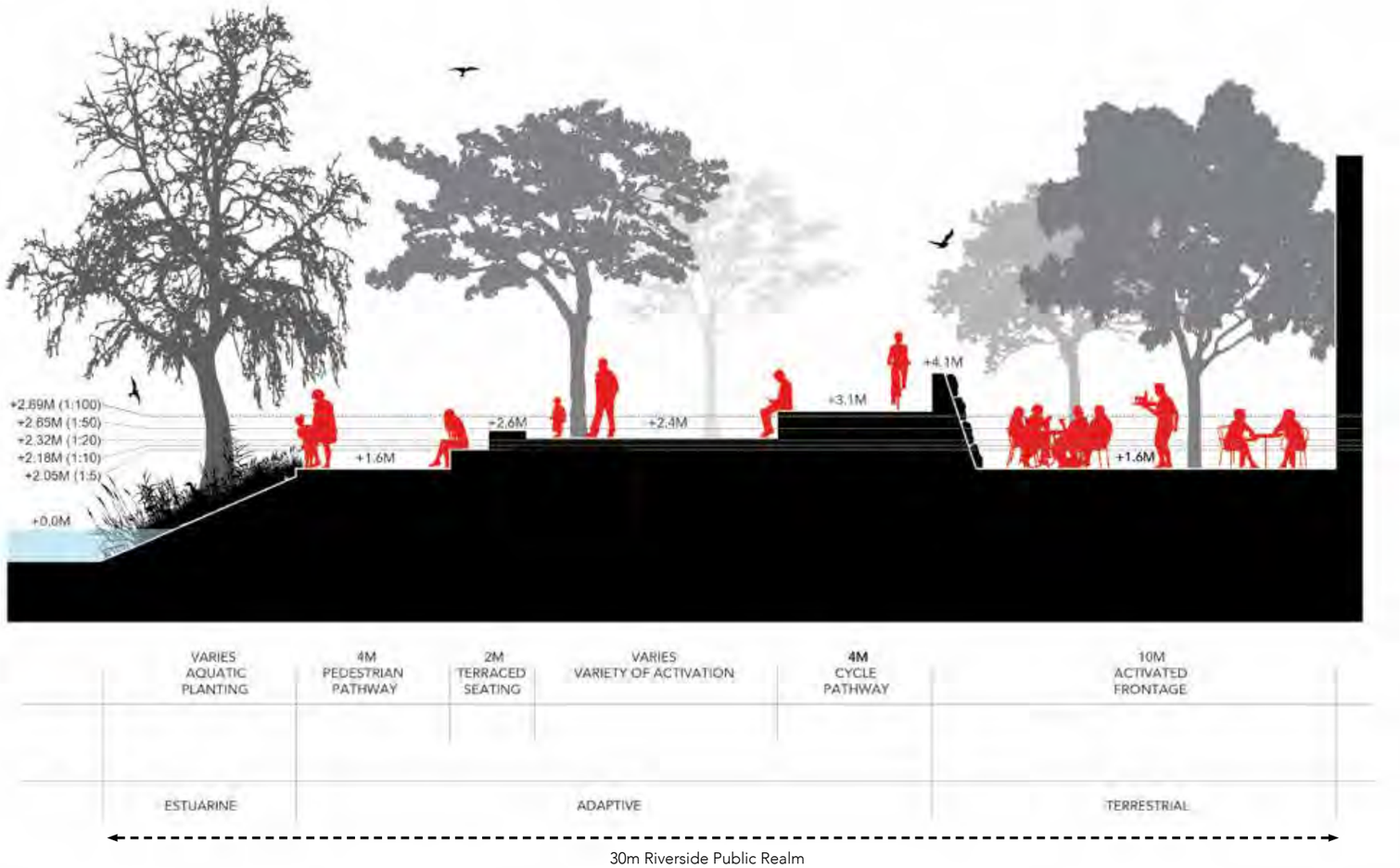


Figure 40: Indicative 30m River Corridor Section

Section C

- Estuarine zone extends halfway into corridor to create substantial riparian habitat. A raised pedestrian walkway meanders through this riparian zone, allowing people to engage with the unique environment
- Adaptive zone is constituted by a pedestrian pathway with terraced edge to promote engagement with the rivers edge
- Terrestrial zone sits at the highest level and is protected from the adaptive zone by a planted dike
- A cycle path with adjacent planting for shading sits in the terrestrial zone. This also provides safe pedestrian movement in 1:100 flood conditions
- Water storage tanks for localized pluvial water storage (from public realm only) sit beneath the cycle path for use in drier month

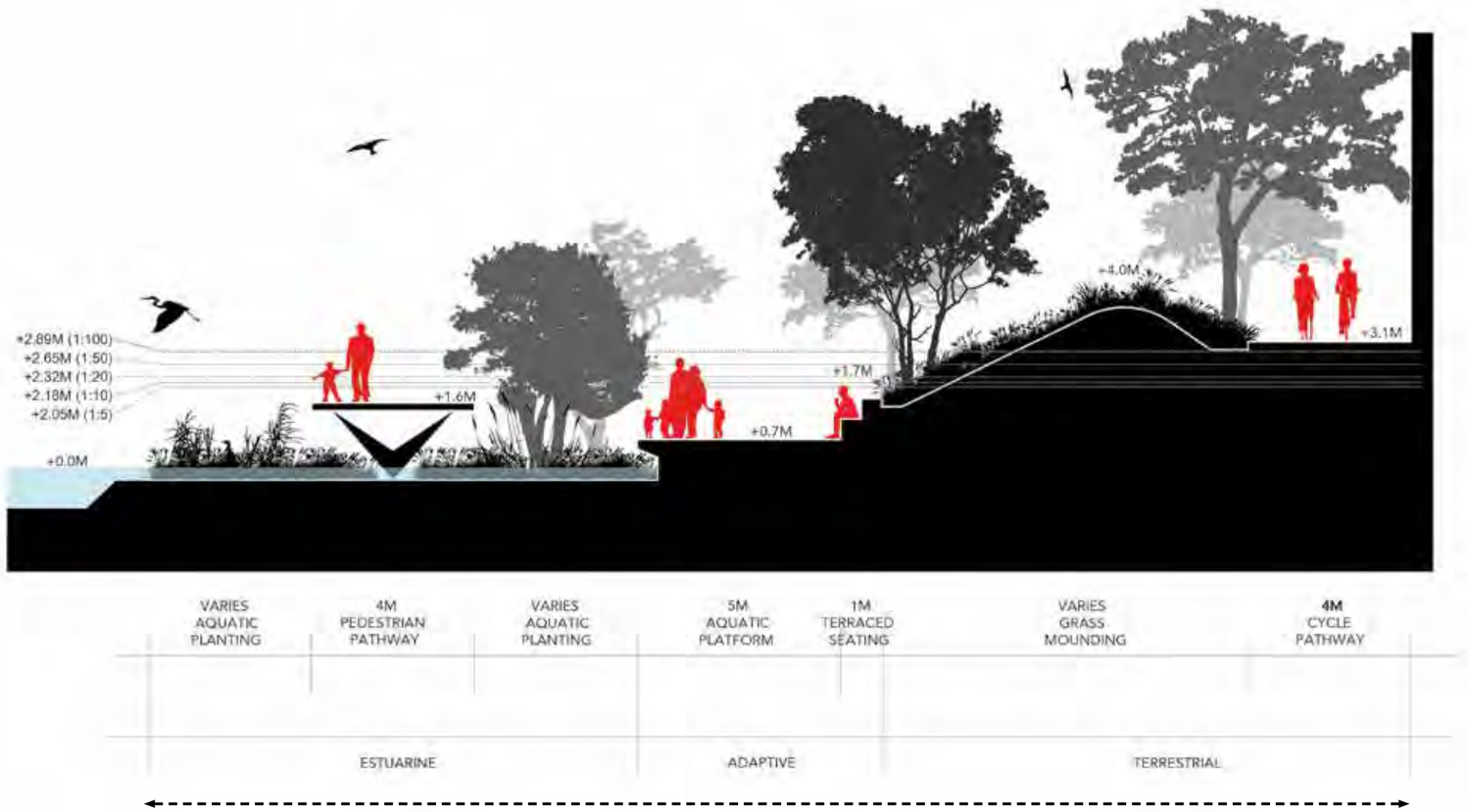


Figure 41: Indicative 30m River Corridor Section

Section D

- Estuarine zone is limited but creates important riparian habitat. A raised pedestrian walkway meanders through this riparian zone, allowing people to engage with the unique environment
- Adaptive zone constitutes of a pedestrian pathway
- Terrestrial zone sits at the highest level and is separated from the adaptive zone by a walled dike.
- It encompasses a cycle path with adjacent planting for shading as well as an unprogrammed plaza type spill out space for activation by buildings adjacent to the corridor
- Safe bicycle movement is integrated into the space by way of a dedicated bike lane in the adaptive zone. This also provides safe pedestrian movement in 1:100 flood conditions.
- Water storage tanks for localized pluvial water storage (from public realm only) sit beneath the cycle path and plaza for use in drier month

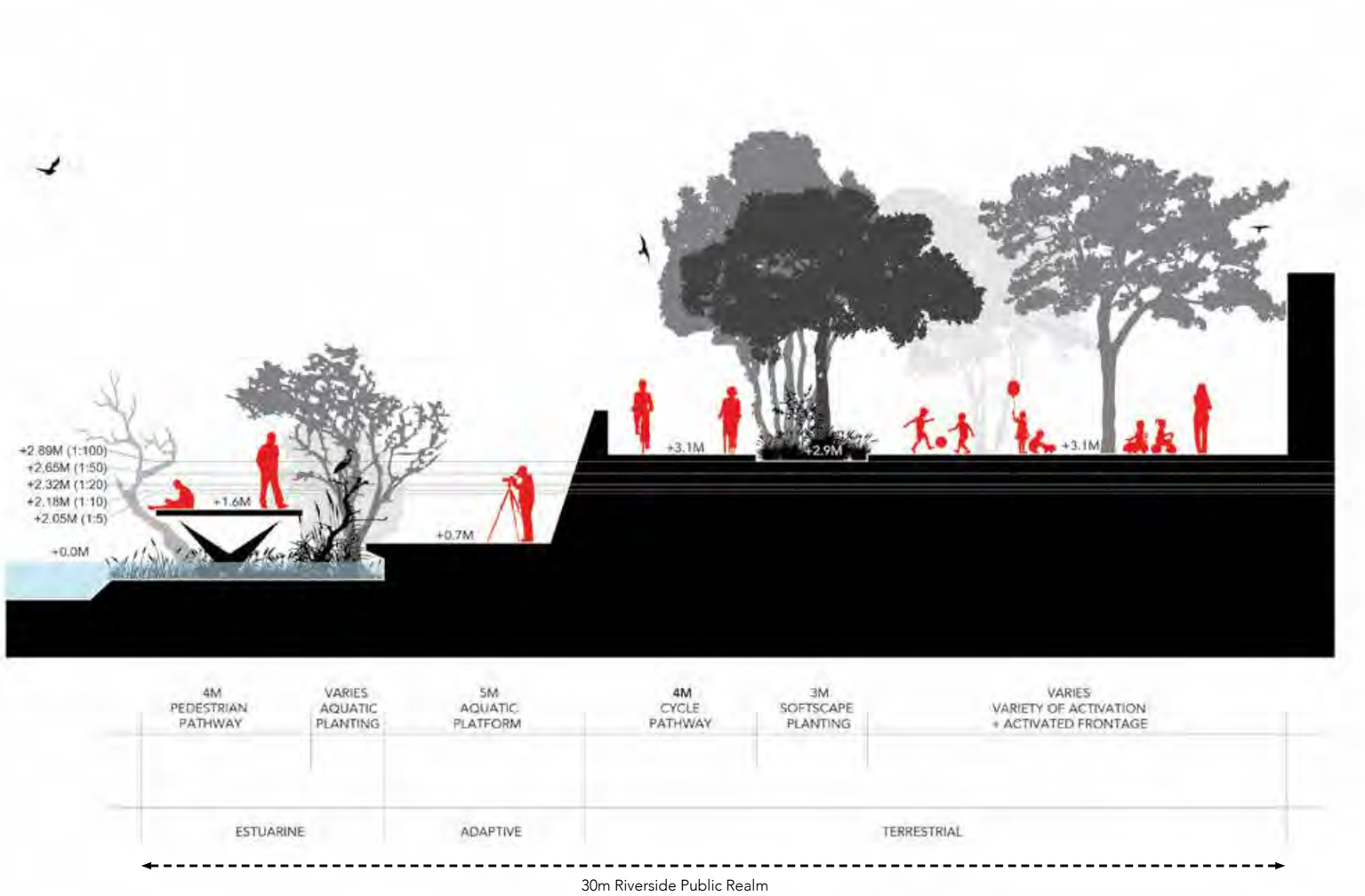


Figure 42: Indicative 30m River Corridor Section

Section E

- Estuarine zone is comprised by a boat launch where canoeists and rowers can enter the waterway easily
- Adaptive zone encompasses a raised pedestrian path adjacent to the boat launch access area as well as planting for shading
- Terrestrial zone is protected from the adaptive zone by a walled dike
- A cycle path with adjacent planting for shading as well as an unprogrammed plaza type spill out space for activation by buildings adjacent to the corridor
- Water storage tanks for localized pluvial water storage (from public realm only) sit beneath the cycle path and plaza for use in drier month

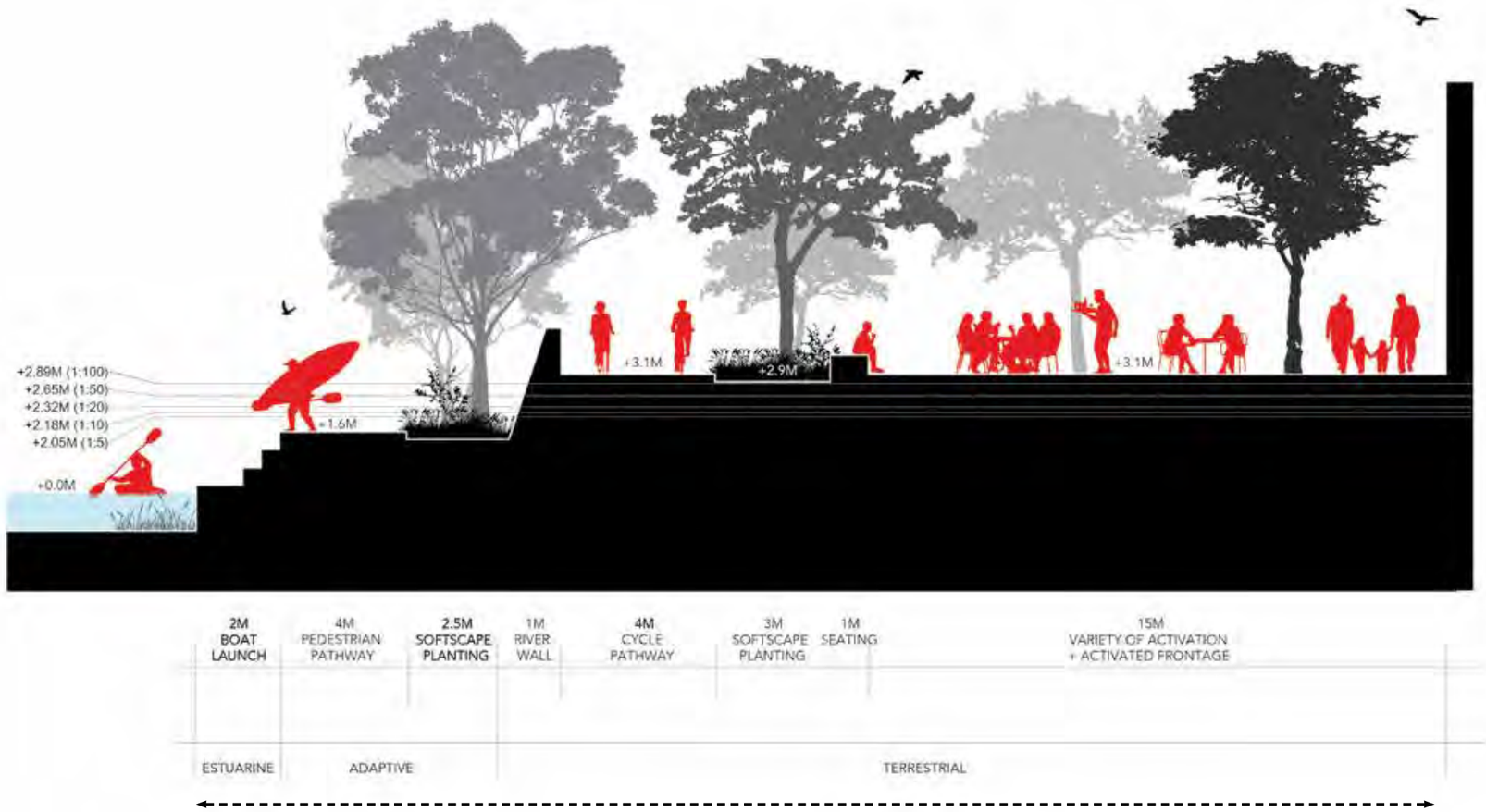


Figure 43: Indicative 30m River Corridor Section

Section F

- Estuarine zone extends halfway into corridor to create substantial riparian habitat.
- A raised pedestrian walkway meanders through this riparian zone, allowing people to engage with the unique environment
- Adaptive zone comprises of an unprogrammed plaza space and bleachers
- Terrestrial zone sits at the highest level and consists of a cycle path and adjacent planting for shading. This also provides safe pedestrian movement in 1:100 flood conditions.
- Water storage tanks for localized pluvial water storage (from public realm only) sit beneath the cycle path for use in drier month

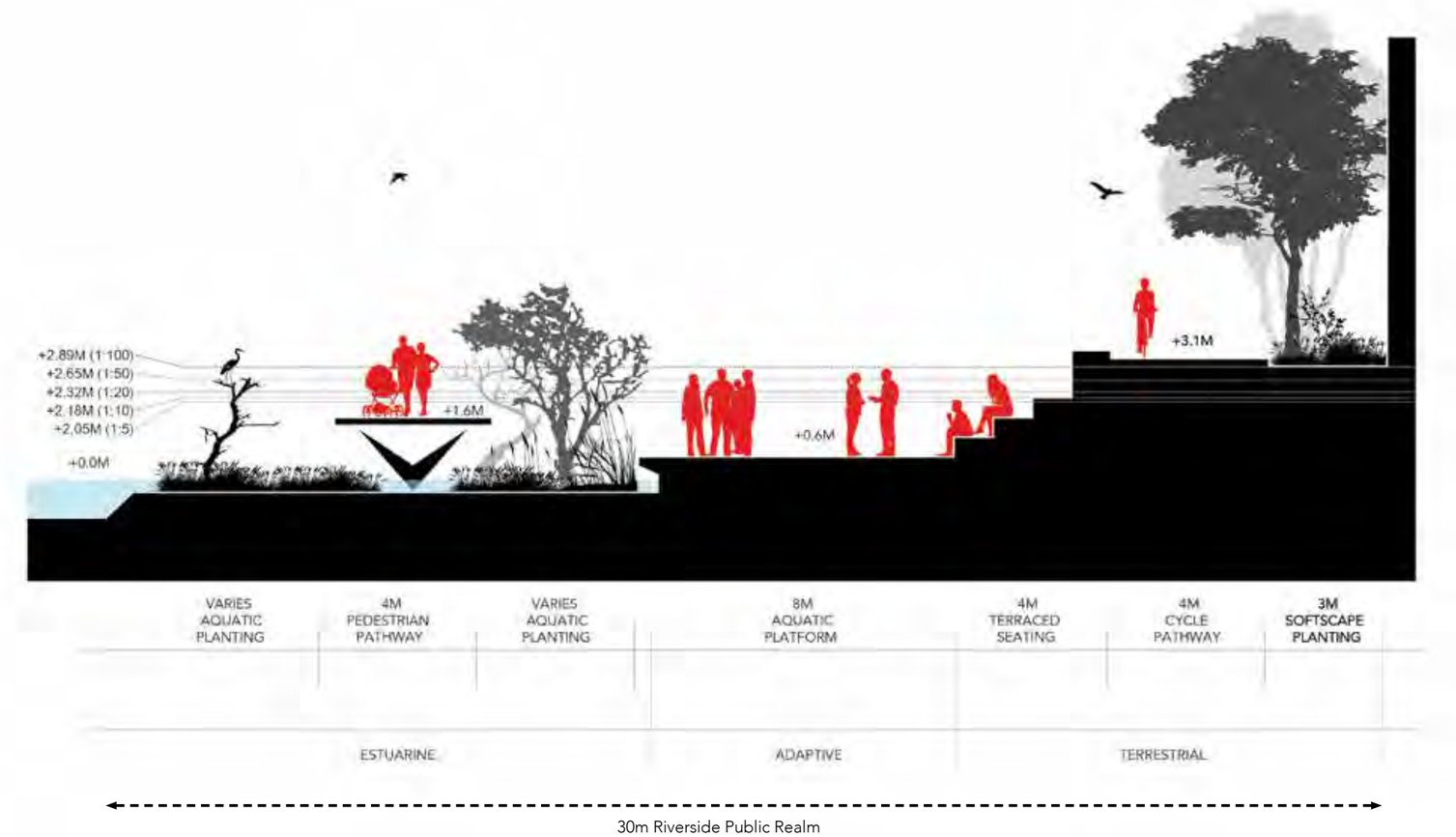


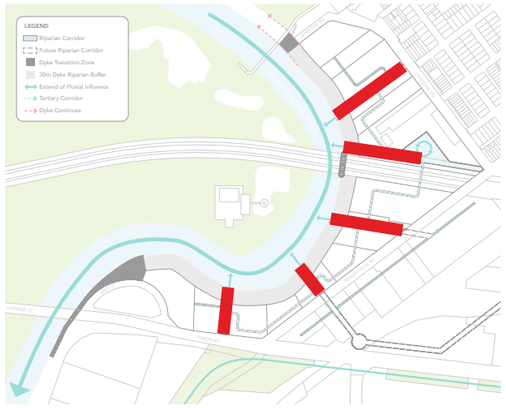
Figure 44: Indicative 30m River Corridor Section

5.7 Riparian Corridor Sections

The following sections show possible options for the riparian corridors. They provide the same level of fluvial flood mitigation in varying arrangements and programming.

Section G

- Estuarine zone sits centrally between two building verges at the lowest level and is flanked by two adaptive zones on either side. This zone creates more sheltered riparian habitat than would be found on the Maribyrnong riverbanks
- Adaptive zones consist of an aquatic platform and bleachers on the left and a pedestrian pathway on the other, bringing people close to the water's edge
- Terrestrial zones on both sides sit at the highest levels and create medium scale plaza/thoroughfare spaces for adjacent buildings to spill out onto. These levels are connected by pedestrian bridges where appropriate



Riparian Corridor location in red

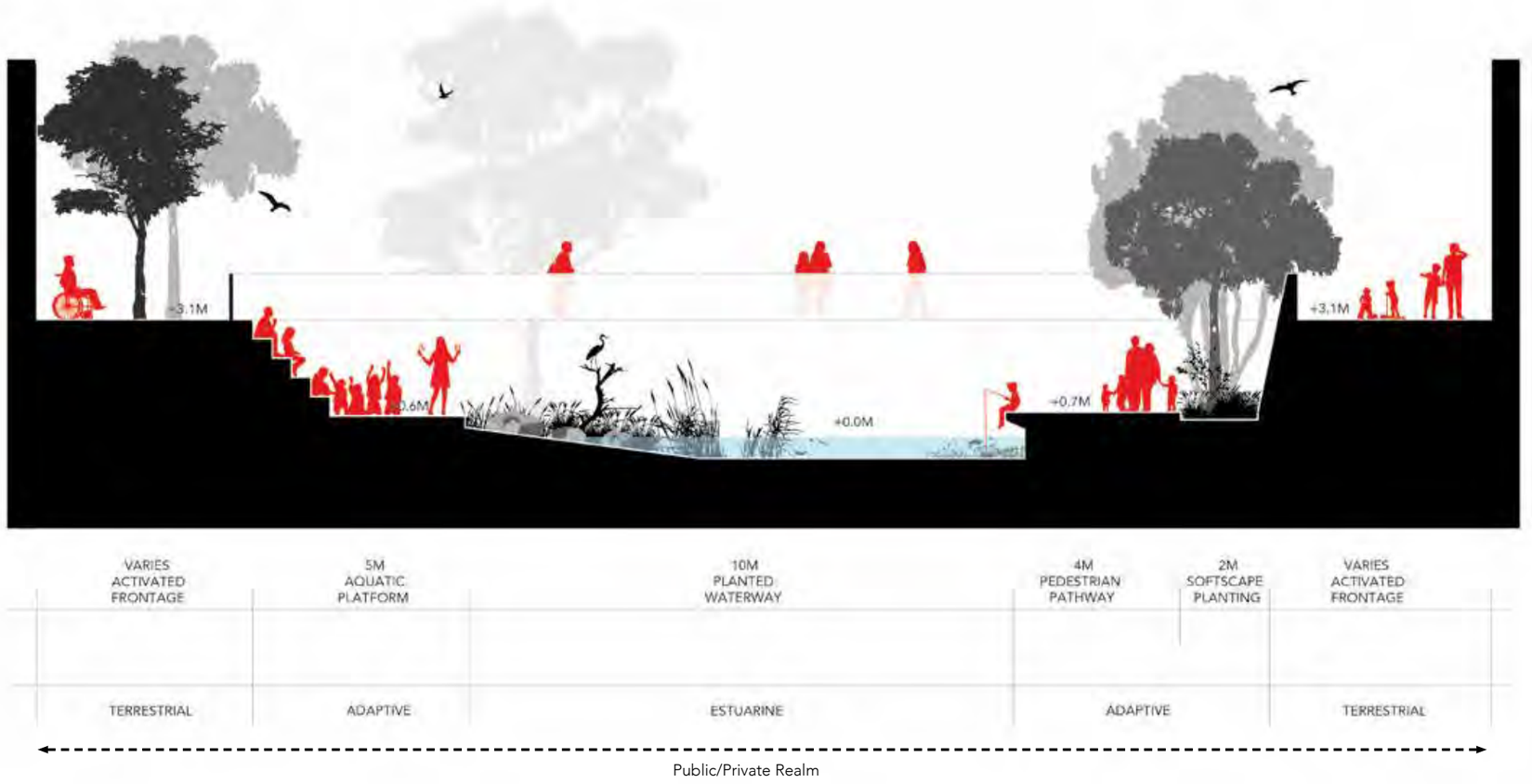


Figure 45: Indicative Riparian Corridor Section

Section H

- Estuarine zone sits in between two building verges at the lowest level and is flanked by two adaptive zones on either side. This zone creates more sheltered riparian habitat than would be found on the Maribyrnong riverbanks
- Adaptive zones consist of an aquatic platform on the left and a pedestrian pathway on the other, bringing people close to the water's edge
- Terrestrial zones on both sides sit at the highest levels and create medium scale plaza/thoroughfare spaces for adjacent buildings to spill out onto

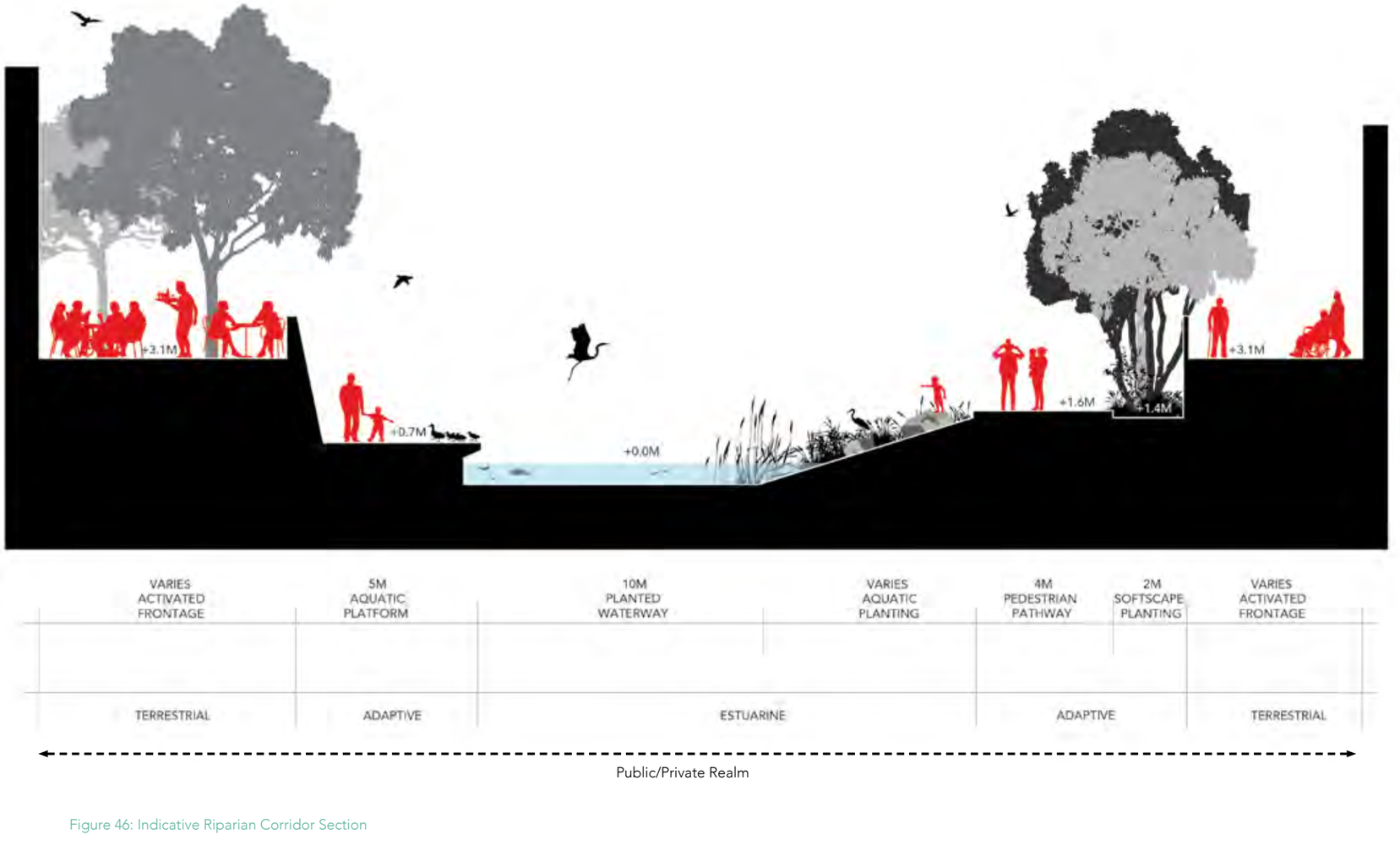


Figure 46: Indicative Riparian Corridor Section

5.8 River Corridor Montage

Figure 47: Montage of indicative 30m River Corridor in typical flow conditions

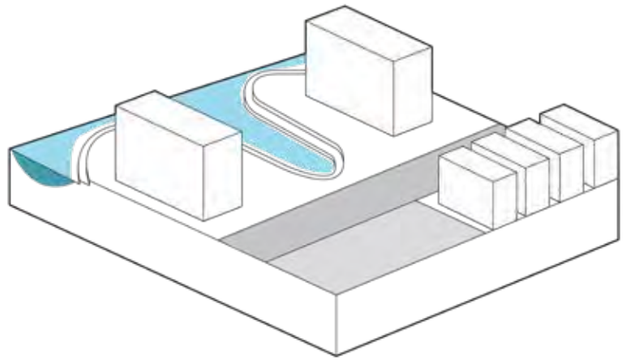
Figure 48: Montage of indicative 30m River Corridor in 1 in 100 year flood conditions

6.1 Pluvial Approach - Public Realm

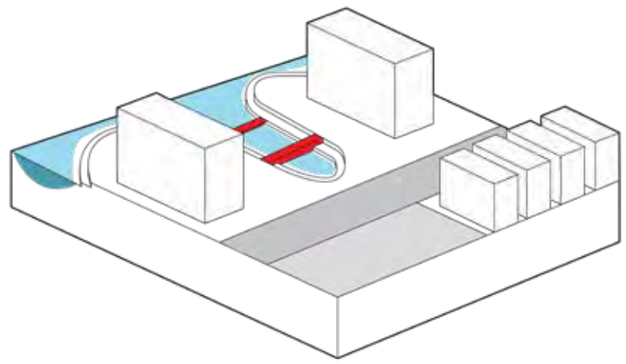
Pluvial flooding occurs when localised stormwater accumulates in an area faster than the area's capacity to shed or infiltrate stormwater. The public open space and streets have the capacity to convey and detain storm water for later release into waterways. This approach creates the opportunity for water filtration, increased biodiversity, urban heat island mitigation and an active multifunctional public realm.

1. Street and other public open spaces currently serve single functions and provide no climate adaptive solutions.
2. Utilizing riparian canals as offline wetland/phytoremediation detention basins by inserting weir walls which ensure a continual presence of water in the canals for aesthetic and habitat purposes during dry periods
3. Application of sponge initiatives and adaptation of currently mono-functional infrastructurally inert street and open public space to act as storm water detention basins which also function as and provide a public and recreational amenity
4. During extreme flood events, climate adapted streets and open public space detains pluvial water within the catchment. Once storm event has passed, water is released back into river system by way of pumping into riparian canals for detention and phytoremediation

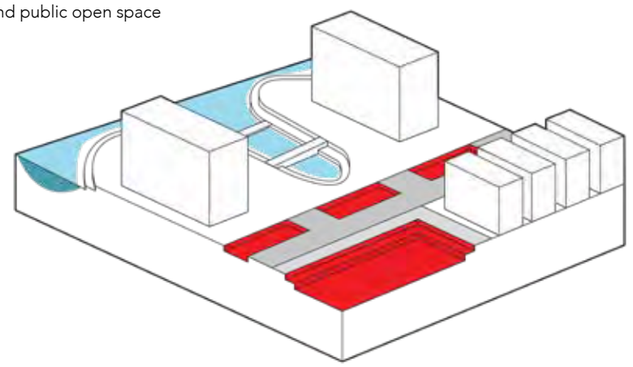
1 Status quo



2 Tidal Canals as offline wetland



3 Integrated above ground detention areas in streets and public open space



4 Pluvial flood waters detained with delayed release

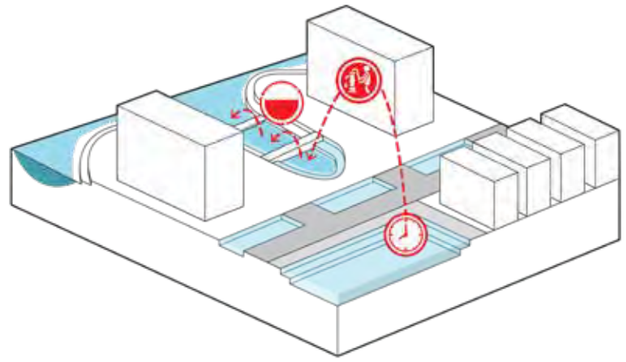


Figure 49: Indicative pluvial approach in the public realm

6.0 Pluvial Strategy

6.2 Pluvial Arrangement - Public Realm

Rain landing in the public realm will be managed in the streets and open spaces; conveying water on surface to strategic detention basins and cleansing areas. Existing underground pipe infrastructure will play a supportive role in extreme conditions only.

Modelling has estimated 650m2 of detention area is required to meet best practice requirements for the 12 ha development area (assuming an impervious fraction of 85%). Detention basins are implemented due to their greater design flexibility (in terms of shape and location) when compared to wetlands. The total area may increase depending on treatment and the depth of the drains feeding into the basins. For example, earth batters would require more area than walled edges to reach the required depth without creating a safety risk. Levels need to be designed so that storm water drains freely to the detention basins.

Various tools will be implemented to manage everyday to extreme rain events:

1. Reconfigure Hobsons Road for local access and integrate a swale for detention and purification of everyday rain events before slowly being released into the riparian corridors.
2. Reconfigure Kensington Road with separated cycle links and rain gardens for detention and purification of everyday rain events before slowly being released into the riparian corridors and Dynon Wildlife Reserve detention.
3. A dedicated detention wetland, capturing everyday and more extreme rain events from Kensington Road, Childers Street and JJ Holland Park, ensuring sport and cultural park activities remain free of flood waters. This will then slowly release into the riparian corridors
4. A multifunctional recreational plaza and water detention area for extreme rain events. These will empty 24 hours after an event to resume recreational functions.
5. Dynon Wildlife Reserve will be re-profiled with varying landforms to detain and purify waters in all rain events, before releasing into the existing canal.
6. Dynon Road Canal will be expanded to detain and purify waters in all rain events, before releasing into the river.

Assets 3, 4, 5 and 6 represent public land. The use of public land for stormwater treatment may require developers to reach an 'offset' agreement with the landowner. Detention areas will be distributed across these locations. Water captured within these locations will then drain freely or be pumped at relatively low flow rates through biofilters to treat storm water that eventually reaches the Maribyrnong River.

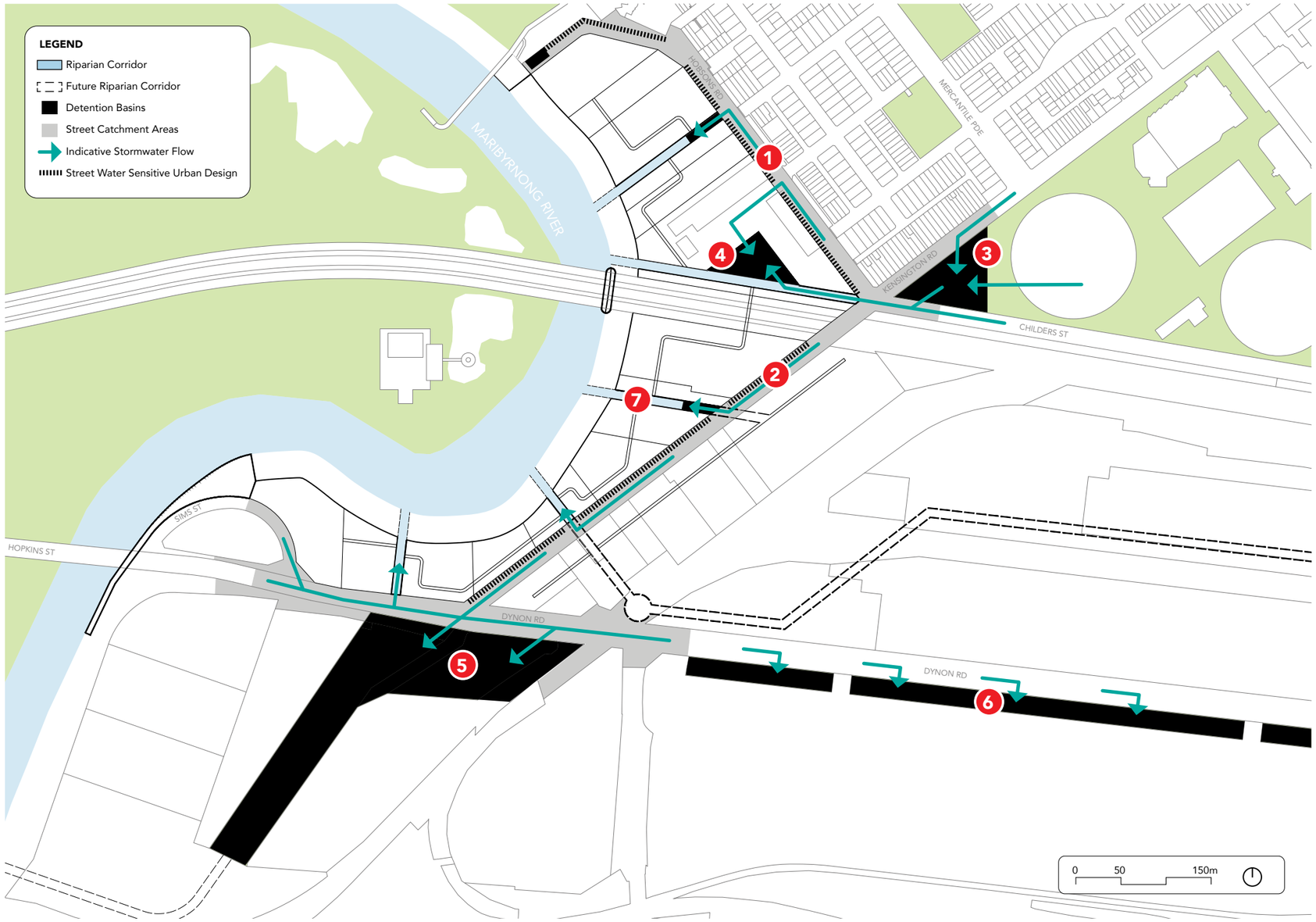


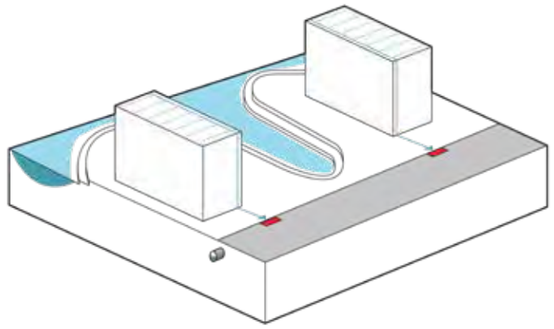
Figure 50: Indicative arrangement of the pluvial approach in the public realm

6.3 Pluvial Approach - Private Realm

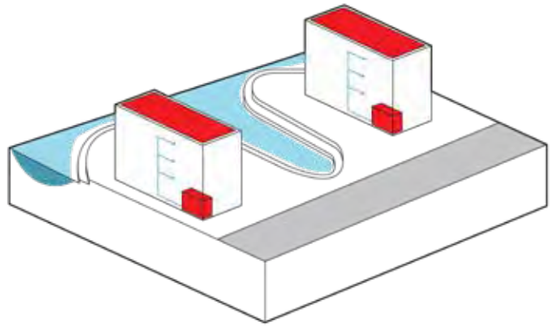
In the private realm the approach advocates for a adaptive built form. This built form has the capacity to detain water for later release into tertiary corridors. This approach creates the opportunity for water detention and recycling.

1. Built form currently serve single functions and provide no climate adaptive solutions
2. Utilising green roofs and rainwater tanks as offline detention, with potential grey water recycling.
3. Application of tertiary corridors either above ground or below ground convey water to the riparian corridors
4. During flood events climate adapted built form detains pluvial water within the catchment. Once storm event has passed, water is released back into the riparian corridors for detention and phytoremediation

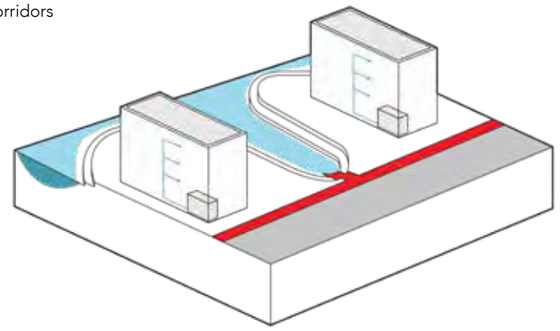
1 Status quo



2 Green roofs and rain water tanks detain pluvial flood waters



3 Tertiary corridors that convey storm waters to ephemeral corridors



4 Pluvial flood waters treated and slowly released once ephemeral corridor levels lower

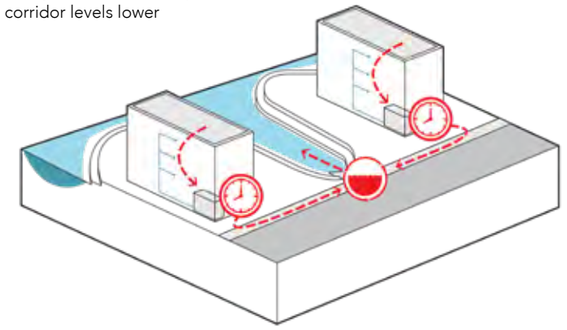


Figure 51: Indicative pluvial approach in the private realm

6.4 Pluvial Arrangement - Private Realm

Developers will be required to manage storm water that lands within each development plot. The Victorian Planning provisions (Clause 53.18 - Stormwater management in urban development), requires all residential multi-dwelling developments to meet best practice stormwater pollution reduction targets. Typically this is achieved via the implementation of water sensitive urban design (e.g. using biofiltration basins or wetland assets).

Rain landing in the private realm will be managed by detention assets integrated within the development itself, and potentially as a part of the tertiary corridors that extend into the development from the riparian corridors. Storm water from the development would be intercepted by biofilters, that cleanse and then released into the receiving waterway.

In this scenario detention will be sized to collectively meet best practice (650m2 of treatment area). Depending upon the urban layout biofilters may not be distributed evenly e.g. a biofilter in one area may 'over-treat' to compensate for another. Therefore the location and size of the detention and biofilters will be the subject to further analysis when there is a better understanding of the development layout on site. Potential detention and biofilter tools include:

- Green roofs for cooling, absorbing stormwater, reducing noise and air pollution and creating a green environment for wildlife.
- Rainwater tanks for detention and grey water recycling. Once a rain event has passed and the public realm management system has recovered, water can then be slowly released into the tertiary and riparian corridors for purifying before entering the river.

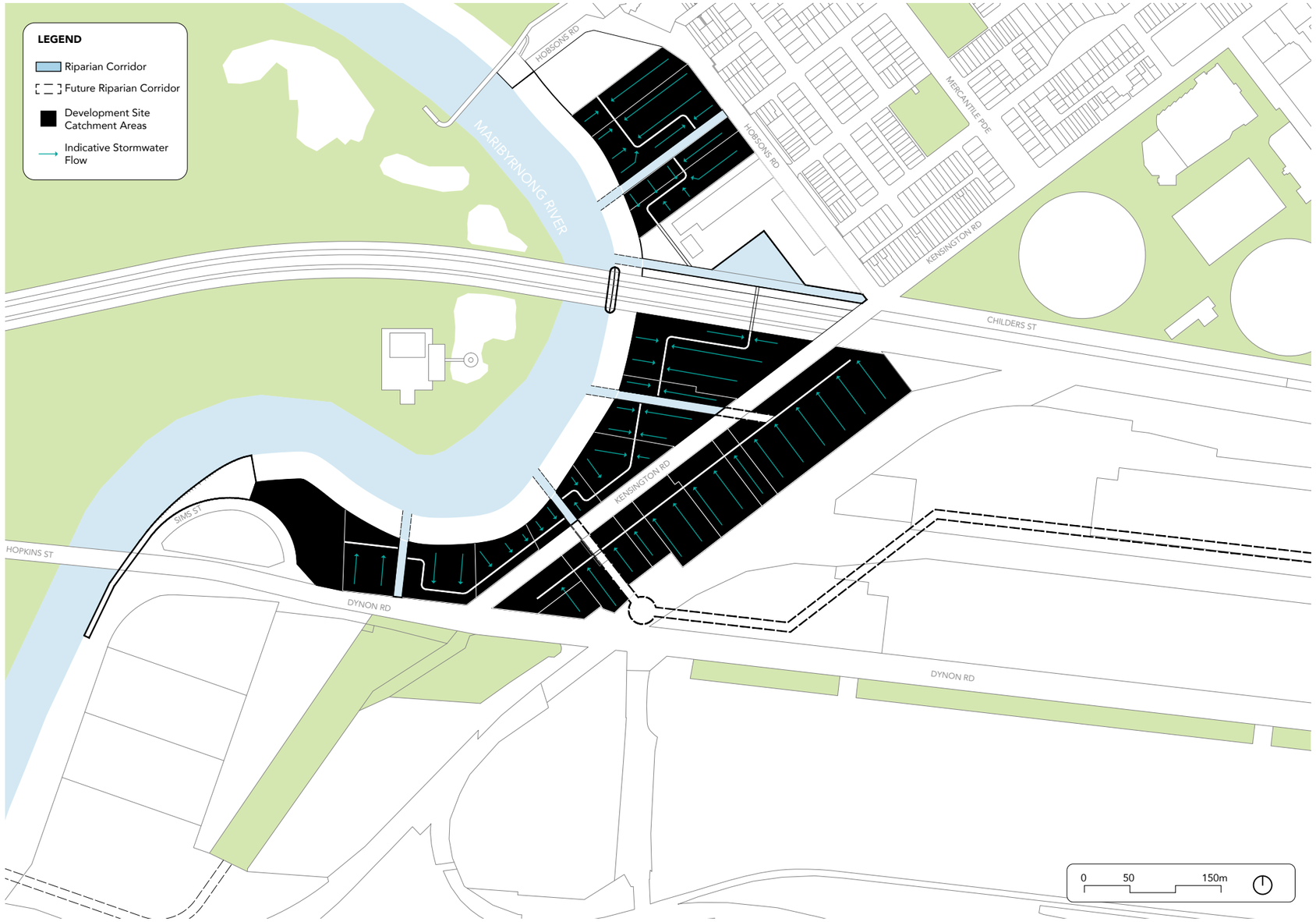


Figure 52: Indicative arrangement of the pluvial approach in the private realm

6.5 Street Sections

Streets will be reconfigured to safely accommodate mobility of all users, manage water flows, provide increased biodiversity and a setting for a growing residential community.

Section - Kensington Road

Movement and access

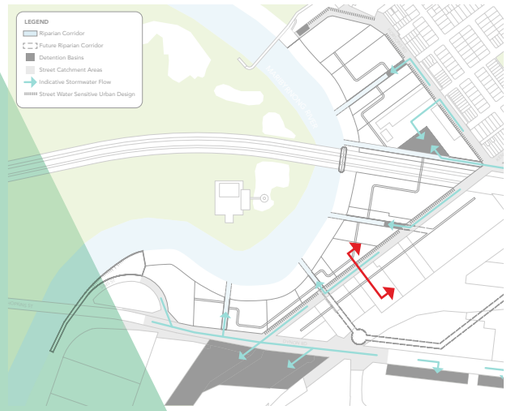
- Footpaths are widened to improve the pedestrian experience
- Safe bicycle movement is integrated through separated bike lanes
- Vehicle lanes are maintained to accommodate freight movement
- Removal of car parking from the streets is relocated into development lots. Further traffic analysis required.

Blue and green

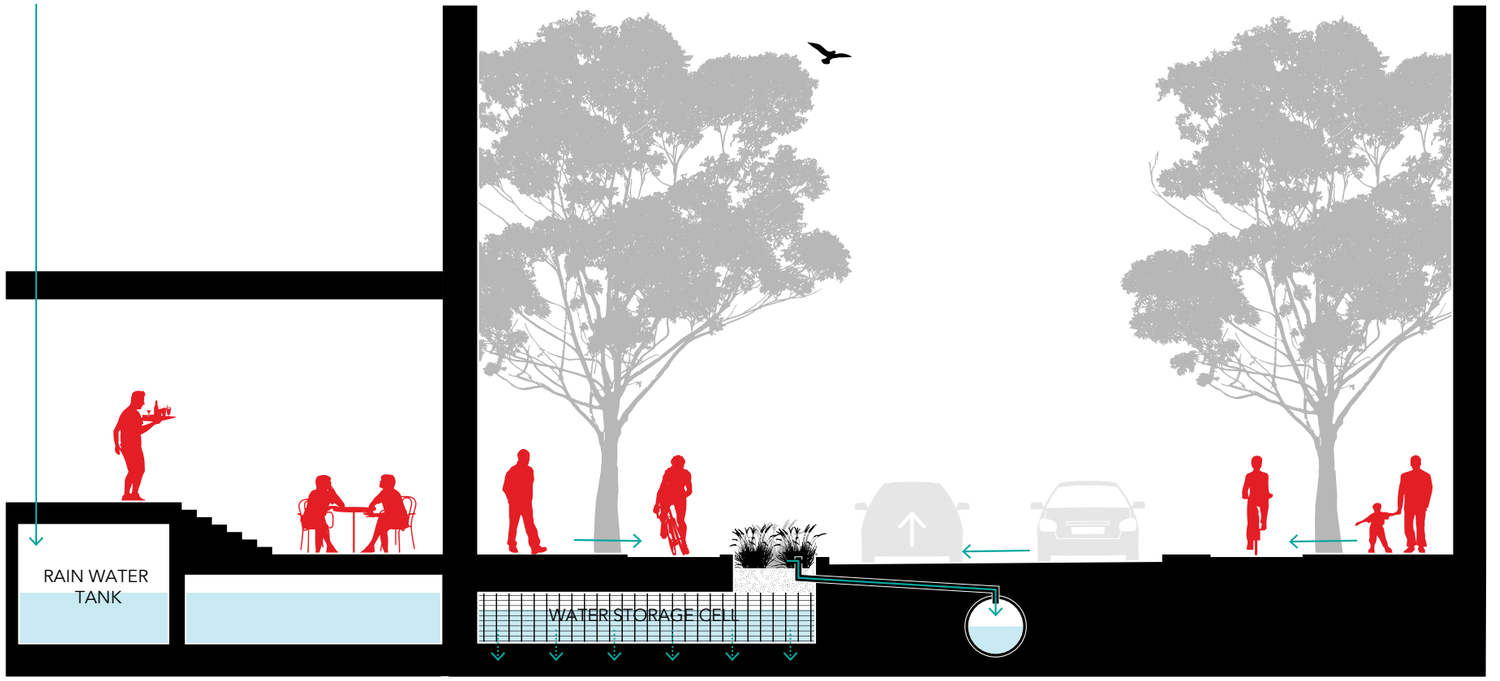
- Existing Plane trees are retained
- Water is conveyed on surface to in-street rain gardens or central detention areas
- Rain gardens and water storage cells detain water locally
- Rain gardens incorporate planting in filtration medium
- Riser pipe provide overflow in extreme events into the underground pipe network

Built form

- Ensure changes in floor level, between exterior and interior spaces, do not rely on external stairs and ramps providing active uses that connect and activate the street.
- Locate permissible non-residential uses at grade
- Rainwater tanks collect and store water runoff during peak flows and store for potential non-potable reuse
- Green roofs improve biodiversity and building insulation, whilst delaying and storing rain waters



Kensington Road section location in red



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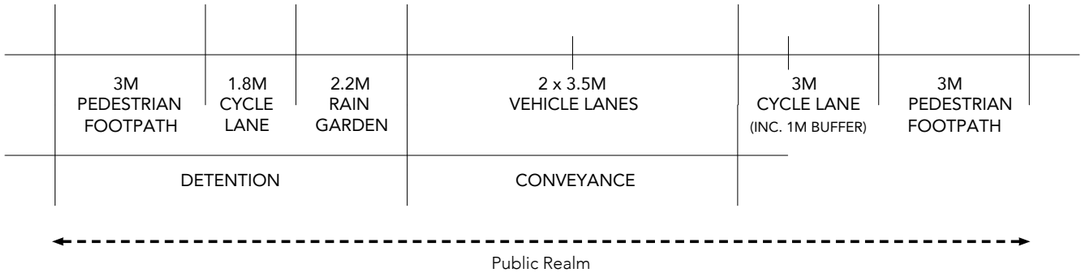


Figure 53: Indicative Kensington Road Section

Section - Hobsons Road

Movement and access

- Footpaths are widened to improve the pedestrian experience
- Vehicle lane widths are downgraded from industrial freight access to local residential programs
- Bicycle and vehicle lanes are combined as a shared, slow speed street
- Limited on street parking is provided, prioritising share cars and drop off points

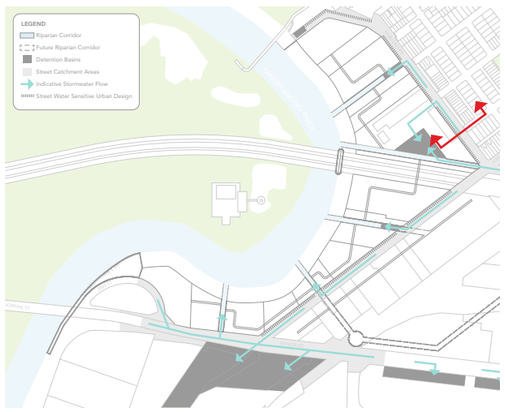
Blue and green

- Existing trees are retained
- Water is conveyed on surface to the in-street swale
- A continuous swale detains water locally and introduces habitat and tree planting opportunities
- Riser pipe provide overflow in extreme events into the underground pipe network

Built form

- Create a direct connection at grade to ground level tenancies, with level transitions contained within the building envelope
- Rainwater tanks collect and store water runoff during peak flows and store for potential non-potable reuse
- Green roofs improve biodiversity and building insulation, whilst delaying and storing rain waters

Figure 54: Indicative Hobsons Road Section



Hobsons Road section location in red

6.6 New Open Space Montage

Figure 55: Potential new public open space in typical conditions

Figure 56: Potential new public open space in 1 in 100 year AEP flood conditions

Conclusion

The primary objective of this strategy is to provide a conceptual plan to manage flooding at Maribyrnong Waterfront. This is achieved through an integrated approach that seeks to maximise the co-benefits of the design for the community.

The management of storm water in this way allows;

- floor levels in buildings to be better integrated, improving commercial value of these buildings and improved connections between the private and public realm
- no requirement for 'humps' in the Kensington and Hobsons Road
- reduced need for underground pipes and pumps
- addition of urban greening and open space provision
- better pedestrian and cycle access and connection, to the river, along the river and across the river
- Improved ecosystems and ecological connectivity

This concept demonstrates how Maribyrnong Waterfront can be an attractive and inviting new area of the City that is not constrained by its relationship with the Maribyrnong River and to storm water, but enhanced by it, defining its very character.

This Integrated Water Management Strategy is the first step in developing a holistic flood management approach. Further analysis is required to identify levels of contamination, staging, implementation and funding approaches.

City of Melbourne practices IWM as a coordinated management of all components of the water cycle including water consumption, rainwater, stormwater, wastewater and groundwater, to secure a range of benefits for the wider catchment. Further work will be undertaken in future stages of the project to address the complete IWM approach outside and above of flood management

1 1

(https://www.itv.com/news/london/2014-03-10/kingstons-floating-cycle-path-helped-win-bid/)

Concluding Casestudies

1. Kingston's floating cycle path:

- Walkways adjacent to riverbank functioning as different entities
- Different walkways facilitating different movement and activity types
- Planting in inner and outer path zones create visual interest

7.0 Conclusion

(www.landezine.com/index.php/2011/06/rhone-river-banks-by-in-situ-architectes-paysagistes/)

(www.landezine.com/index.php/2011/06/rhone-river-banks-by-in-situ-architectes-paysagistes/)

2. Rhone River Banks, LRM Landscape Architects:

- Seamlessly integrating levee into landscape
- Facilitating and prioritizing non-vehicular movement in both inner and outer levee zones

3. Rhone River Banks, LRM Landscape Architects:

- Allow leveew system to function as amenity and feature in landscape

4. Domino Park, James Corner Field Operations

- Using dikes as opportunities for circulation, egress and amenity

5. Benthem Plein, De Urbanisten:

- Implement flood mitigation multi-purpose infrastructure to deal with pluvial flooding

(https://www.archdaily.com/914548/domino-park-james-corner-field-operations)

(http://yousense.info/7761746572/water-square-in-rotterdam-by-de-urbanisten-uncube.html)

(www.dezeen.com/2018/01/16/zalige-bridge-next-architects-hns-landscape-architects-stepping-stones-nijmegen-netherlands/)

(www.landezine.com/index.php/2012/06/kallang-river-at-bishan-ang-mo-kio-park-by-atelier-dreiseitl/)

(https://www.npr.org/2011/09/03/140063103/the-inside-track-on-new-yorks-high-line)

6. Zalige bridge, Next Architects

- Allowing for egress in all weather conditions

7. Yanweizhou Park, Turenscape:

Resilient landscapes which function in spite of climate change and environmental fluctuations. Landscapes designed to flood

8. High Line:

- Using defunct rail infrastructure to prioritize non-vehicular movement and facilitate urban place-creation

9. Bishan Park, Ramboll Studio Dreiseitl:

- Educational and recreational aspect to connecting people to clean water in an urban environment

(www.dezeen.com/2015/11/06/turenscape-yanweizhou-park-landscape-of-the-year-2015-award-world-architecture-festival/)

Glossary

Pluvial - Localised stormwater that accumulates in an area faster than the area's capacity to shed or infiltrate stormwater.

Fluvial - Flood waters that come from the river when it bursts its banks.

Blue Infrastructure - Rivers, creeks, ponds and lakes that exist as natural features within cities, or be added to an urban environment as an aspect of its design.

Green Infrastructure - Parks, reserves, habitat areas, green roofs and walls, street trees etc. that provide important environmental, recreational or social services for communities.

Blue-Green Infrastructure - Blue infrastructure is commonly associated with green infrastructure in the urban setting and may be referred to as "blue-green" infrastructure when in combination.

Sponge Initiatives - Infrastructure systems that collect, store and treat (excess) storm water through blue-green planning and design.

An Integrated Dike - A dike or levee is an elongated artificially constructed fill embankment or wall, which regulates water levels. It is usually earth and often parallel to the course of a river in its floodplain.

Riparian Corridors - A riparian area is the interface between land and a river creating unique ecologies.

Tertiary Corridors - A hard or landscaped channel that conveys storm water to a desired location.

Detention Basins - A detention or retarding basin is an excavated area installed to store storm water for a set period of time before being released back into a river.

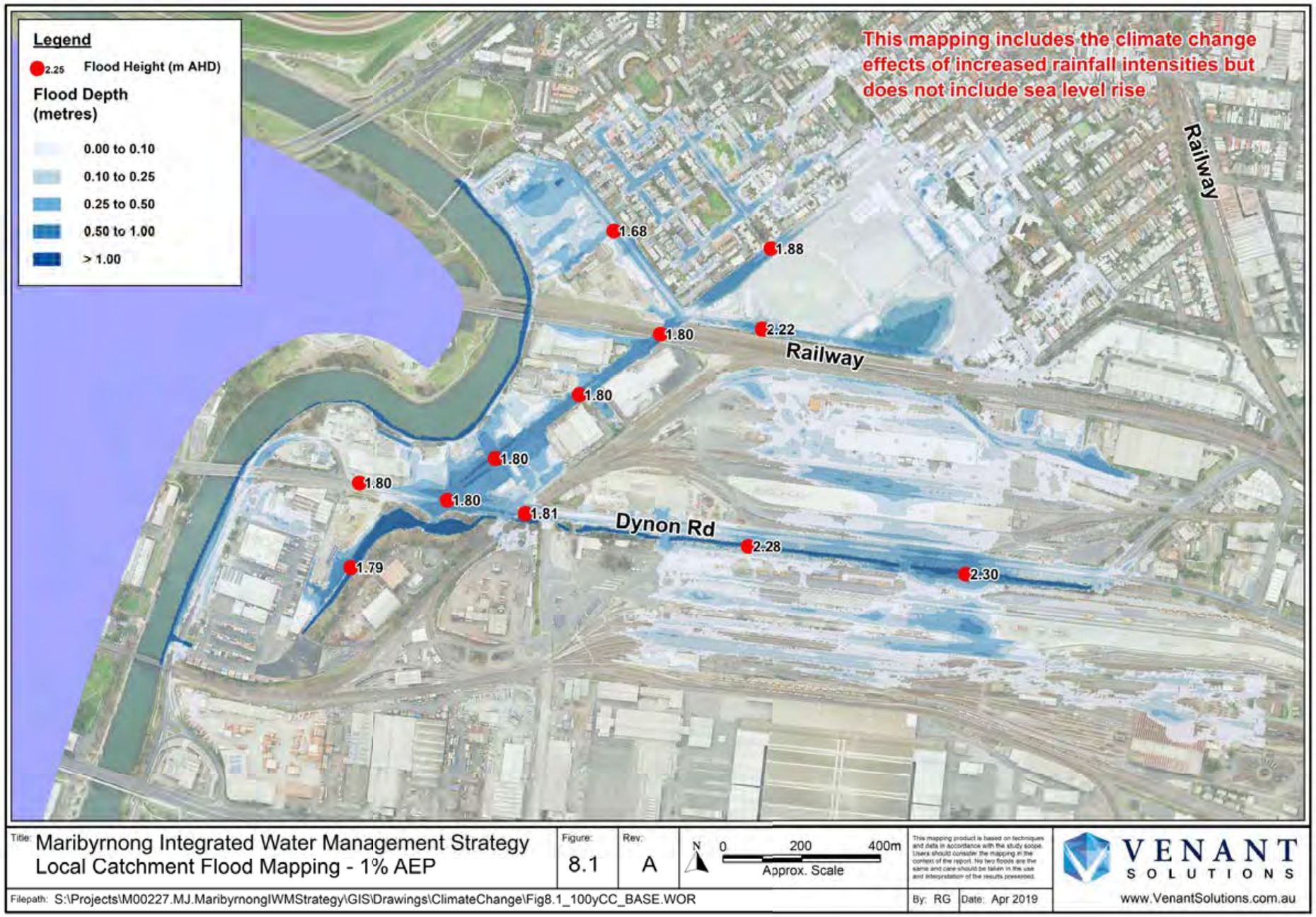
Blue-green Streets - A street that provides public thoroughfare whilst integrating garden beds, tree planting and water sensitive urban design (WSUD).

Green roofs - A roof of a building that is covered with vegetation and growing medium, planted over a waterproofing membrane.

Rainwater Tanks - A tank used to collect and store rain water runoff, typically from rooftops via pipes.

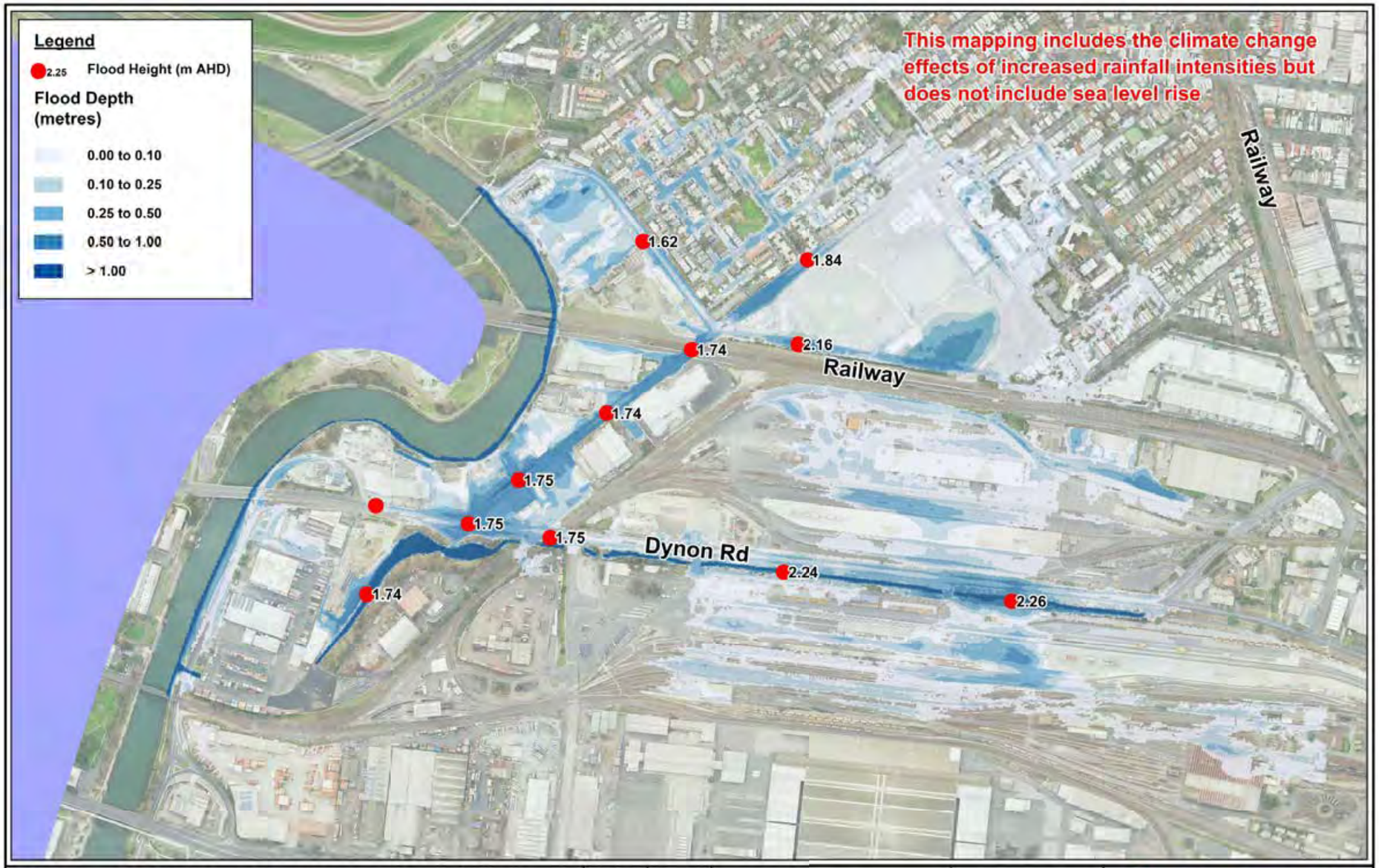
Community Assets - Public facilities that service the community including community centres, youth centres, private facilities that provide a community service, art galleries, gyms or architectural elements that contribute to the character of place. For the purposes of this report parks and open space are dealt with separately.

8.1 Appendix



6.0 Appendices

8.2 Appendix



Title: Maribyrnong Integrated Water Management Strategy Local Catchment Flood Mapping - 2% AEP	Figure: 8.2	Rev: A	N 0 200 400m Approx. Scale	This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.	VENANT SOLUTIONS www.VenantSolutions.com.au
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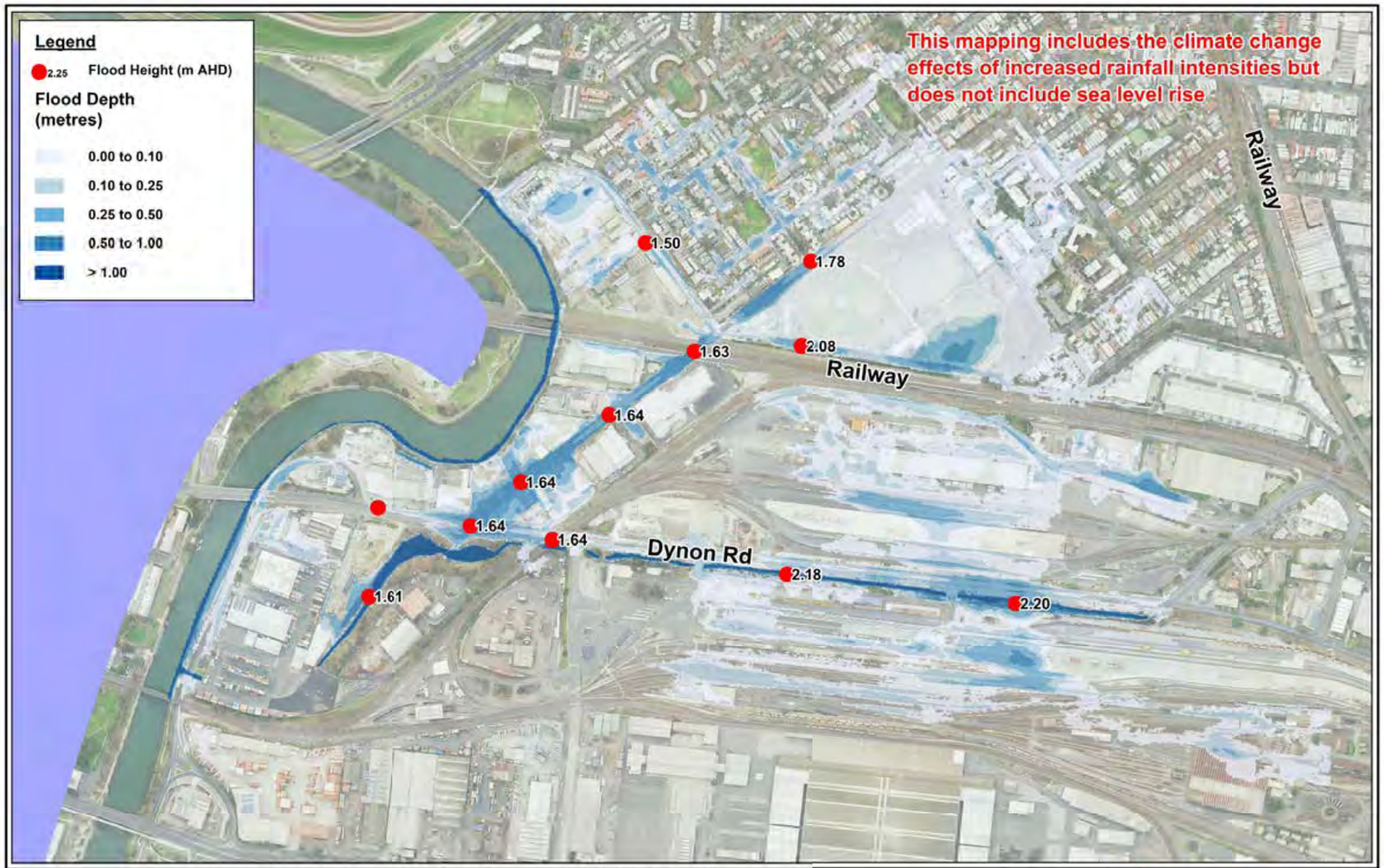
8.3 Appendix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Flood Depth (metres)
0.00 to 0.10
0.10 to 0.25
0.25 to 0.50
0.50 to 1.00
> 1.00
This mapping includes the climate change effects of increased rainfall intensities but does not include sea level rise
Railway
Railway
Dynon Rd
1.50
1.78
1.63
2.08
1.64
1.64
1.64
1.61
2.18
2.20
Title: Maribyrnong Integrated Water Management Strategy
Local Catchment Flood Mapping - 5% AEP
Figure: 8.3
Rev: A
N
0
200
400m
Approx. Scale
This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.
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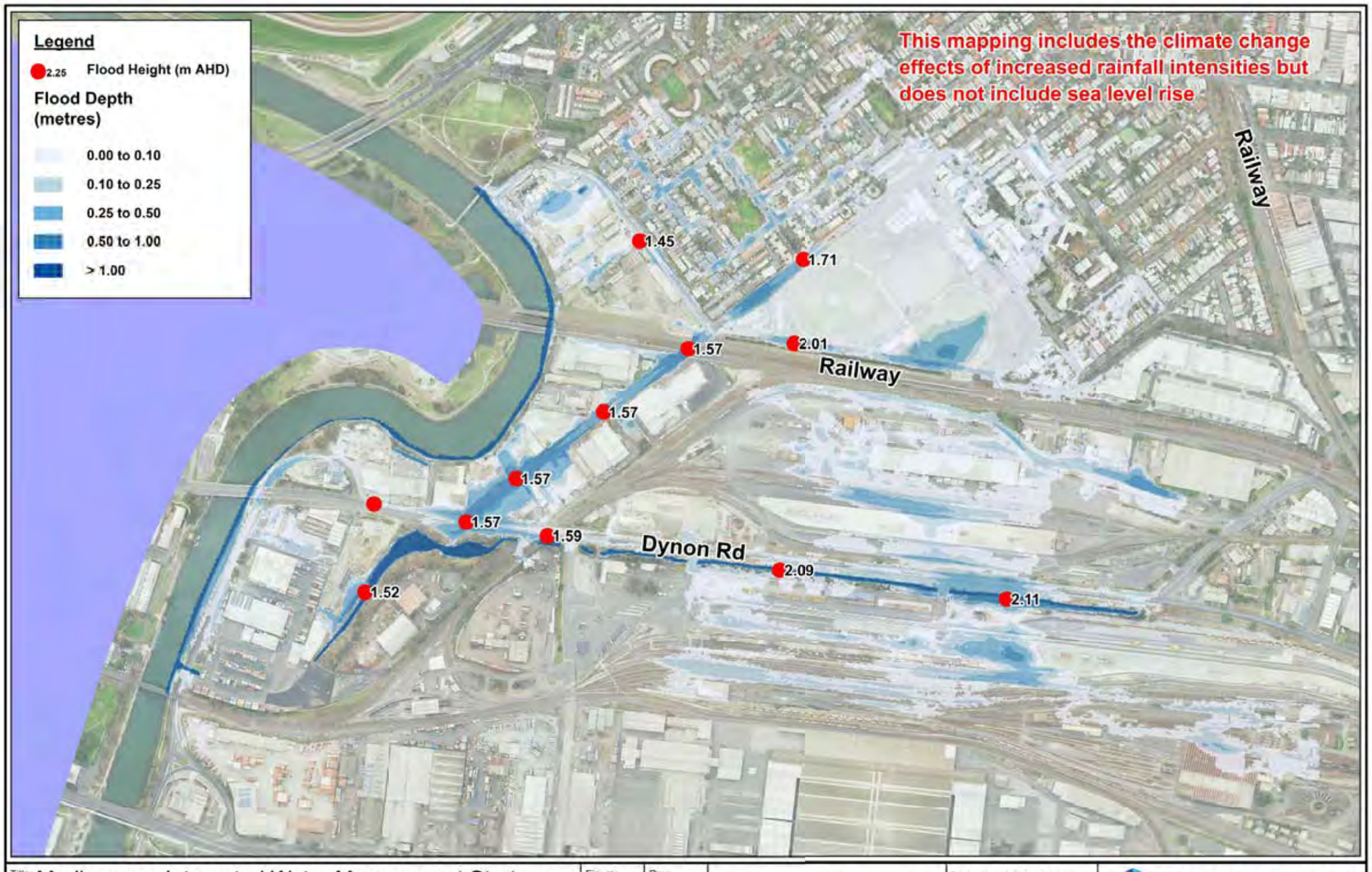
8.4 Appendix



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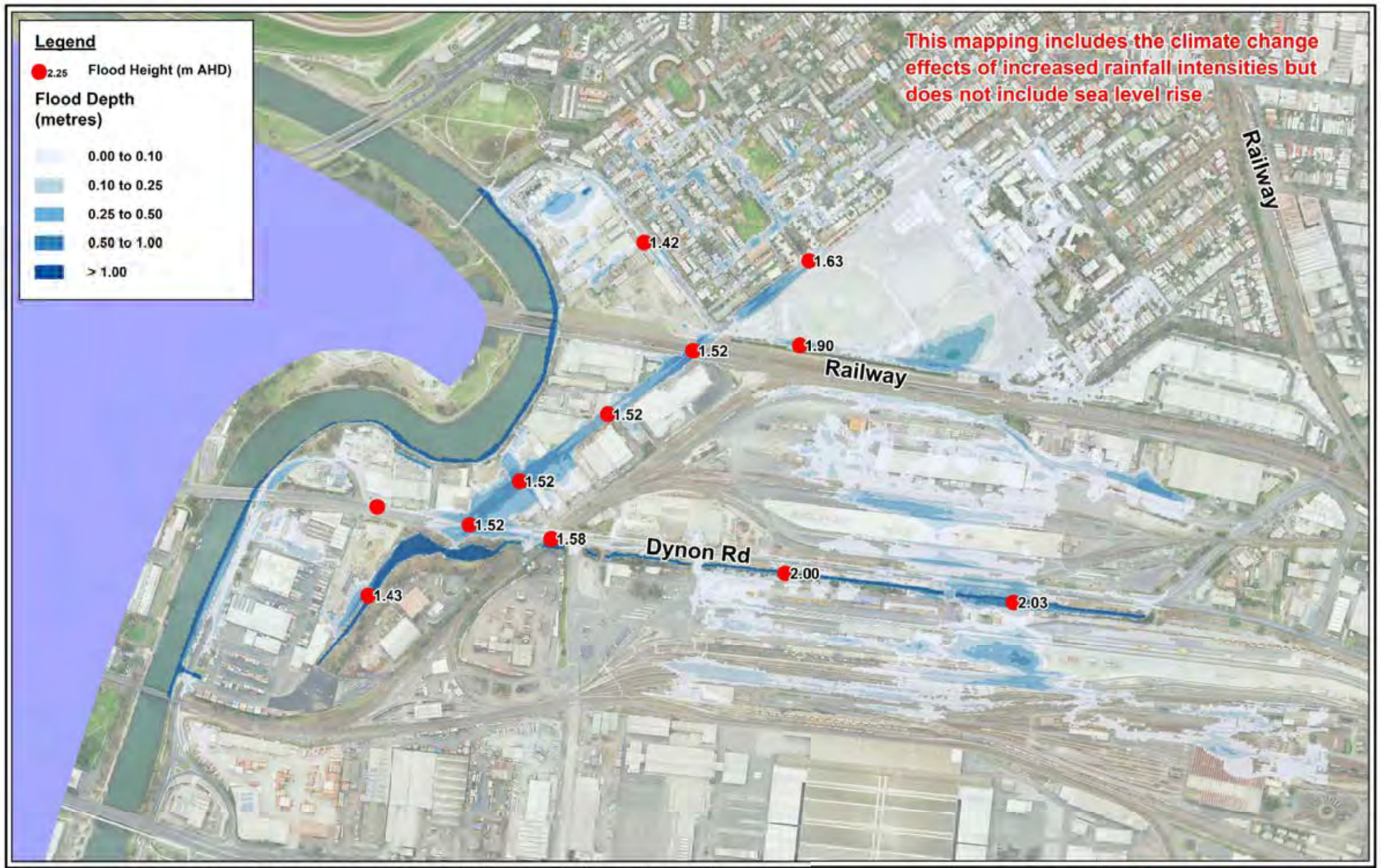
8.5 Appendix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Flood Depth (metres)
0.00 to 0.10
0.10 to 0.25
0.25 to 0.50
0.50 to 1.00
> 1.00
This mapping includes the climate change effects of increased rainfall intensities but does not include sea level rise
1.42
1.63
1.52
1.90
Railway
1.52
1.52
1.52
1.58
Dynon Rd
2.00
1.43
2.03
Railway
Title: Maribyrnong Integrated Water Management Strategy
Local Catchment Flood Mapping - 20% AEP
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Rev: A
N
0
200
400m
Approx. Scale
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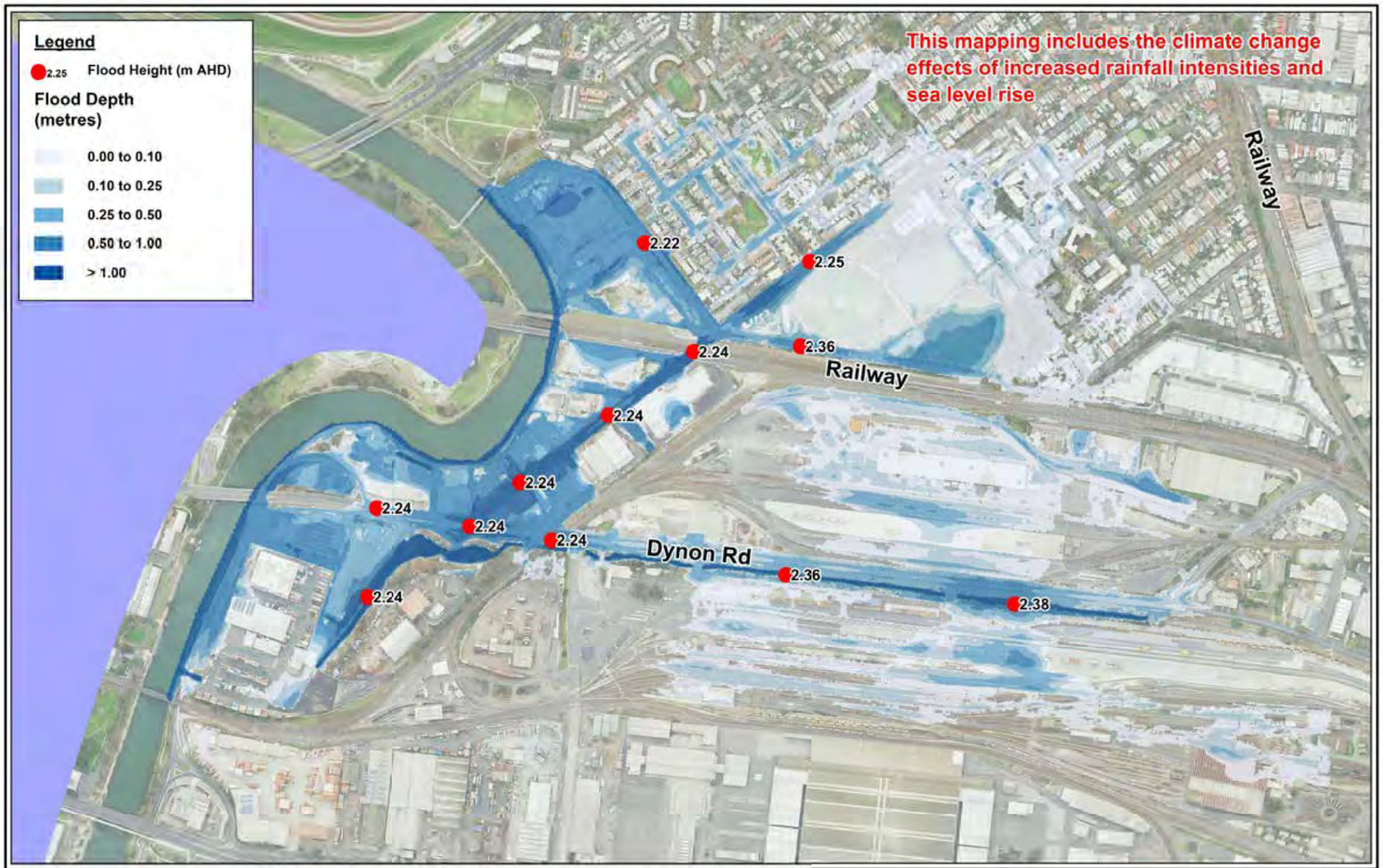
8.6 Appendix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Flood Depth (metres)
0.00 to 0.10
0.10 to 0.25
0.25 to 0.50
0.50 to 1.00
> 1.00
This mapping includes the climate change effects of increased rainfall intensities and sea level rise
Railway
Railway
Dynon Rd
2.22
2.25
2.24
2.36
2.24
2.24
2.24
2.24
2.24
2.36
2.38
Title: Maribyrnong Integrated Water Management Strategy
Local Catchment Flood Mapping - 1% AEP
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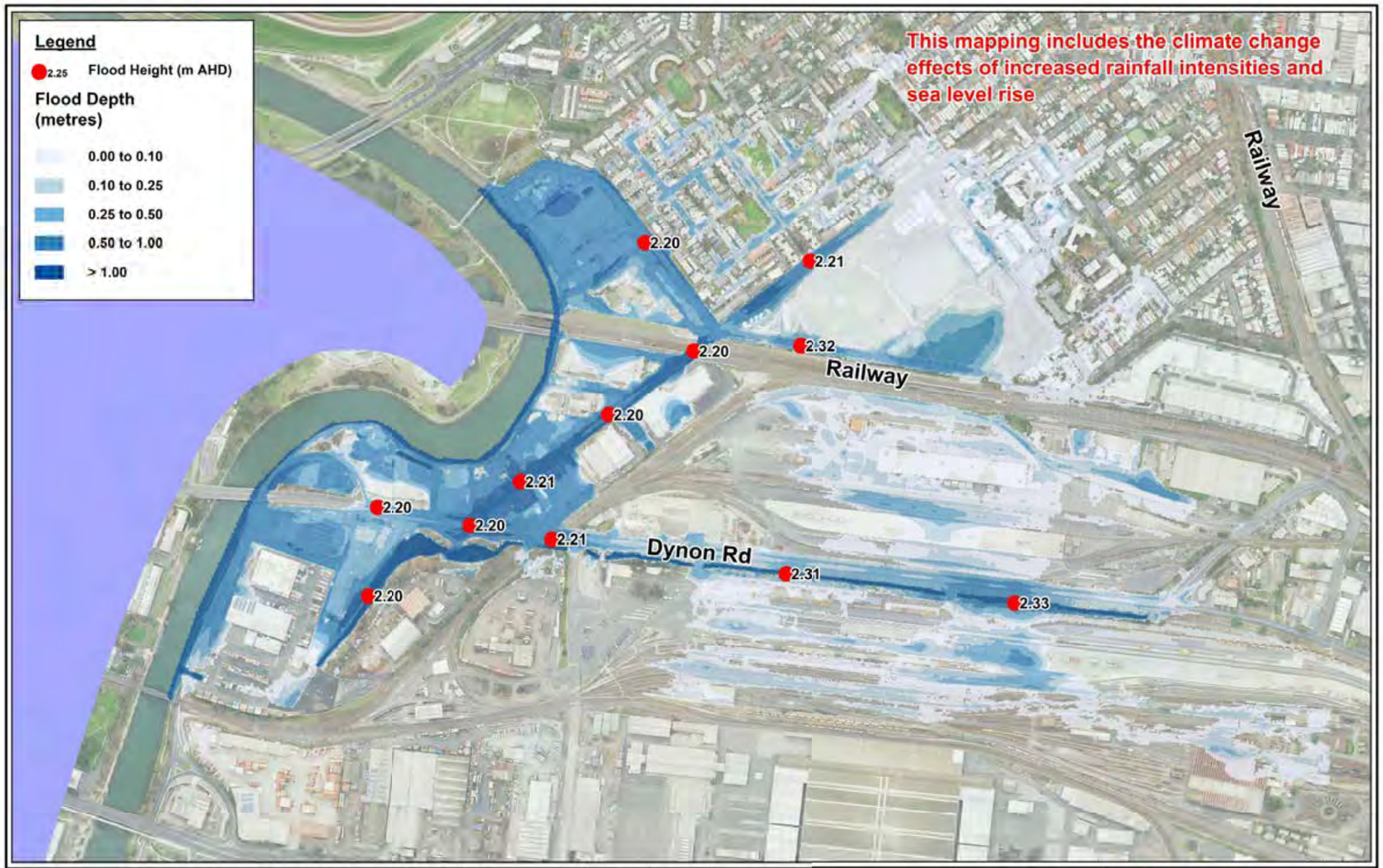
8.7 Appendix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Flood Depth (metres)
0.00 to 0.10
0.10 to 0.25
0.25 to 0.50
0.50 to 1.00
> 1.00
This mapping includes the climate change effects of increased rainfall intensities and sea level rise
Railway
Railway
Dynon Rd
2.20
2.21
2.20
2.32
2.20
2.21
2.20
2.20
2.21
2.31
2.33
Title: Maribyrnong Integrated Water Management Strategy
Local Catchment Flood Mapping - 2% AEP
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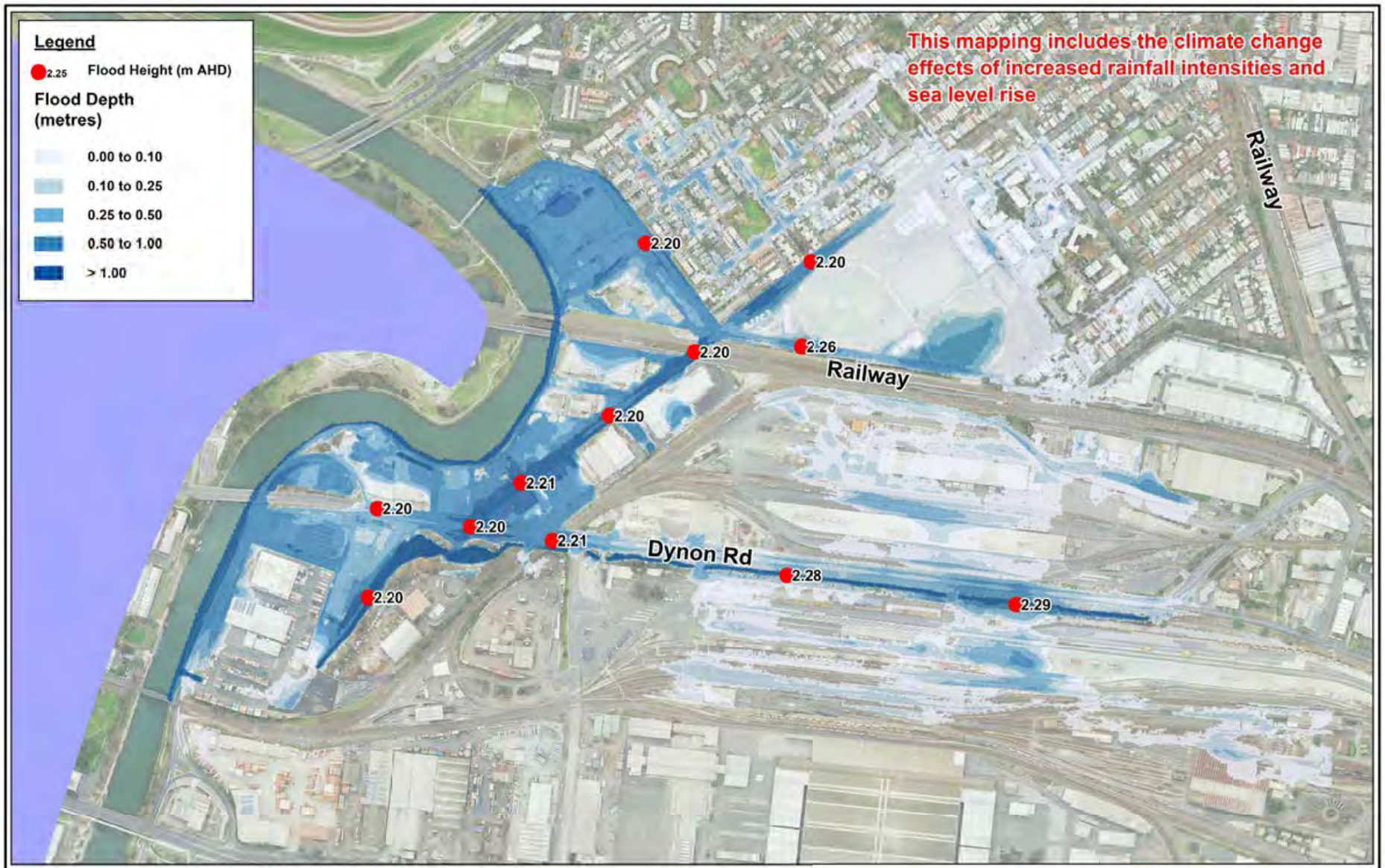
8.8 Appendix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Flood Depth (metres)
0.00 to 0.10
0.10 to 0.25
0.25 to 0.50
0.50 to 1.00
> 1.00
This mapping includes the climate change effects of increased rainfall intensities and sea level rise
Railway
Railway
Dynon Rd
2.20
2.20
2.20
2.26
2.20
2.21
2.20
2.20
2.21
2.28
2.29
Title: Maribyrnong Integrated Water Management Strategy
Local Catchment Flood Mapping - 5% AEP
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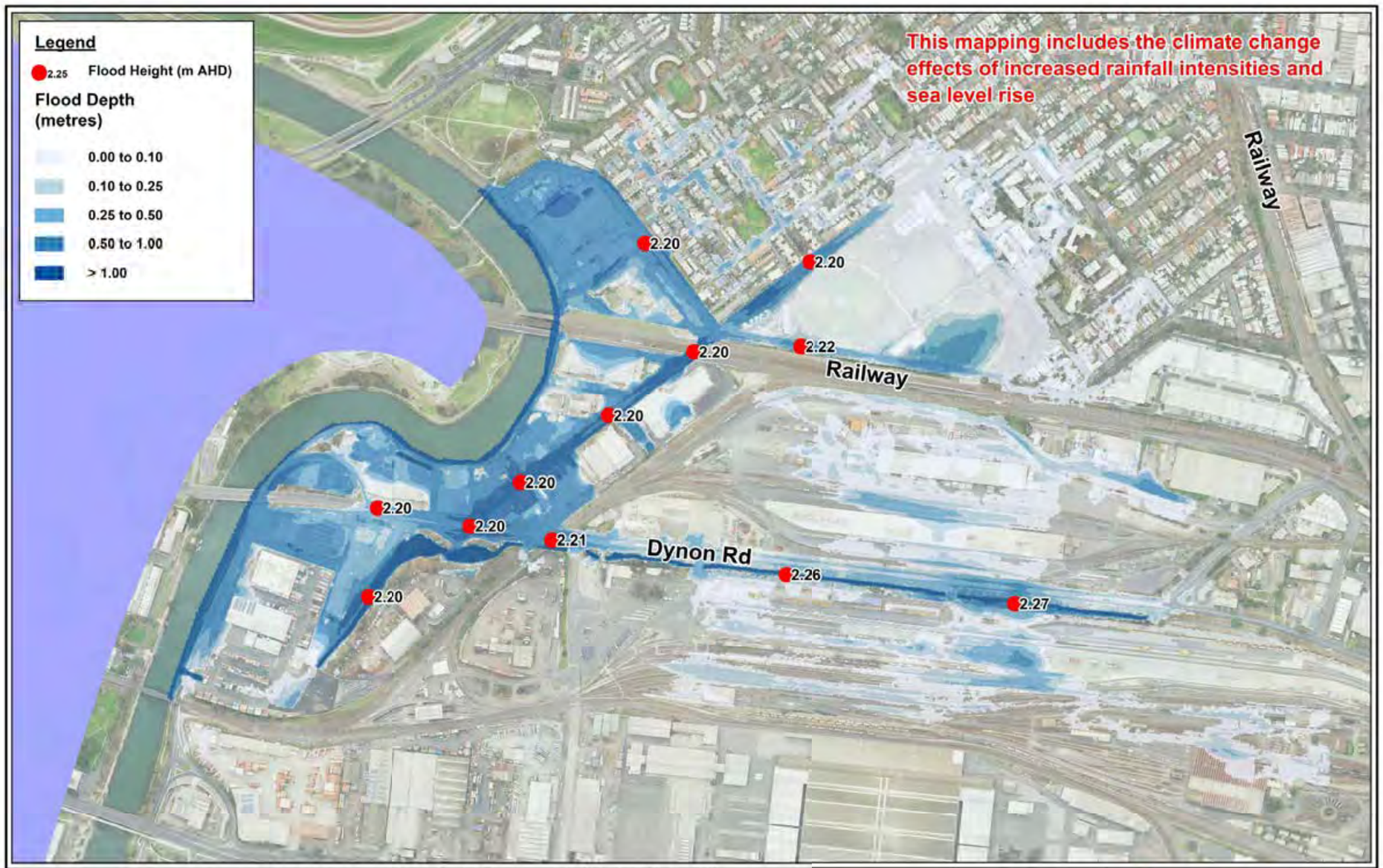
Date: Apr 2019

8.9 Appendix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Flood Depth (metres)
0.00 to 0.10
0.10 to 0.25
0.25 to 0.50
0.50 to 1.00
> 1.00
This mapping includes the climate change effects of increased rainfall intensities and sea level rise
Railway
Railway
Dynon Rd
2.20
2.20
2.20
2.22
2.20
2.20
2.20
2.20
2.21
2.26
2.27
Title: Maribyrnong Integrated Water Management Strategy
Local Catchment Flood Mapping - 10% AEP
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N
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Approx. Scale
This mapping product is based on techniques and data in accordance with the study scope. Users should consider the mapping in the context of the report. No two floods are the same and care should be taken in the use and interpretation of the results presented.
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Date: Apr 2019

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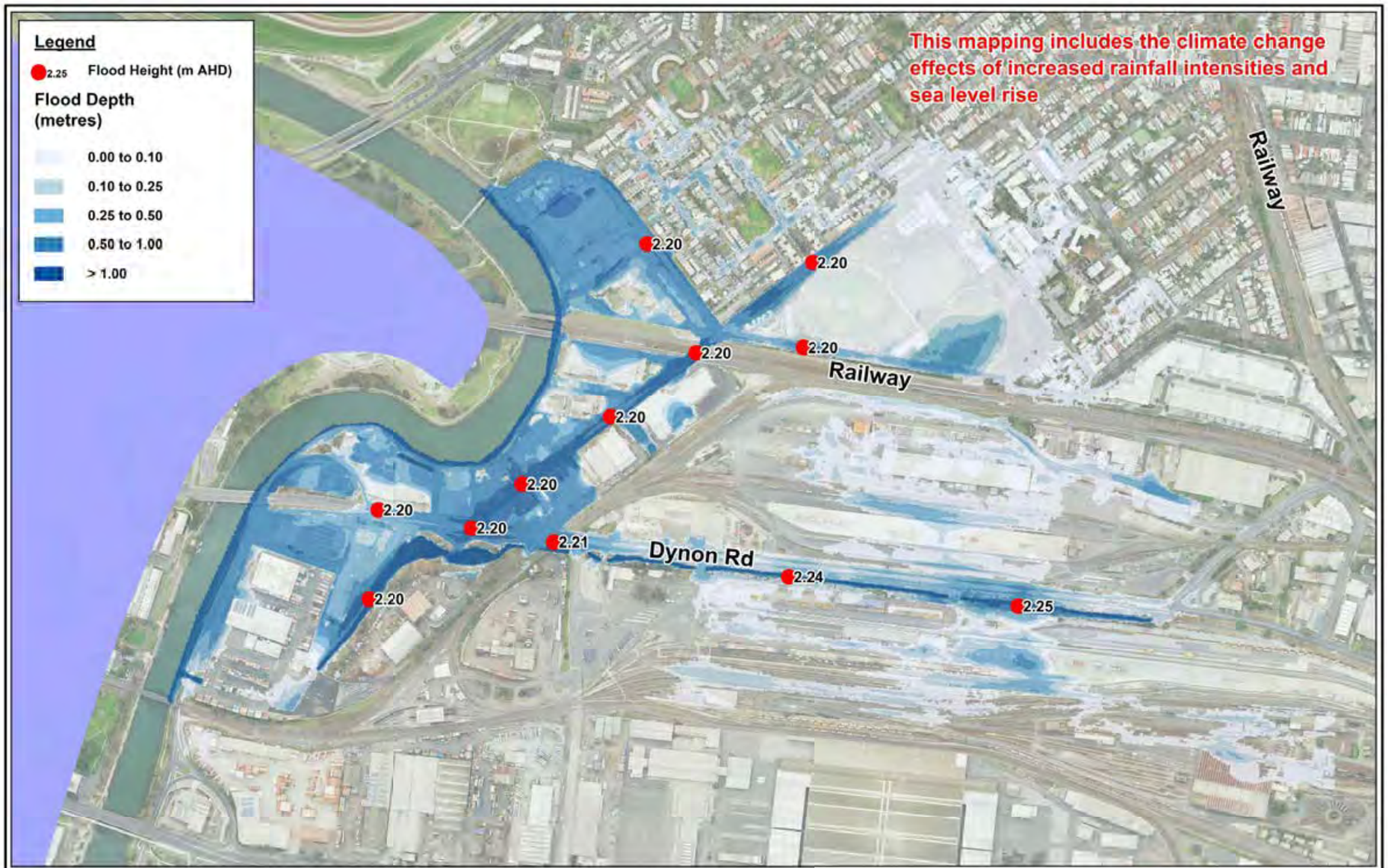

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