

Copperfield Drive Technical Study



NSW Department of Planning,
Industry and Environment

September 2021



Acknowledgement of Country

NSW Department of Planning, Industry and Environment acknowledges the Traditional Custodians of the land and pays respect to all Elders past, present and future.

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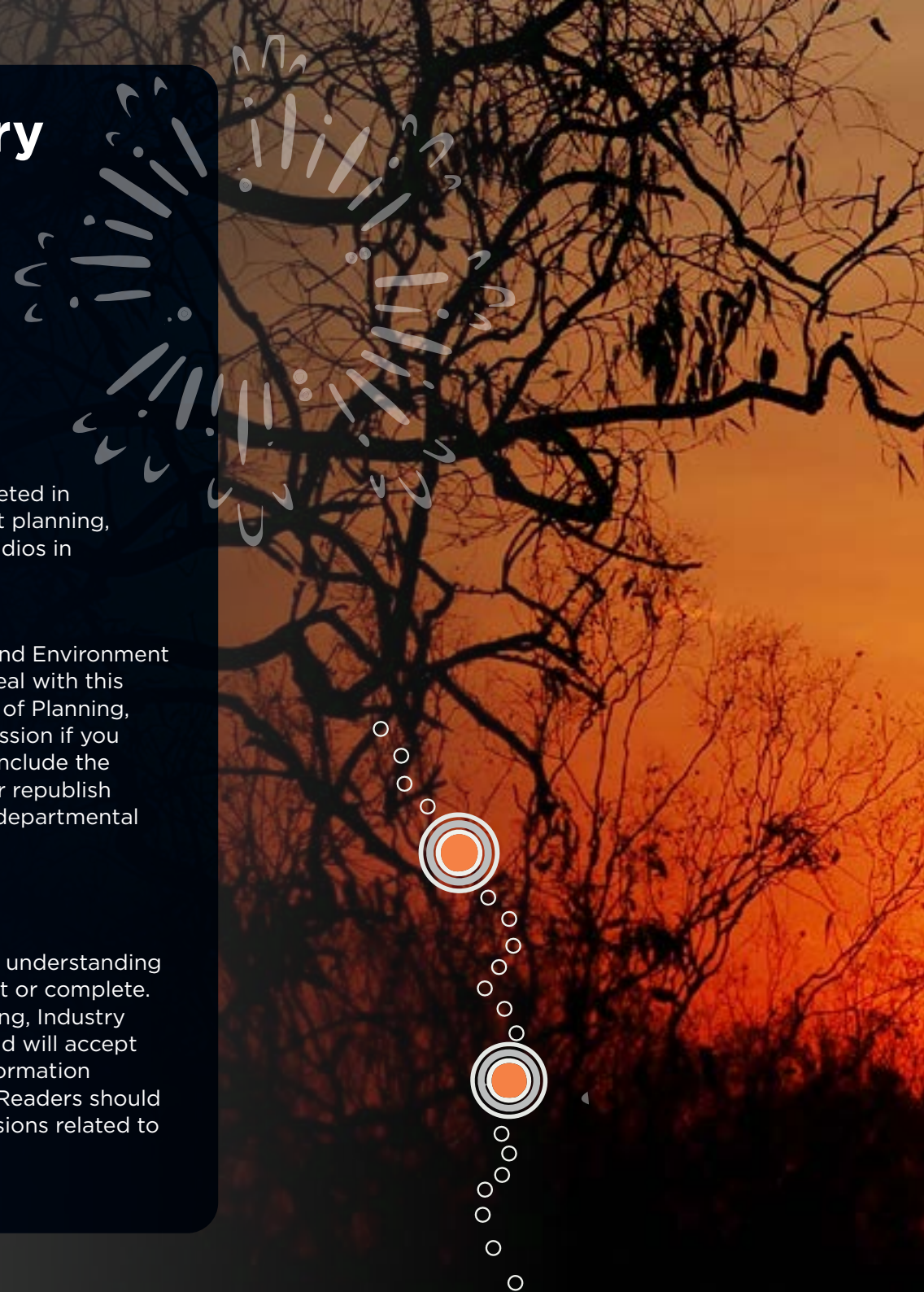
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Illustration: Credit Nikita Ridgeway







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Introduction



5 Million Trees Program

The Department of Planning, Industry and Environment's 5 Million Trees for Greater Sydney Program (5MT) aims to plant trees in both the public and private realm to expand urban tree canopy to 40% across 33 local government areas within the Greater Sydney metropolitan area.

The overall objectives of 5MT are:

- Plant five million more trees in Greater Sydney by 2030
- Increase Greater Sydney's urban tree canopy towards 40%
- Assist in the amelioration of climate extremes by providing shade and cooling of urban areas through tree planting
- Create a healthier, more liveable and greener Greater Sydney.

The 5MT program aims to support the delivery of two NSW Premier's Priorities:



Greening our city – Increase the tree canopy and green cover across Greater Sydney by planting 1 million trees by 2022.



Greener public spaces – Increase the proportion of homes in urban areas within 10 minutes' walk of quality green, open and public space by 10 per cent by 2023.

Demonstration project objectives

Rosemeadow has been selected as an initial demonstration project for the 5MT program for a variety of reasons: a substantial open space network, challenging hydraulic site conditions, community demographics and a low existing canopy cover of 5.63%.

The Rosemeadow Demonstration Project aims to:

- increase canopy cover across Rosemeadow towards 40% using both public and private land
- demonstrate Campbelltown City Council's commitment to achieving a vibrant, liveable city
- demonstrate how to achieve 40% canopy cover in constrained urban environments
- improve the amenity and walkability of Rosemeadow by increasing the shading and cooling of streets and parks
- investigate the role of trees in stormwater management systems

- establish a healthy tree canopy supported by water-sensitive urban design (WSUD) approaches to mitigate nuisance flooding and urban heat island effects
- educate and advocate to the community and stakeholders on the benefits of urban canopy and increase stewardship to ensure the retention of existing and newly planted trees
- encourage local residents to plant trees in their own yards to increase tree canopy across the private realm
- increase habitat for urban wildlife
- incorporate leading-edge plant species and diversity research
- achieve best-practice collaborative outcomes with project stakeholders.

The intention is to use Rosemeadow as a case study and share the methodology, learnings and outcomes to create a useful framework for future urban canopy projects for use across Greater Sydney.

Copperfield Drive design objectives

The Copperfield Drive concept design has six key objectives:

Improve the walkability of Copperfield Drive by increasing the shading and cooling of streets and supporting the Walk Safely to School program.

Establish a healthy tree canopy supported by water-sensitive urban design (WSUD) approaches to mitigate nuisance flooding and urban heat island effects, and to demonstrate that urban canopy can be integrated with stormwater management systems.

Improve the amenity of Copperfield Drive by increasing shade and cooling to link housing, schools, shops and community services.

Increase habitat for urban wildlife and incorporate leading-edge plant species and diversity research.

Reconfigure the spatial hierarchy of Copperfield Drive to create space for healthy tree growth.

Achieve best practice collaborative outcomes with project stakeholders and the community to create 'Safe Active Streets'.



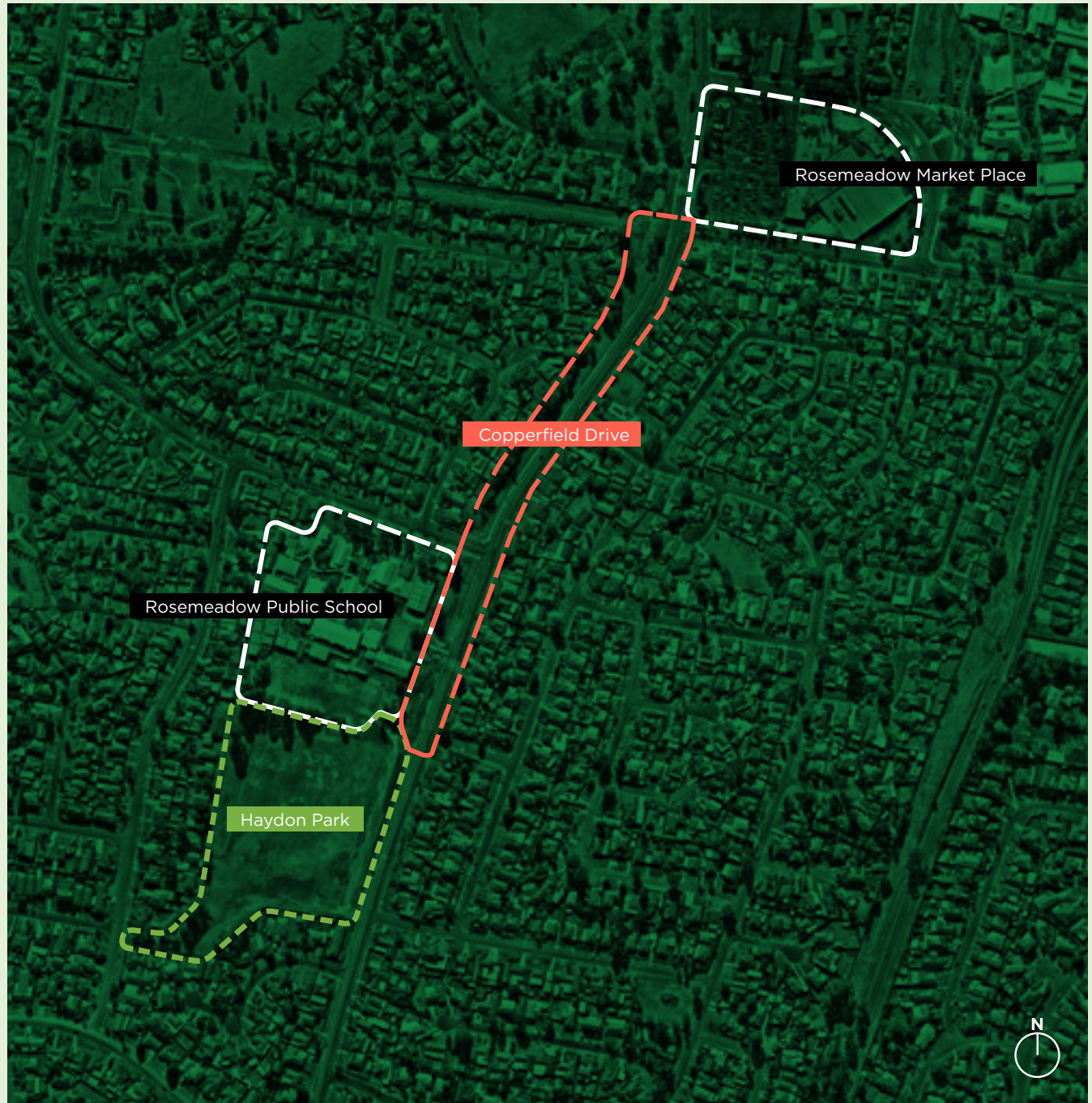
Study area

This study demonstrates the design and technical requirements to integrate trees into streets and stormwater management systems.

Copperfield Drive has been identified as the study area for tree planting, as it:

- has minimal existing canopy cover
- provides opportunity to integrate tree planting into the open channel stormwater system running adjacent to Copperfield Drive
- has existing drainage infrastructure that can be retrofitted for passive tree irrigation and storm water filtration
- provides opportunity to integrate tree canopy shade along routes for improved walking/cycling amenity
- is a significant neighbourhood connector street that links housing, schools, shops, community services and is an important bus route connection
- provides sufficient carriageway width, that can accommodate tree stand outs within the kerb side lane
- provides opportunity to reduce speed limits with the introduction of street tree planting.

Figure 1: Rosemeadow study area – Copperfield Drive and key surrounding public infrastructure.



Methodology

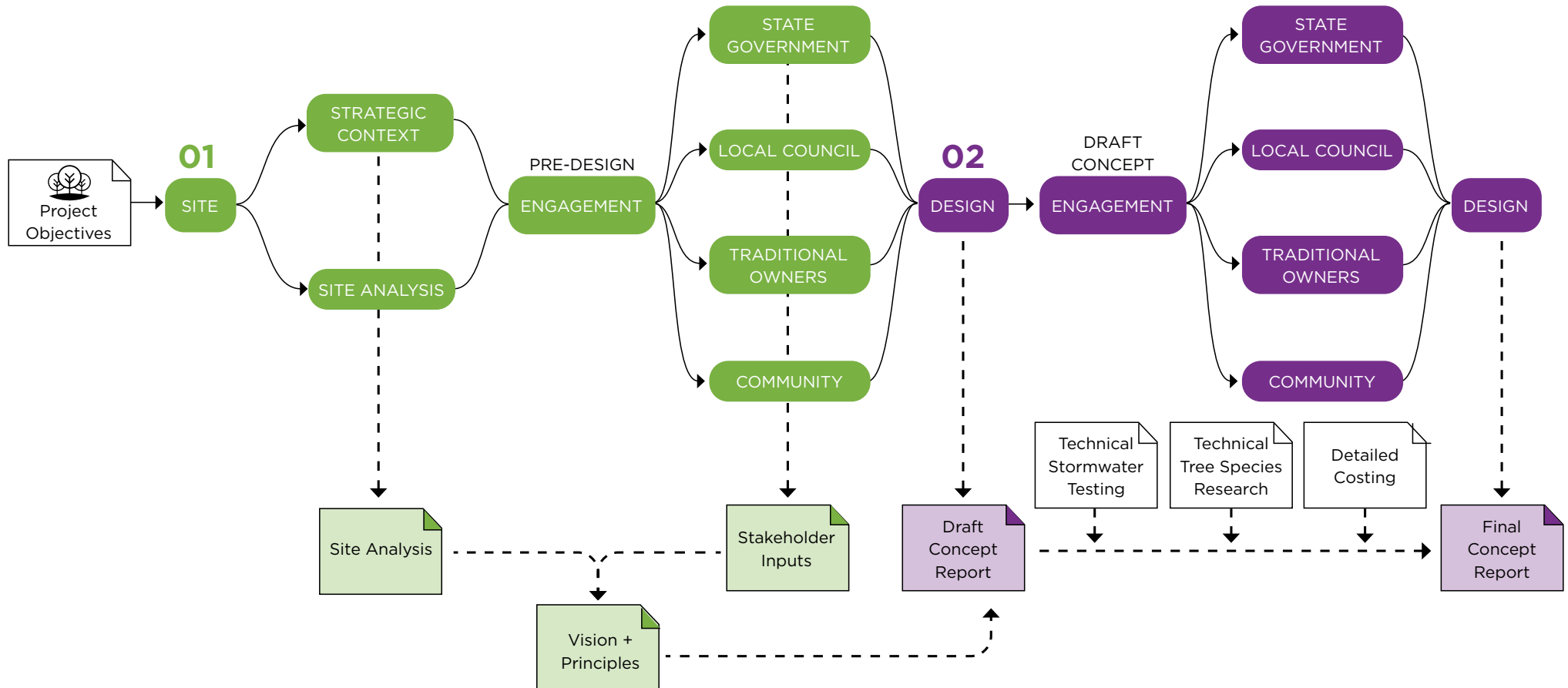
The Copperfield Drive design is informed by two defined processes as described and illustrated below. These processes also inform the structure of this report.

01 Site

The first part of this study outlines a number of studies, strategies and reports that have been undertaken by the NSW Government and Campbelltown City Council. On-site analysis and stakeholder engagement furthers the understanding of the site and helps inform the constraints, opportunities and future requirements for tree planting.

02 Design

The second part of this study outlines the spatial arrangements and system toolkits that make up the proposed Copperfield Drive design. The design is refined through stakeholder engagement, technical testing and research and cost analysis.







Part 1:

Site analysis



Strategic context

A number of studies, strategies and reports have been undertaken across NSW Government departments that explore constraints, opportunities and future requirements for green and blue infrastructure through the lens of urban growth and conservation. Campbelltown City Council strategies locate priorities within the Campbelltown and Rosemeadow context. These strategies are key to understanding the broad and detailed visions proposed for the study area and are summarised on the following pages.

Key themes stemming from this work show a significant emphasis on:

- future-proofing communities from the effects of climate change
- improving everyday life through sustainable urban and natural systems
- enriching the overall experience, quality and offering of place.

NSW Government

NSW Government Premier's Priorities

The Hon Gladys Berejiklian, Premier of NSW, June 2019

The Premier has set priorities that aim to tackle tough community challenges, lift the quality of life for all citizens and put people at the heart of creating a better environment.

Greener public spaces - Increase the proportion of homes in urban areas within 10 minutes' walk of quality green, open and public space by 10 per cent by 2023.

Greening our city - Increase the tree canopy and green cover across Greater Sydney by planting 1 million trees by 2022.

Greater Sydney Region Plan

Greater Sydney Commission, 2018

The vision for A Metropolis of Three Cities sets out how residents will live within 30 minutes of jobs, education and health facilities, services and great places. The regional plan focuses on supporting a growing community through land use and transport to boost liveability, productivity and sustainability. Of relevance to this manual, the Greater Sydney Regional Plan sets to achieve:

‘Urban tree canopy will be valued for its economic, social and environmental benefits – a network of walking and cycling links will become increasingly important.

- The coast and waterways are protected and healthier
- Biodiversity is protected, urban bushland and remnant vegetation is enhanced
- Scenic and cultural landscapes are protected
- Urban tree canopy cover is increased
- Public open space is accessible, protected and enhanced
- The Green Grid links parks, open spaces, bushland and walking and cycling paths
- Heatwaves and extreme heat are managed’

Western City District Plan

Greater Sydney Commission, 2018

The Western City District Plan sets out the 20-year vision for the Western Parkland City, which draws on the strength of the new Western Sydney Airport and the first stage of a North-South Rail Link. The Western Parkland City will capitalise on the established centres including Campbelltown. Of relevance to this study, the following planning priorities have been considered;

‘Planning Priority W15: Increasing urban tree canopy cover and delivering Green Grid connections

- Objective 30: Urban tree canopy cover is increased.
- Objective 32: The Green Grid links parks, open spaces, bushland and walking and cycling paths.

Planning Priority W18: Delivering high quality open space

- Objective 31: Public open space is accessible, protected and enhanced.’

The Green Grid - Creating Sydney’s Open Space Network

The NSW Government Architect’s Office, 2018

An integrated approach to the green infrastructure of the district – waterways, bushland, urban tree canopy and open spaces – will improve sustainability.

The Greater Sydney Green Grid will provide cool, green links and a network of high-quality open spaces to support walking, cycling and community access to open space.

‘A spatial framework for regional planning providing:

- Opportunity to put policy into action
- Adds value to urban development
- Increases access to open space
- Promotes healthy living
- Improves sustainable travel connections
- Conserves and enhances biodiversity and increase access to nature facilitates
- Adaptation to climate extremes and promotes urban greening
- Enhances distinctive destinations and boosts the visitor economy’



Greener Places: An urban green infrastructure design framework for New South Wales

Government Architect NSW's Office, 2020

Greener Places is a green infrastructure policy produced by the Government Architect NSW to guide the planning, design and delivery of green infrastructure in urban areas across NSW. It aims to create a healthier, more liveable and sustainable urban environment by improving community access to recreation and exercise, supporting walking and cycling connections, and improving the resilience of urban areas.

Flood risk management in NSW

The Floodplain Development Manual and the Flood-prone Land Policy guide local government in managing flood risk in their communities as it pertains to land development. The manual and policy is targeted at a strategic management level:

- 1.1: Flood-prone Land Policy for New South Wales recognises that 'flood prone land is a valuable resource that should not be sterilised by unnecessarily precluding its development'.
- 1.1.1: The Floodplain Development Manual policy objective is 'to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible'.

The manual includes information on the preparation of flood studies, floodplain risk management studies and plans, and guidance regarding flood planning levels and areas.

While the manual and policy apply at a strategic level and for land development projects, meaning at a policy level they are not applicable for projects such as this, the principles of the manual and policy remain relevant and should be followed. The key principle is about protecting the safety of people and property within and outside the project boundaries. Other principles include taking into account social, economic and ecological factors; these factors are primary drivers for the Rosemeadow Demonstration Project and others like it.

Safe Active Streets

Integrated Services Plan, 2018–2024

Transport for NSW is currently carrying out work to deliver 'Safe Active Streets' that promote active transport including cycling and walking across areas of Greater Sydney.

It aims to create an 'interconnected network of active pathways which connect residents to Metro, transport and retail hubs, schools, recreational facilities, and suburban points of interest. Provides a safe network for current users and creates future users by focusing on developing confidence amongst younger residents.'

Integrating the principles developed in the plan will help the community understand how tree planting can:

- promote healthier alternatives to driving
- facilitate safe streets for children that encourage independent trips over short distances and other street uses (playing on street)
- connect transport hubs and points of interest to create safe and efficient routes between destinations
- calm traffic and create a safe active environment for active travel modes
- incorporate branding so residents know when they are entering an Active Zone
- be developed in collaboration with street communities.

Growing Healthy Kids in South West Sydney

NSW Department, 2018

Campbelltown City Council and South Western Sydney Local Health District's 'Growing Healthy Kids in South West Sydney' strategic plan for the prevention and management of childhood obesity in South West Sydney aims to:

- 'Monitor the extent to which active living principles are incorporated into design of urban centres and local housing.
- Increase the extent to which councils adopt recommended actions to facilitate active living (e.g. improving recreation opportunities)'

There is an opportunity to demonstrate how urban tree canopy implementation can create walkable and convivial streets that encourage kids and families to be more active by walking or riding to school.



Campbelltown City Council

Reimagining Campbelltown CBD – Sydney’s Southern Gateway

Campbelltown City Council, 2018

Reimagining Campbelltown sets out a vision for a sustainable Campbelltown CBD, responding to the future pressures of climate change and population growth.

The proposals in Reimagining Campbelltown have direct relevance to Rosemeadow and the contents of this study and include:

- Re-purposing of existing infrastructure, particularly of drainage infrastructure, to provide broader benefits
- Creation of a network of blue and green infrastructure through improvement of open spaces
- Improved biodiversity across the urban area
- Reduction in urban heat island effect
- Improved amenity of open spaces for play and leisure

‘Blue and Green Infrastructure [is] an integrated network [that] will assist in transforming the urban structure through improved and increased natural areas of open space ...significantly reduce the temperature of local spaces and the effects of heat island by providing increased shade and canopy cover, while also bringing the “bush” back into the centre.’

Campbelltown 2027 – Community Strategic Plan

Campbelltown City Council, 2018

‘Strategies:

- Implement and advocate for initiatives that conserve the city’s natural environment
- Activate the city’s natural bushland and open spaces, fostering enhanced community stewardship of these areas
- Conserve and care for our city’s biodiversity
- Plan for and ensure that development in our city is sustainable and resilient’

Campbelltown 2025 – Looking Forward

Campbelltown City Council, 2004

Campbelltown 2025 – Looking Forward (2004) highlights the importance of redefining the role of infrastructure in providing a healthy urban environment into the future.

‘Not only should infrastructure facilitate sustainable urban living, it must in itself be economically, socially and ecologically sustainable.’

Campbelltown Bicycle Plan

Campbelltown City Council, 2018

The Bicycle Plan sets out a vision for cycling across Campbelltown, that looks to increase the number of residents who ride for recreation, education, shopping, travel to work or any other purpose.

- ‘Improve cyclist safety, especially for vulnerable cyclists such as children;
- Increase the range of people who cycle in the area;
- Facilitate healthy communities through increased physical activity and fun;
- Improve the liveability of neighbourhoods and increase social connections;
- Increase opportunities for local cycling trips that support Campbelltown’s economy (e.g. cycling to shops, reserves, schools etc.).’

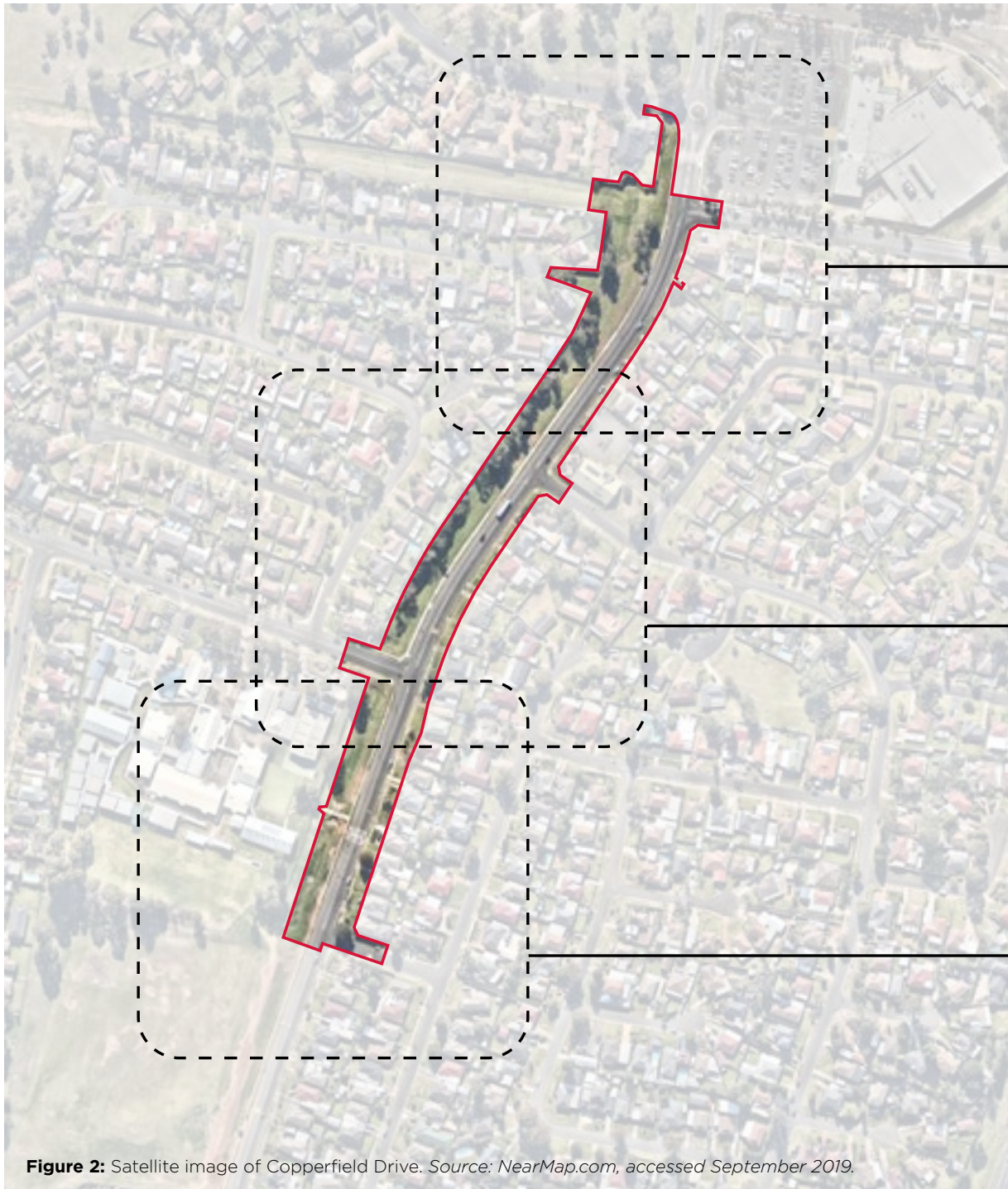


Figure 2: Satellite image of Copperfield Drive. Source: NearMap.com, accessed September 2019.

Site appreciation

For the purposes of clarity, the analysis and design drawings have been split into Copperfield North, Copperfield Central and Copperfield South.



Figure 3: Pedestrian crossing on Copperfield Drive near the Market Place.



Figure 4: Looking north up Copperfield Drive.



Figure 5: Drainage channel crossing from Copperfield Drive to Rosemeadow Public School.

Copperfield North



Figure 6: Satellite image of Copperfield Drive. Source: NearMap.com, accessed September 2019.

- | | | |
|---|---|---|
| <p>1 Lack of street trees
Opportunity: reconfigure Copperfield Drive to provide shade for thermal comfort of active transport users</p> <p>2 Easement outlet into underground pipe
Opportunity: capture surface flows in sandy soaks to recharge soil moistures for tree growth and create a tree grove.</p> <p>3 Poor pedestrian crossing
Opportunity: improve quality of pedestrian crossing</p> | <p>4 Existing trees adjacent to residential rear fences provide some of the best tree canopy in the study area
Opportunity: protect and infill with further tree planting to screen unattractive fences</p> <p>5 Bus stop (route 888 & 887) connecting the local area with Campbelltown centre
Opportunity: provide shade canopy from bus stops to community amenities</p> <p>6 Copperfield Drive easement provides an mono-functional encumbered linear green space</p> | <p>Opportunity: utilise stormwater for passive tree irrigation and integrate further open space amenity</p> <p>7 Limited boundary fences interfacing Copperfield Drive creating ambiguity of where the boundary between public and private land sits.
Opportunity: plant trees on private land for public benefit. Responsibility of planting, ownership and maintenance will need to be resolved with Campbelltown Council and the property owners.</p> |
|---|---|---|

Copperfield Central



Figure 7: Satellite image of Copperfield Drive. Source: NearMap.com, accessed September 2019.

- 1** Copperfield Drive easement
Opportunity: plant riparian tree species in the easement. Daylight lateral inflows into the easement as a passive watering source for new trees.
- 2** The Rosemeadow Anglican Church holds morning and evening Sunday congregations.
Opportunity: provide urban tree canopy to the church for thermal comfort of active transport users.
- 3** Pedestrian crossing.
Opportunity: improve quality of pedestrian crossing.
- 4** Pedestrian footpath to both sides. Due to lack of existing canopy, the footpaths are exposed to the elements creating an uncomfortable environment for walking or active transport uses.
Opportunity: use urban tree canopy to provide a shaded path along Copperfield Drive for both walking and cycling.
- 5** Lack of street trees.
Opportunity: reconfigure Copperfield Drive to provide shade for thermal comfort of active transport users.
- 6** It is anticipated that the series of pits will surcharge during, at the least, a 20% Annual Exceedance Probability (AEP) event bubbling up into the grass open channel.
Opportunity: utilise surcharge stormwater to recharge soil moistures for tree growth.
- 7** Pedestrian crossing.
Opportunity: improve quality of pedestrian crossing.
- 8** Easement culvert under Anthony Drive
Opportunity: capture surface flows in sandy soaks to recharge soil moistures for tree growth and create a tree grove.

Copperfield South



Figure 10: Satellite image of Copperfield Drive. Source: NearMap.com, accessed September 2019.

- 1** Impermeable road surface.
Opportunity: harvest stormwater run-off for passive tree irrigation. Inclusion of street tree-pits would have no impact on the flood protection level of service.
- 2** Sediment accumulation increasing surface levels by at least 100mm to 300mm higher than the concrete at several surcharge pits.
Opportunity: increase cross-sectional area for flood conveyance and create further volume to introduce vegetation and tree planting.
- 3** School entry crosses the open channel via a bridge. This creates a poor school gateway and pinch point.
Opportunity: Create a gateway to the school with feature trees and improve crossing point across Copperfield Drive.
- 4** Existing trees in nature strip.
Opportunity: protect and infill with further passively irrigated tree planting.
- 5** Significant trees on school grounds.
Opportunity: to protect existing trees and enhance with additional infill planting.
- 6** Haydon Park basin outlet pit draining into 600mm low flow pipe and surcharges into the Copperfield Drive open channel.
Opportunity: harvest water for passive tree irrigation along the open channel.



Existing stormwater infrastructure

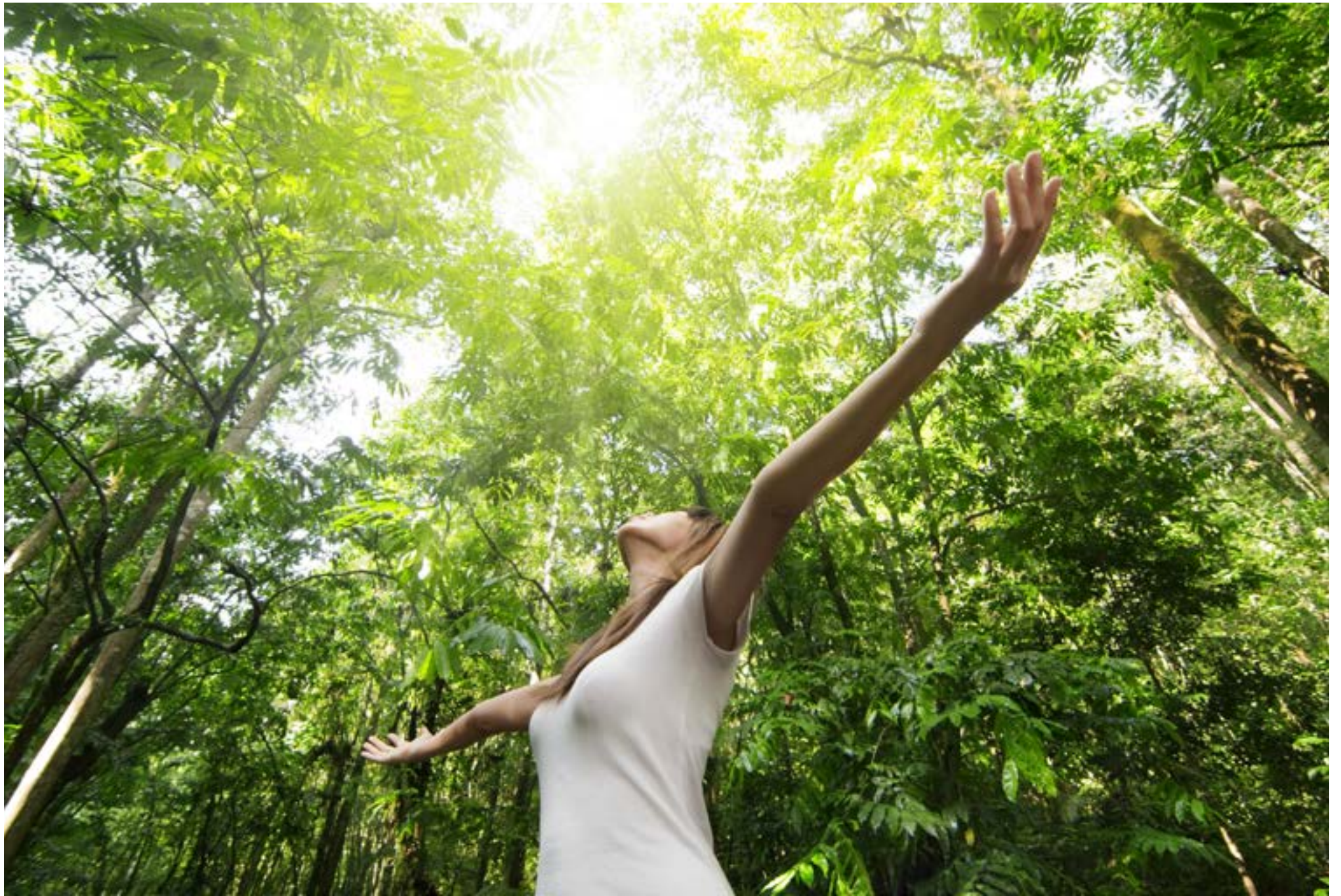
The understanding of the site hydraulics is based on constructed drawings, GIS data, and flood maps provided for the 1% Annual Exceedance Probability (AEP) and 20% AEP events.

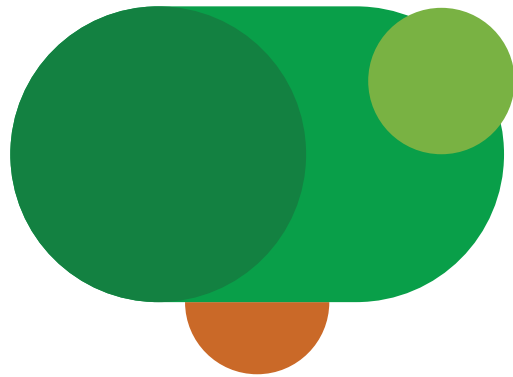
- ❶ Total catchment area of 104ha entering the Copperfield Drive open channel at the Fitzgibbon Lane downstream discharge point. Major catchment inflow points are from the Haydon Park retarding basin, and approximately in-line with each side street (Regan St, Anthony Dr, and Hamlet Cres).
- ❷ Copperfield Drive is situated downstream from the Haydon Park retarding basin and acts as the major conveyance channel for a series of catchments in the local area.
- ❸ Velocities during the 20% AEP flood event vary from 0.3-1m/s at the upstream end of the channel, to 1-2m/s at the downstream end. Velocities are highest around culvert and bridge structures, as well as within the northern downstream end of the channel, where the slope of the channel is greatest.
Opportunity: Prioritise tree planting in low velocity areas where erosion risks are lowest.
- ❹ The drainage easement consists of a grass open channel, 675mm low flow pipe and a series of surcharge pits along the length of the open channel. The series of pits connect lateral piped inflows from the Copperfield Drive road network to the east and steep

adjacent catchments to the west. The 675mm pipe also conveys water from the 47.5ha upstream catchment that connects to the Haydon Park retarding basin. The existing 675mm pipe under the drainage open channel has an estimated flow capacity (0.72m³/s) less than the Q₃ month (1.3m³/s) flow of the upstream catchment, meaning the pits surcharge under at least the Q₃ month event, flowing into the open channel.

Opportunity: Plant trees within open channel, irrigated by surcharged flows and surface flows. Use gravel drains to maximise retention of surface flows and excess water from Copperfield Drive tree systems.

- ❺ Sediment accumulation is occurring along the length of the open channel. Surface levels of the channel are now at least 100mm to 300mm higher than the surface of the concrete at several surcharge pits.
Opportunity: Reprofile surface levels during tree planting works to improve hydraulic capacity.
- ❻ Copperfield Drive road reserve has a mostly uniform two-way cross-fall and longitudinal slope (1.5-2.5% slope), with pits along both sides of the road (unevenly spaced).
Opportunity: Direct road runoff into passively watered trees on either side of road.





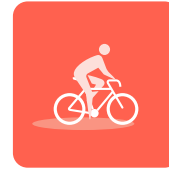
Part 2:

Design



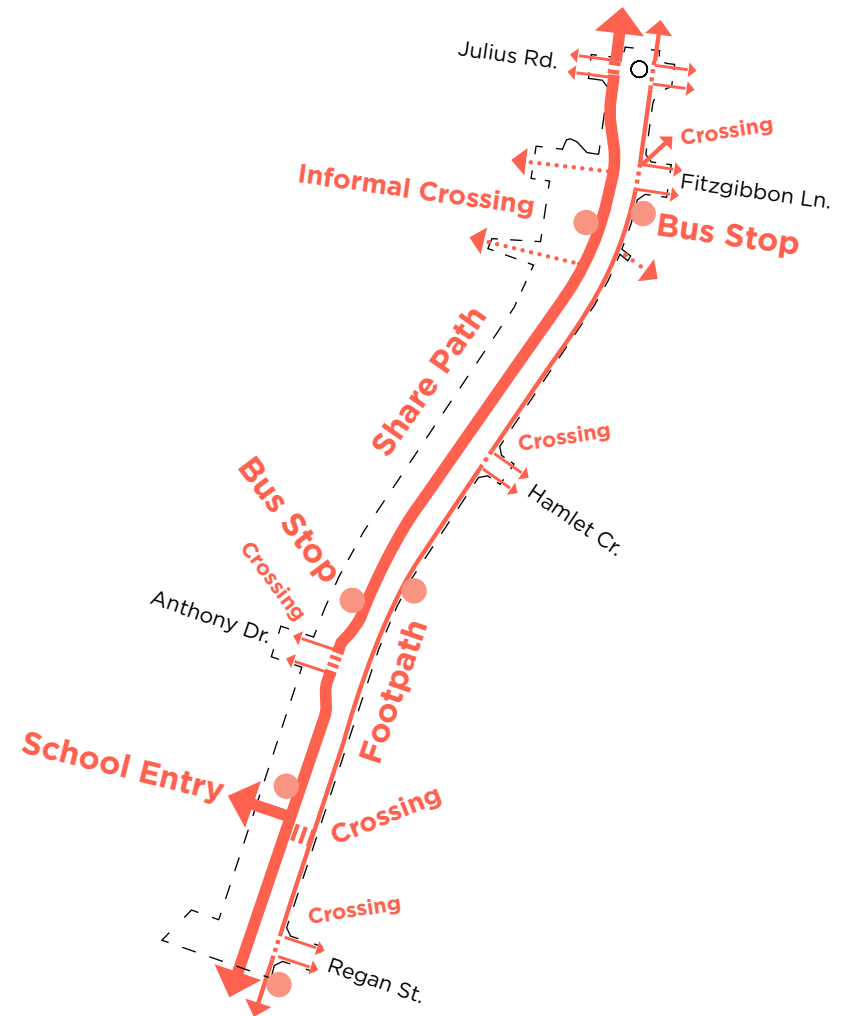
Design principles

Six design principles have been developed to ensure that the project objectives and opportunities are achieved. These are layered to create a functional, resilient and liveable street design.



Access and movement

Entry points to and from surrounding spaces, desire lines, pedestrian paths, bike paths, street crossings, delivery and service routes, pick-up and drop-off points, parking.

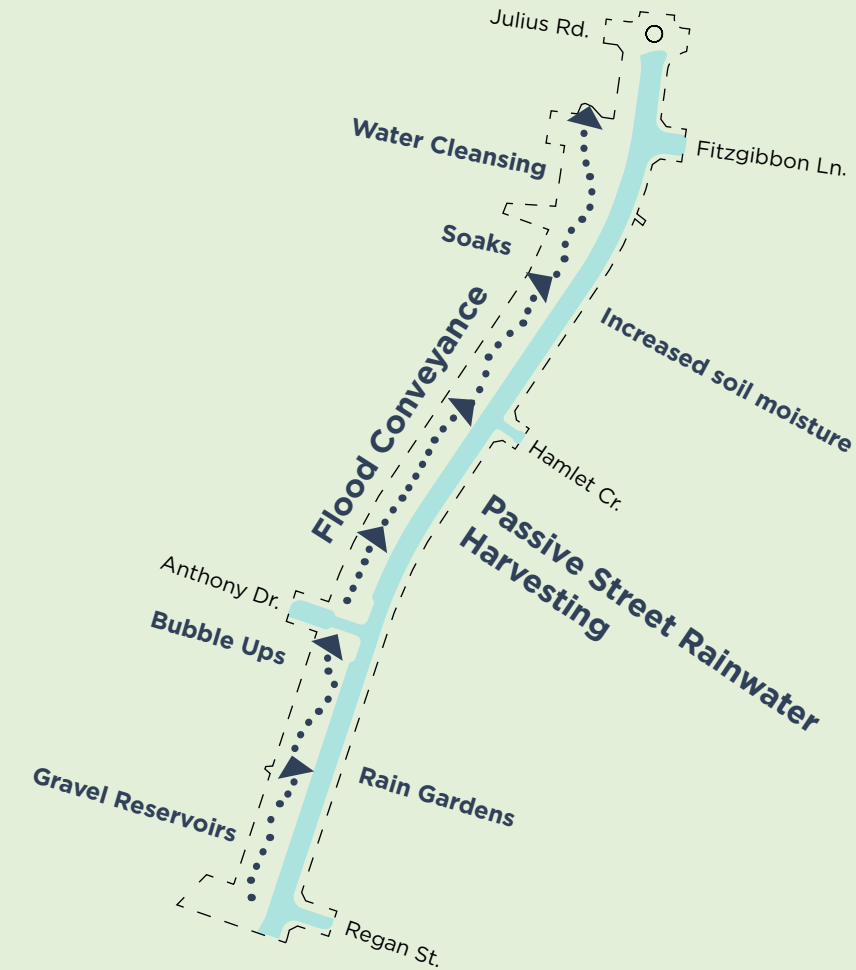


Project Objective 1: Improve the walkability of Copperfield Drive by increasing the shading and cooling of streets and supporting the Walk Safely to School program.



Hydrology

A multifunctional stormwater system including improved water quality, flood management, passive irrigation and potential alternative urban water sources (i.e. stormwater harvesting).

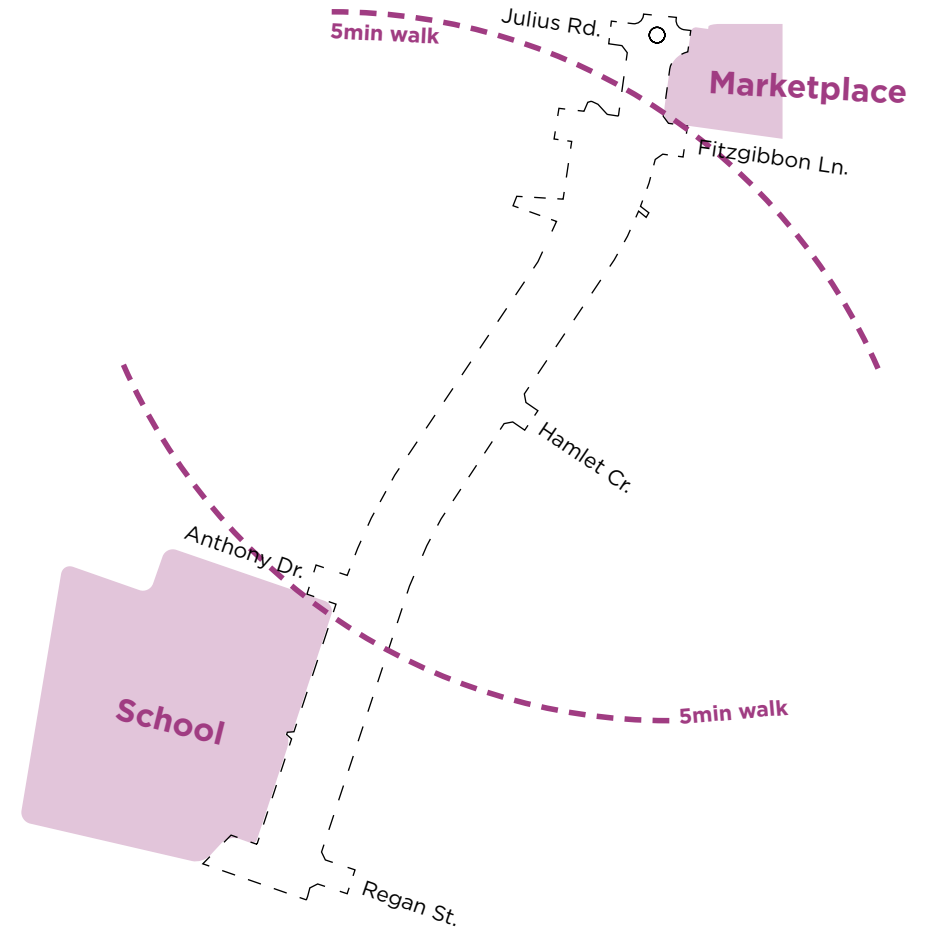


Project Objective 2: Establish a healthy tree canopy supported by water-sensitive urban design (WSUD) approaches to mitigate nuisance flooding and urban heat island effects.



Social infrastructure

Physical structures or fabric that reinforces occupation of the street, such as community services linked by streets including, schools, shops, community centres.

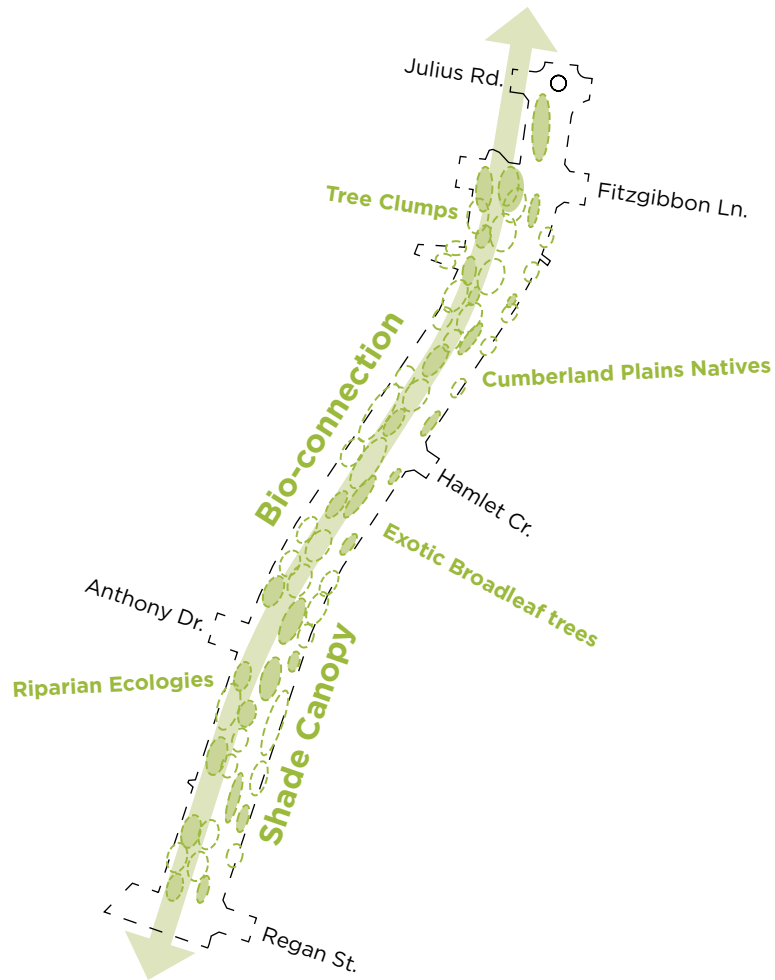


Project Objective 3: Improve the amenity of Copperfield Drive by increasing shade and cooling to link housing, schools, shops and community services.



Ecology

Not just trees, but a series of spatial and structural elements that are central to the implementation of the Green Grid and ecological habitat.



Project Objective 4: Increase habitat for urban wildlife and incorporate leading-edge plant species and diversity research.



Spatial hierarchy

A range of spaces (both existing and proposed) to establish in Copperfield Drive or link to along Copperfield Drive, such as bus waiting area, school meeting space etc.

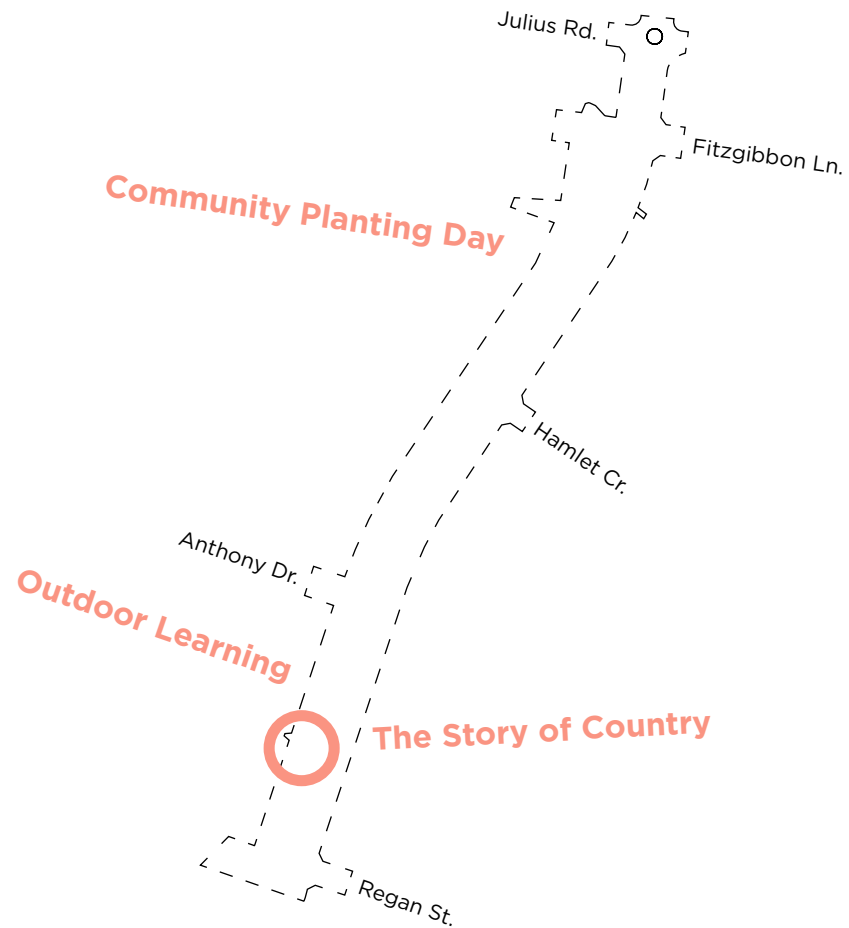


Project Objective 5: Reconfigure the spatial hierarchy of Copperfield Drive to create space for healthy tree growth.



Activities and events

Not necessarily built or physical - a catalogue of existing activities, compiled along the street as a means of visualising the street network in operation.



Project Objective 6: Achieve best-practice collaborative outcomes with project stakeholders and the community to create 'Safe Active Streets'.



Tree canopy

The community will benefit from the planting of trees in Copperfield Drive. Extensive tree planting will reduce the urban heat island effect, encourage the use of active transport and bring healthy ecosystems into Rosemeadow.

Approximately 250 trees will be planted along Copperfield Drive and the parallel open channel, which are anticipated to create well over 40% tree canopy cover across the study area. These follow a rhythm of clumped tree copses that echo a natural formation and will provide an overlapping canopy that maximises shade and minimises heat trap underneath the canopy with breaks providing ventilation.

A mix of tree species with different canopy forms are planted to optimise cooling outcomes and selected to match the range of growing conditions. Trees indigenous to the Cumberland Plains are planted as a priority for habitat, with exotic broad leaf trees introduced to maximise shade canopy, supporting urban cooling and promoting active transport connection between the school and Rosemeadow Marketplace.

Tree species selection is also informed by the volume of water made available through passive irrigation and drainage characteristics of subsoils, ensuring drier zones are matched with appropriate drought-tolerant species, and likewise for wetter zones with species that can handle inundation.

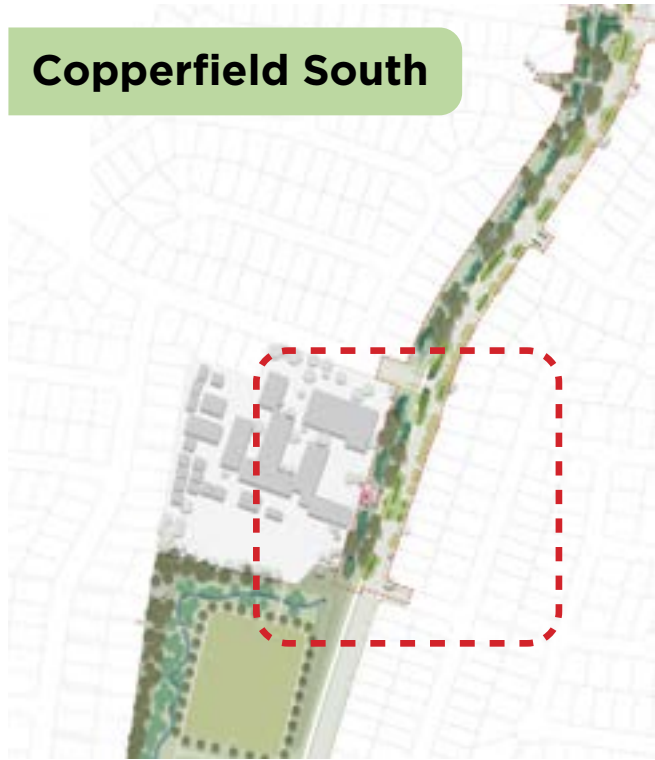
Providing good soil volumes, soil condition and access to water will:

- double tree growth rates (Grey, V. et.al 2018)
- create healthier tree canopies up to 8-10 times larger (Hitchmough, J. 1994)
- increase the lifespan of the trees to a possible 50 years (Skiera, B. and G. Moll. 1992)



Figure 12: Conceptual Plan of Copperfield Drive.

Copperfield South



Legend:














-  Feature tree planting
-  In street tree planting
-  Nature strip tree planting
-  Gravel channel tree planting
-  Soak tree planting
-  Existing trees
-  ① School entry space with meeting tree and bridge
-  ② Upgrade of existing crossing
-  ③ New shared path - 3m
-  ④ New footpath - 1.5m
-  ⑤ Pedestrian crossing subject to further investigation
-   Passive irrigation flow



Figure 13: Concept Plan of southern portion of Copperfield Drive.

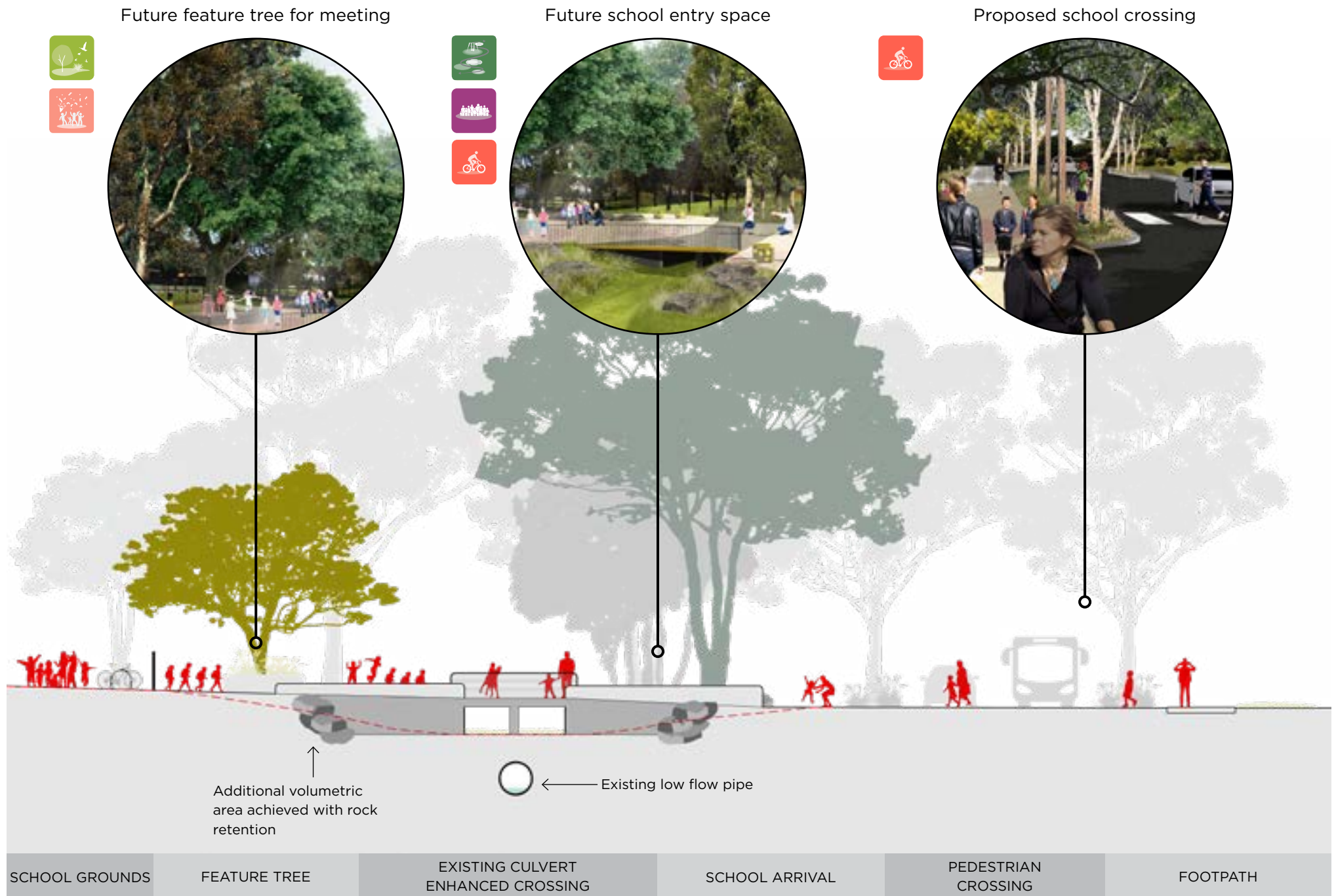


Figure 14: Section A - Rosemeadow Public School Entrance.



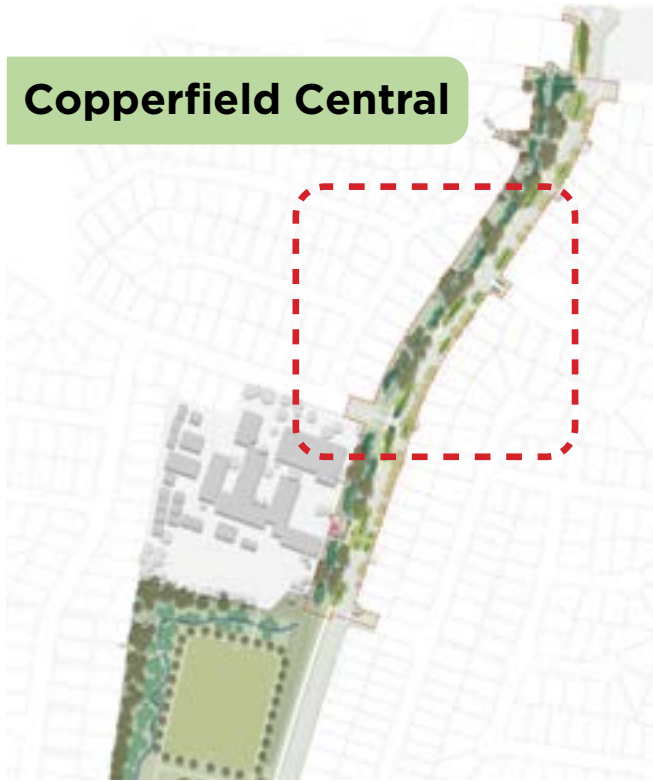
Figure 15: Section B - Copperfield Drive south of Anthony Drive intersection.



Combining nature, local community and smart flood management solutions to build upon Rosemeadow's existing qualities and unique local spirit.

Figure 16: Perspective illustration of Copperfield Drive and Rosemeadow Public School interface on a dry day.

Copperfield Central



Legend:










-  In street tree planting
-  Nature strip tree planting
-  Gravel channel tree planting
-  Soak tree planting
-  Existing trees
-  ① New shared path - 3m
-  ② New footpath - 1.5m
-  ③ Pedestrian crossing subject to further investigation
-  Passive irrigation flow



Figure 17: Concept plan of central portion of Copperfield Drive.



Figure 18: Section C - Copperfield Drive north of Anthony Drive intersection.



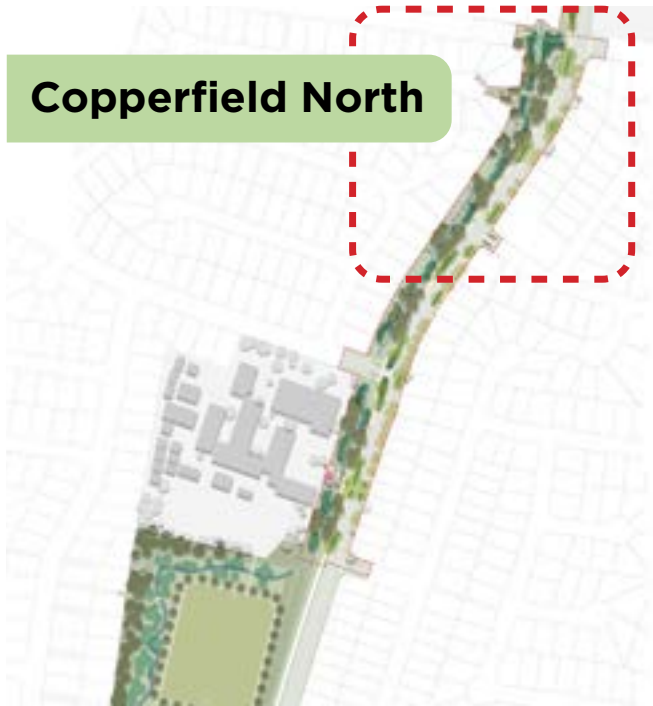
Figure 19: Section D - Copperfield Drive South of Hamlet Crescent intersection.



Stormwater is collected and used locally for passive tree irrigation while excess water is conveyed from Haydon Park to the Georges River being cleansed by natural systems along Copperfield Drive.

Figure 20: Perspective Illustration of Copperfield Drive and Rosemeadow Public School interface during a 1% AEP flood event.

Copperfield North



Legend:

- In street tree planting
- Nature strip tree planting
- Gravel channel tree planting
- Soak tree planting
- Existing trees
- Existing bus stop retained
- Stone riffle
- Informal stepping stones
- Existing easement outlet
- New shared path - 3m
- New footpath - 1.5m
- Pedestrian crossing subject to further investigation
- Passive irrigation flow

Figure 21: Concept Plan of northern portion of Copperfield Drive.



Figure 22: Section E - Copperfield Drive at Balthasar Close pedestrian access point.



Future informal stepping stones

Proposed dry soak



Existing low flow pipe

Additional volumetric area achieved with rock retention

Figure 23: Section F - Copperfield Drive near drainage channel outlet.

WET SOAK

EASEMENT STONE RIFFLE

WET SOAK

SHARE PATH

Figure 24: Section F - Copperfield Drive near drainage channel outlet.



Retrofitting open channels for tree planting

This approach to planting in channels has been developed as part of the Haydon Park technical study. The study identified the technical requirements for stormwater infrastructure to ensure the main functional aspects were being upheld. This chapter provides additional information about the characteristics of channels and the relationship to the design of Copperfield Drive .

Open channel

In urban stormwater catchments, open channels are a common form of stormwater conveyance, where waterways, ephemeral creeks and natural overland flow paths have been replaced with constructed engineered channels. These channels are designed to convey water efficiently in a constrained environment. Their conveyance capacity is critical to protecting adjacent areas from what is known as fluvial flooding during major and extreme flood events.

Fluvial flooding (flooding when channels, creeks and rivers exceed their capacity) is influenced by channel capacity, sinuosity (i.e. how much a channel bends and its related bed slope) and roughness. Projects that involve planting trees in open channels can influence all three of these factors.

The following principles apply to all urban open channels. These principles underpin the design for the Copperfield Drive open channel.

Introducing roughness

Trees placed within the extent of inundation will increase channel roughness and slow flows, so too can other vegetation, rock and timber. The greater extent and/or height of the roughness, the slower water flow during flood events, which will increase water levels and may cause unacceptable flooding.

If the Copperfield Drive channel roughness treatment is altered through tree planting, the channel will need to compensate for this increased roughness. This will require an increase in its cross-sectional capacity.

* Coefficient roughness used in the Manning's formula to calculate flow in channels.

Increasing channel capacity

The geometry of the channel and its physical capacity naturally changes the conveyance capacity of the system. Usually, the channel capacity will be altered in a channel naturalisation project (or where significant new volumes of trees are introduced within the inundation extent) to compensate for increased roughness and meandering, ensuring that the works maintain or improve existing flood protection. This can be done by steepening the side slopes or increasing the depth of the channel to create more cross-sectional capacity and mitigating unacceptable flooding.

Figure 25: Diagram demonstrating the relationship between channel roughness and flow capacity.





Where to plant trees

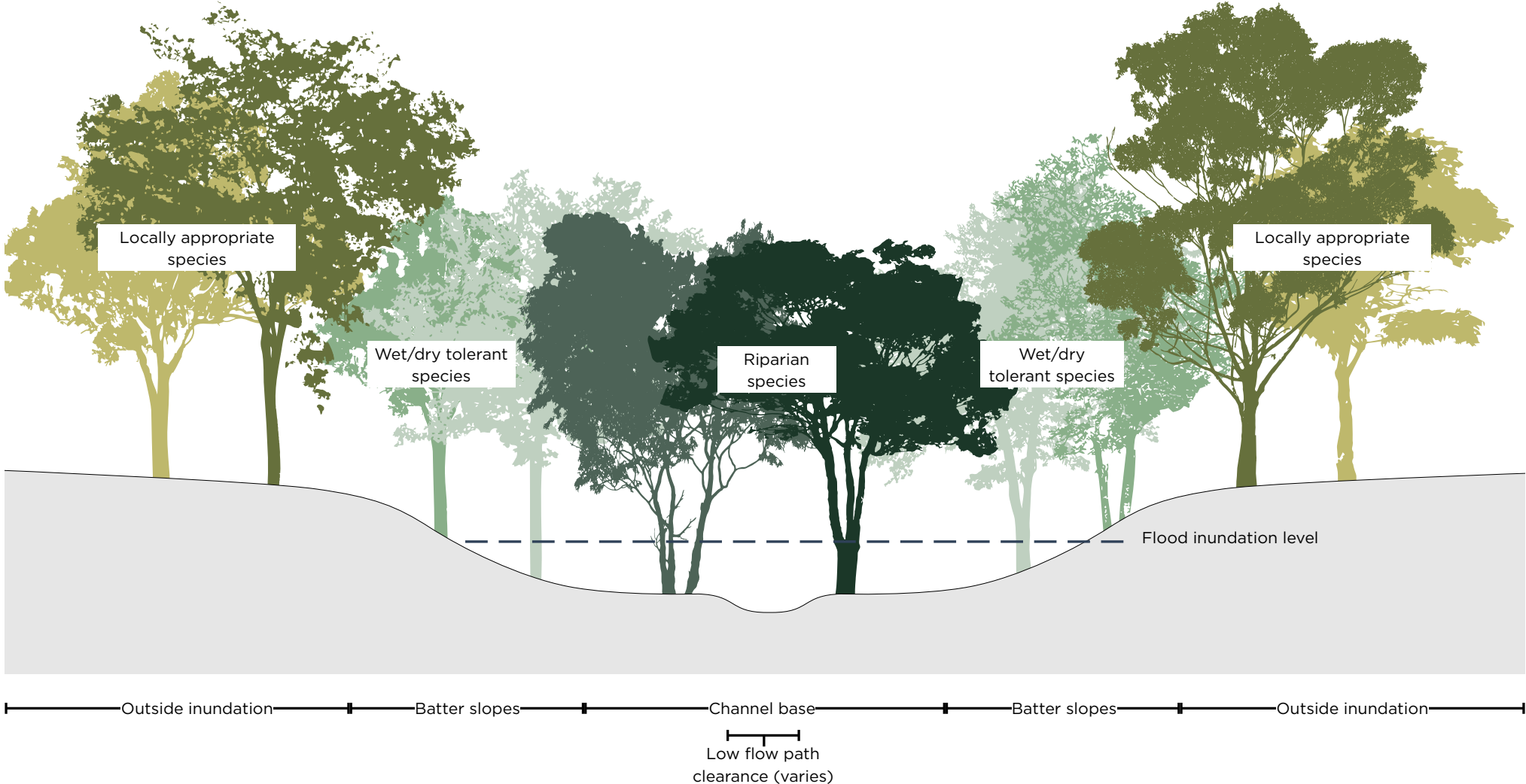
The placement of trees within open channels is essentially dictated by the relationship between the site's spatial and hydraulic constraints. The more free space for stormwater conveyance capacity, the more freedom to plant trees while maintaining flood protection. Other site factors such as underground and overhead services will also influence where trees can be located.

Table 1: Planting trees in open channel, avoid trees within the low flow path to reduce conveyance of leaf litter and fallen limbs.

Open channel location	Trees	Species selection
Outside flood inundation extent	✓	Locally appropriate
Batter slopes	✓	Wet/dry tolerant species
Base of channel (provide clearance for low flow path, width will vary for each site/design)	✓	Riparian species

Note: Hydraulic conveyance capacity checks needed. Excavation may be required to maintain flood performance.

Figure 26: Diagram demonstrating suitable location for trees within a typical drainage channel.



Case study: Small Creek

Small Creek was once a meandering stream surrounded by large iconic tree species and an under storey of native grasses and rushes. During the early 1980s, the creek was replaced with a concrete open channel. The local council is currently in the process of transforming Small Creek into a living waterway once again, with native vegetation and trees, pools and riffles of shallow running water. The project is delivering a large stream of benefits for the environment and community, including water quality improvement, improved aesthetics, habitat for native fish and animals, and a cooler thermal corridor for people to enjoy. In 2019, a fish survey confirmed that Small Creek had become a functioning ecosystem with numerous native fish and other aquatic species detected.

These images show Small Creek in its early weeks, months and years of establishment, following construction and planting of tube stock. While there are no trees visible in the photo, the saplings are a mixture of groundcovers and tree species, which are designed to eventually form a closed canopy over the creek as the trees mature.

Context: urban stormwater drain converted into forested creek and linear park.

Design: existing concrete drain removed and replaced with meandering flow path. The cross-section was widened to compensate for the increase in roughness.

Demonstration: Trees, plants and channel bends can be introduced in urban stormwater channels by using compensatory earthworks to maintain flood conveyance capacity. The result is a win for the environment and provides a highly valued community asset, shady park (as trees mature) and a cooler walking and cycling route to connect students to the nearby school.



Figure 27: Small Creek. Source: E2 Design Lab



Figure 28: Small Creek shortly after renaturalization. Source: E2 Design Lab



Tree toolkit

Stormwater and passive irrigation

Although the open channel is subject to periodic flooding, drought is a significant site constraint to tree establishment and canopy growth.

In 2017, all of NSW was declared in drought and for much of the state this has continued up until 2020. Climate models predict a hotter and drier climate into the future and it is anticipated that the changes in climate will bring prolonged periods of drought. Therefore, water conservation and management is both timely and critical.

Utilizing all available water to increase soil moisture for trees requires a creative re-imagining of how trees are planted and maintained in urban environments.

Objectives

- More sustainable water management that will assist with ameliorating climate extremes i.e cooling urban environments, efficient use of water etc
- Demonstrate how to integrate urban canopy into drainage land as a means of unlocking open space for community use and greater ecological benefits in greater Western Sydney
- Develop creative and integrated solutions to convey, capture and store stormwater in soil for trees - passive irrigation.
- Use a systems-based approach to integrate landscape and public realm solutions with necessary water management infrastructure.
- Integrate tree planting and water management to cultivate healthy tree canopies and a more resilient urban forest.





Passive irrigation – system toolkit

There are a number of ways to incorporate water-sensitive urban design solutions into streetscapes and open channels. Factors such as site conditions, catchment sizes, land availability and budget all influence the appropriate solution.

The Copperfield Drive tree toolkit incorporates a suite of innovative systems that vary in scale and cost, and represent a broad range of solutions that could be adopted at other sites.

The suite of tree planting tools take into account the varying available water catchments (street, Haydon Park and open channel) and existing hard drainage system to create a set of interventions that can be deployed along Copperfield Drive and the open channel length.

Together, the individual tools create a comprehensive system toolkit that is applicable to the specific site conditions. However, these tools can be applied in isolation from each other, across various different site conditions and environments.

Harvested stormwater will pass through the system toolkit to irrigate trees and recharge soil moisture, while also filtering and removing stormwater pollutants.

Each passive irrigation system is linked to provide sequential water treatment and maximum use of the stormwater before entering the downstream stormwater system. These systems maintain the hydraulic function of the street and open channel, ensuring the network conveyance capacity is maintained.

At street level, runoff enters a series of open tree pits, which function similarly to rain gardens - capturing, holding and filtering stormwater before excess water is discharged.

The open tree pit discharge then flows into a series of gravel trenches along the open channel via small underground pipes. These gravel trenches provide a second opportunity for soil moisture recharge and irrigating trees planted within the open channel.

Surcharge stormwater entering the open channel from the Haydon Park basin is also captured within the open channel through a series of surface soaks. These are located to infiltrate the surcharge water and use it to irrigate more trees planted within the open channel.

This combination of these systems are estimated to:

- Reduce total suspended solids (TSS) by more than 380 kg/y
- Reduce total nitrogen (TN) by more than 3.4kg/y
- Reduce total phosphorus (TP) by more than 0.74kg/y
- Reduce total annual surface runoff by more than 1.6ML/y

These estimates are based on a MUSIC model (modelling tool) for the open tree pits on the western side of Copperfield Drive and the gravel infiltration trenches within the open channel. Further detail is provided in the following pages.

Despite passive irrigation, as with any tree planting, all trees within this project should be directly irrigated during the first growing season to support the trees' healthy establishment.

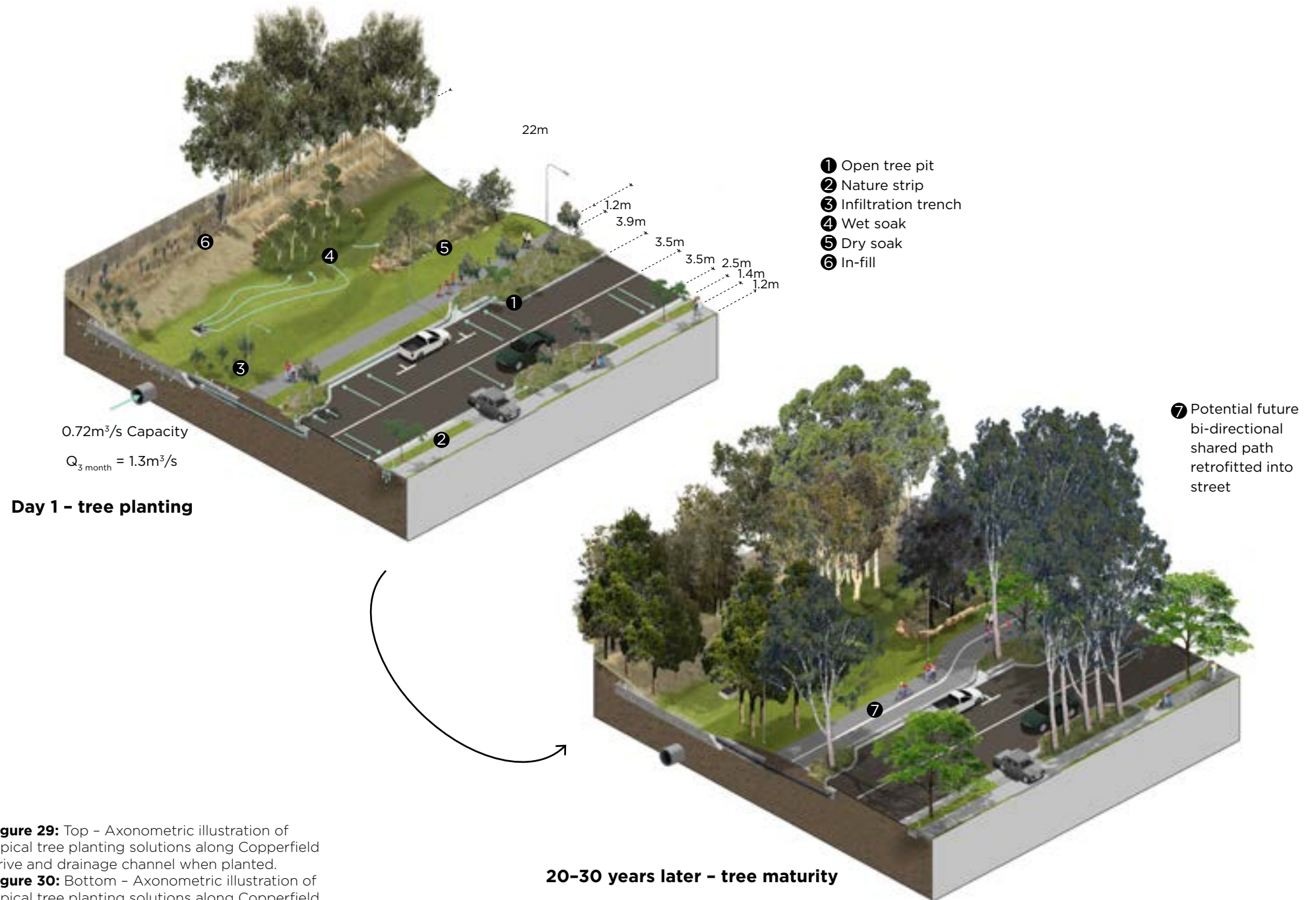


Figure 29: Top - Axonometric illustration of typical tree planting solutions along Copperfield Drive and drainage channel when planted.

Figure 30: Bottom - Axonometric illustration of typical tree planting solutions along Copperfield Drive and drainage channel when mature.



Open tree pit

The open tree pit captures runoff from the road via the kerb and channel. The design features a tilted kerb inlet from the road edge, and 'broken' kerb on the road-side. As the soil surface is lower than the channel invert, water is able to pond temporarily and infiltrate into the growing media. A drainage connection will be required to prevent water logging.

Open tree pits with large soil volumes, overflow pits and underground drainage provide a best practice solution to supporting large street tree canopies. These are high-cost solutions that fall within the top-end of streetscape passively watered trees.

Location

The open tree pit has a back of kerb ag-drain which can connect to the existing stormwater drainage. In Copperfield Drive, the open tree pits have been located along the west side of the road besides the open channel drainage corridor. This reduces the cost to install underground drainage and connections to the infiltration trenches within the open channel.

Predicted water availability

- Event inflow rate: 150L/event/tree. This varies along the channel. Typically these events would occur every three days subject to seasonal patterns.
- Well-watered, drained, and aerated soil/horticultural soil

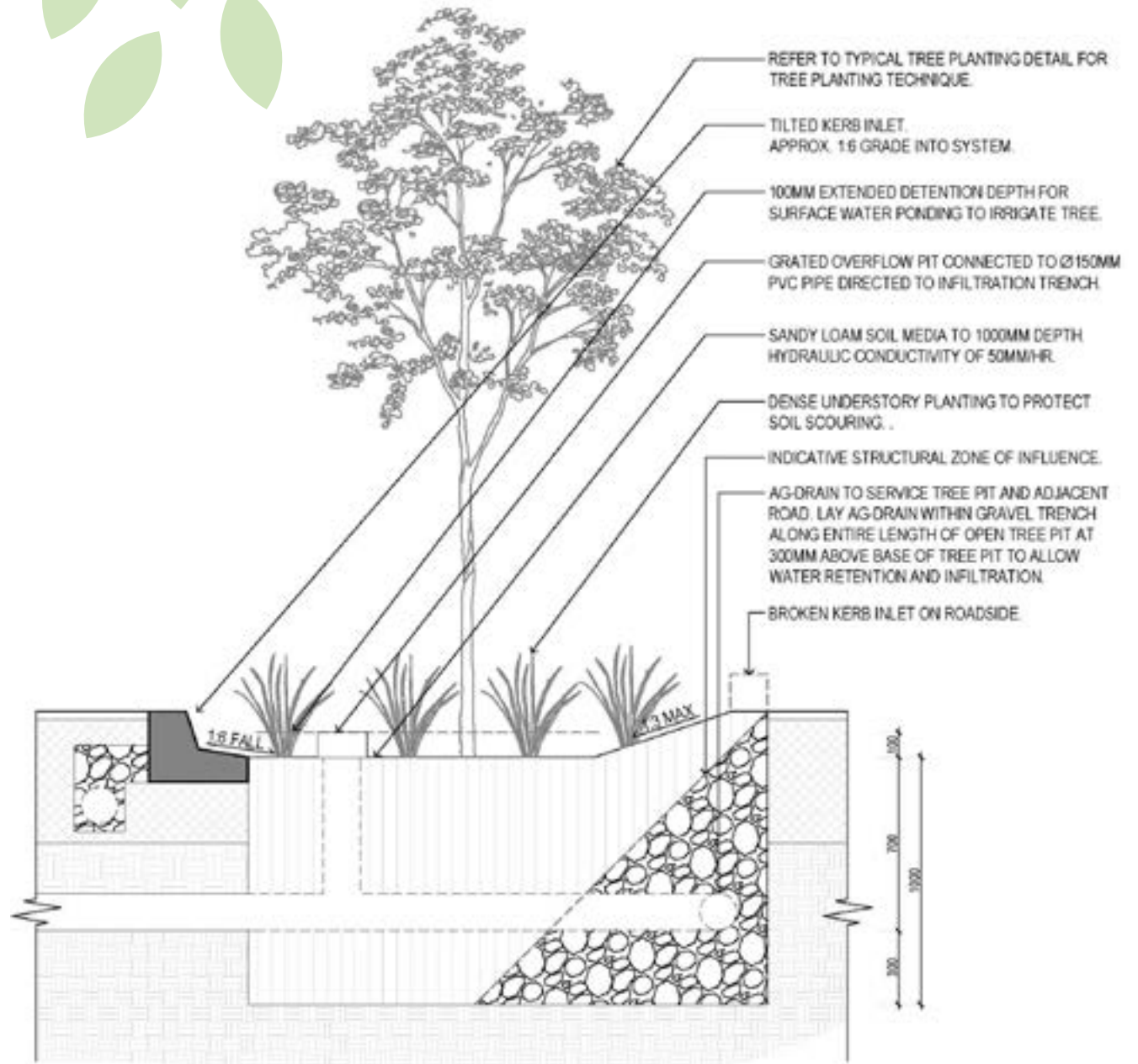


Figure 31: Open tree pit detail (1:25 at A3)



Nature strip

Nature strip gravel trenches support trees planted within the nature strip on the residential side of the road. The gravel trenches feature an 'in-and-out' flexible, ag-pipe loop installed using kerb adapters that direct inflows into the gravel trench, where water can soak into the surrounding soils for the tree. This solution is innovative in how it minimises costly underground services and pavement works. It provides a lower-cost solution to get water to trees.

Predicted water availability

- Event inflow rate: ~150 L/event/tree. Based on Western Sydney's rainfall events, these would typically occur every three days subject to seasonal patterns.
- Drier soil

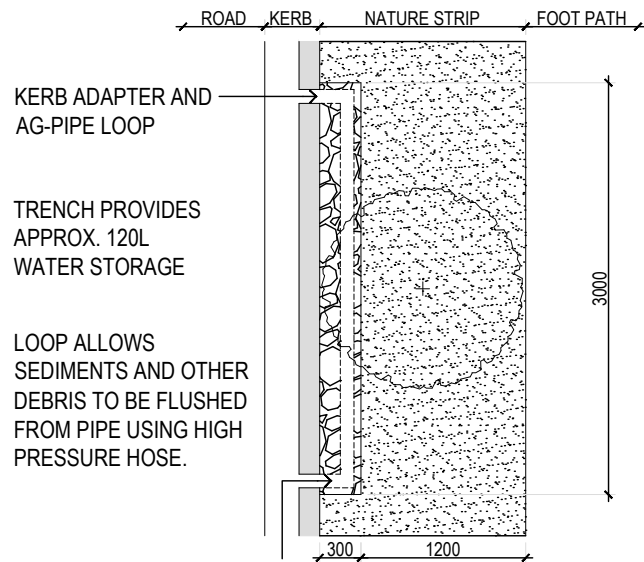


Figure 32: Nature strip plan detail (1:50 at A3)

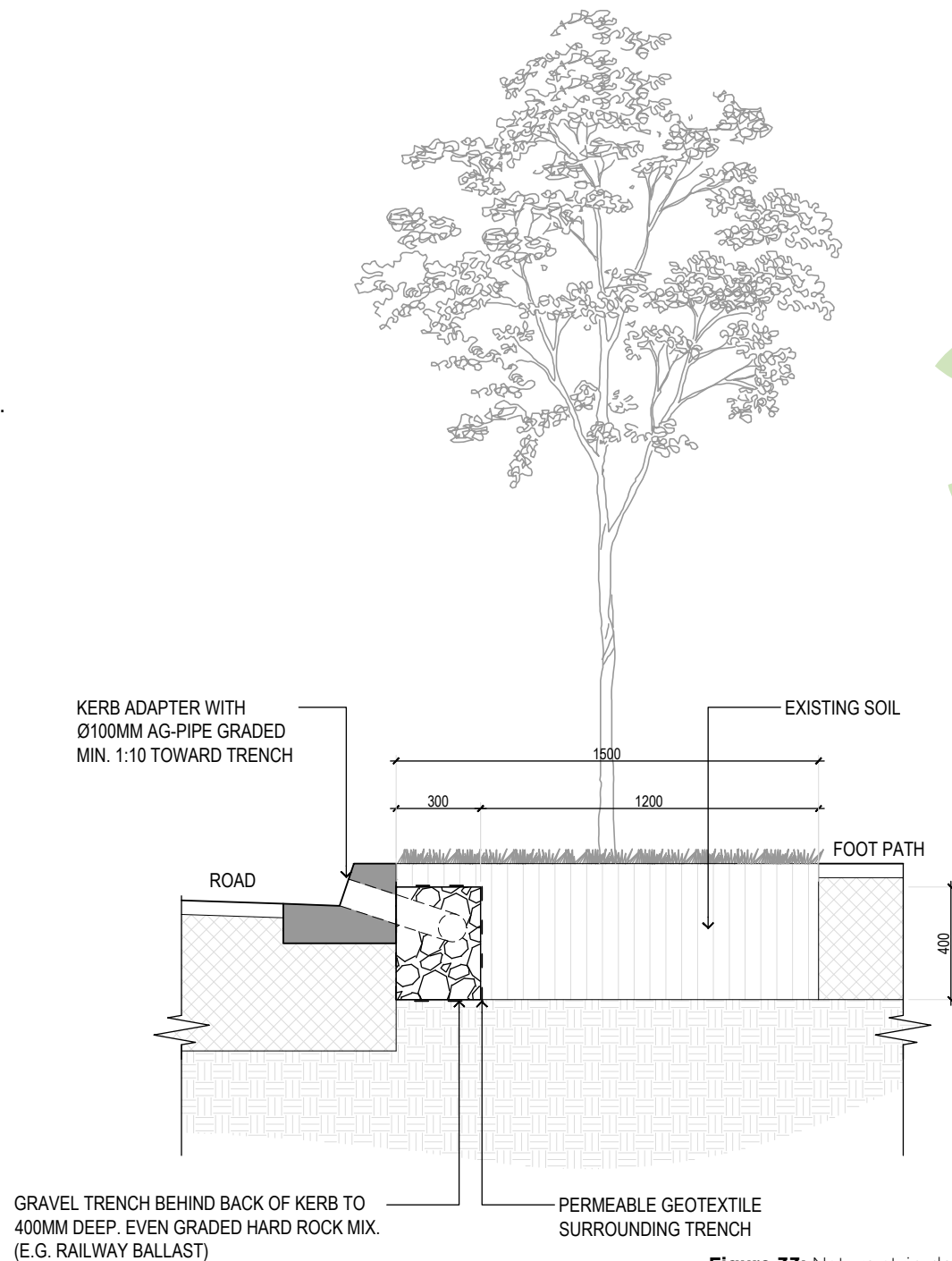


Figure 33: Nature strip detail (1:25 at A3)



Infiltration trench

Infiltration trenches in the drainage easement consist of gravel infiltration zones that collect overflow from the open tree pits. These are simple, low-cost solutions that recharge soil moisture in the drainage easement. As the trees within the lower portions of the batter slopes mature, their roots can draw water from the soils around the gravel trench, supporting their long-term growth and resilience.

Predicted water availability

- Event inflow rate: -180-900 L/event. This varies along the channel. Based on Western Sydney's rainfall events, these would typically occur every three days subject to seasonal patterns.
- Upper bank - Native soil with moisture at depth
- Lower bank - Native soil with moisture close to soil surface

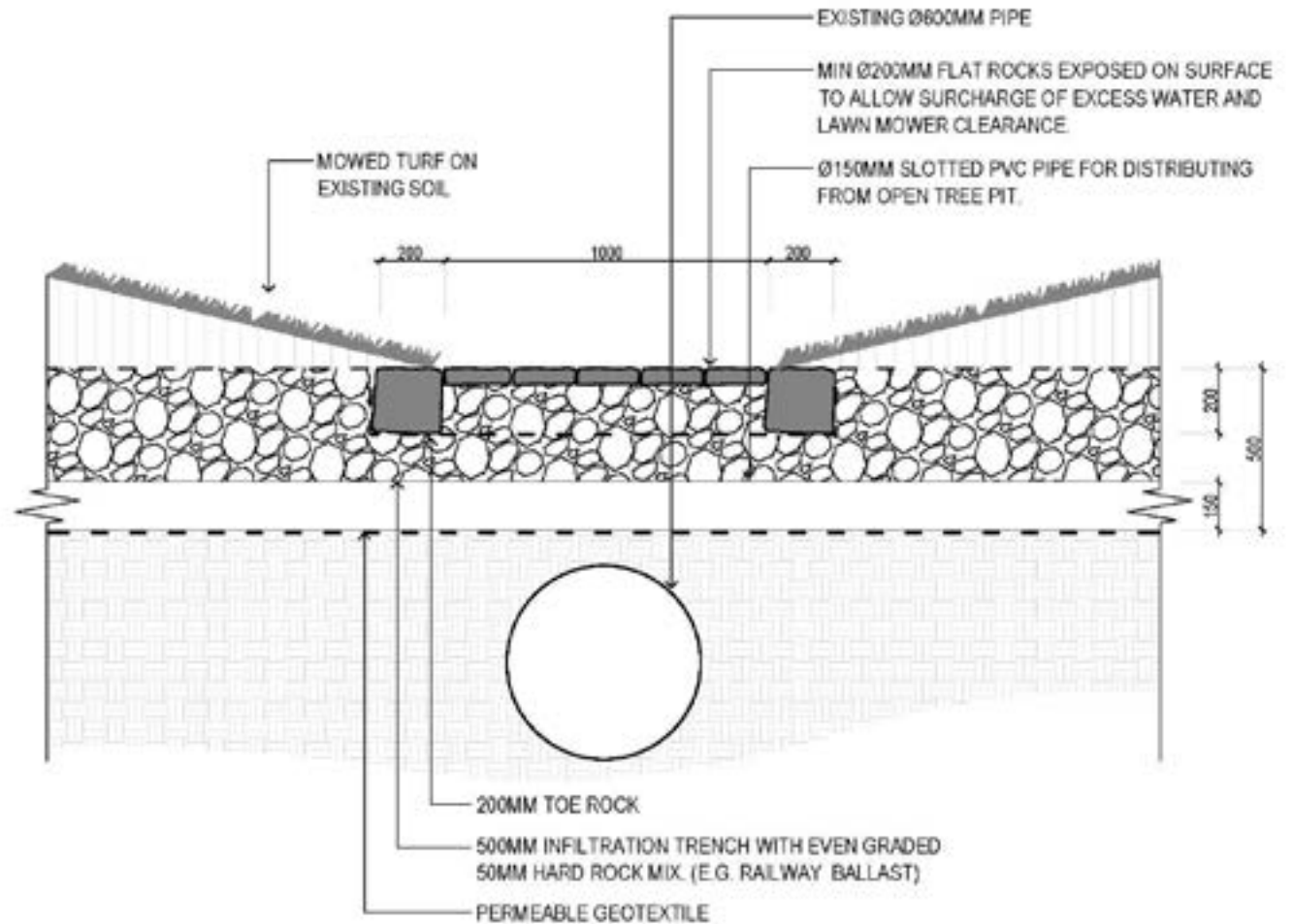


Figure 34: Infiltration trench detail (1:25 at A3)



Wet and dry soaks

Wet and dry soaks are sandy depressions within the drainage easement that capture excess flows from the infiltration trenches, surcharged flows from the underground pipe, and any overland flows within the channel. These holes periodically fill up and drain through infiltration and evapo-transpiration. Wet soaks are located closest to the infiltration trenches and surcharge pits, with more frequent access to water. Dry soaks are located further downstream between these elements, and receive water less frequently. The soaks are excavated into the landscape, to ensure the channel maintains hydraulic conveyance capacity.

Wet soak predicted water availability

- Event inflow rate: ~40L to 250L/event. This varies along the channel. Based on Western Sydney's rainfall events, these would typically occur every three days subject to seasonal patterns.
- Wetter - Sandy loam filled holes
- Dry soak predicted water availability
- Inflow frequency: water from the existing stormwater pits will surcharge under at least the Q3 month event
- Drier - Sandy loam filled holes

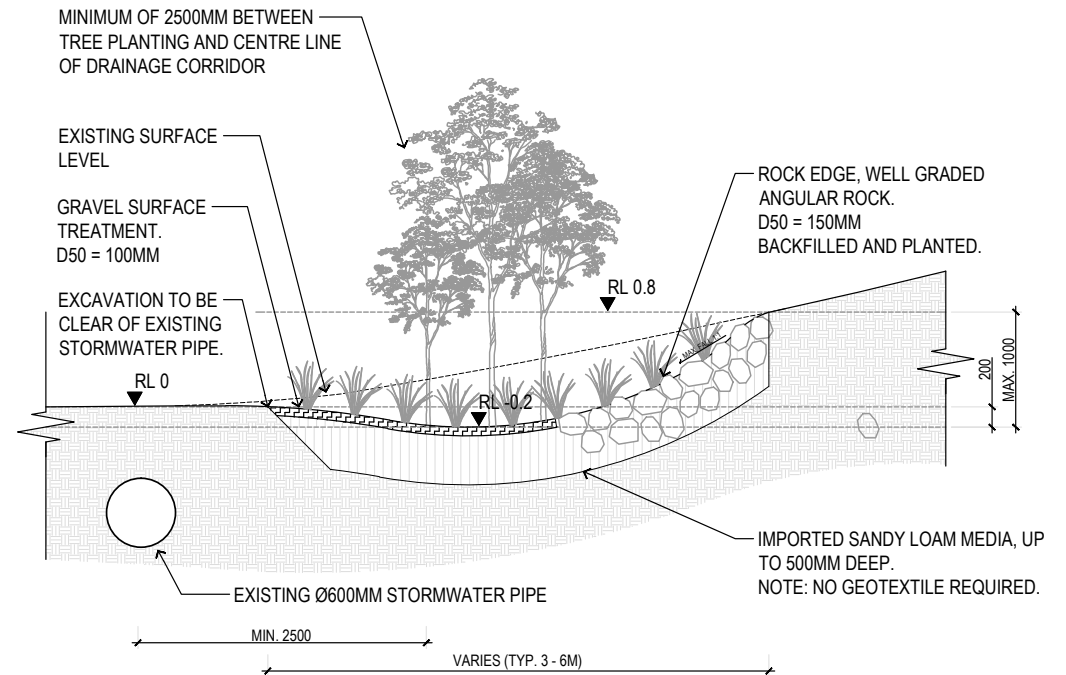


Figure 35: Wet and dry soak transverse section detail (1:25 at A3)

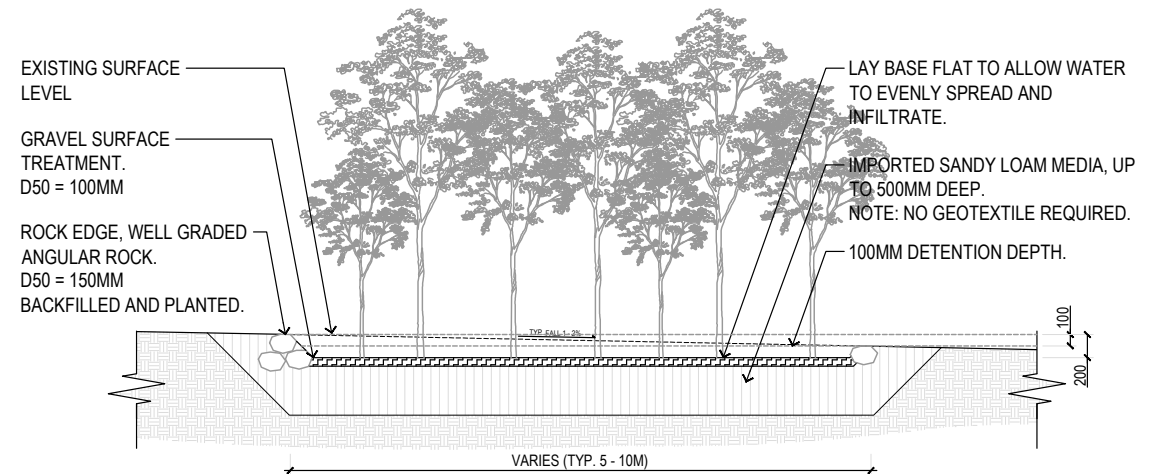


Figure 36: Wet and dry soak longitudinal section detail (1:25 at A3)



In-fill

Trees will be planted outside the inundation extent in some areas to create a connected canopy. These trees will not be passively irrigated; therefore, they will be slower growing than other trees along Copperfield Drive, with a potentially higher mortality rate. However they will require minimal investment to plant.

Predicted water availability

- Trees will rely on direct rainfall (plus any manual irrigation, greater maintenance burden due to manual watering through establishment period)
- Drier soil

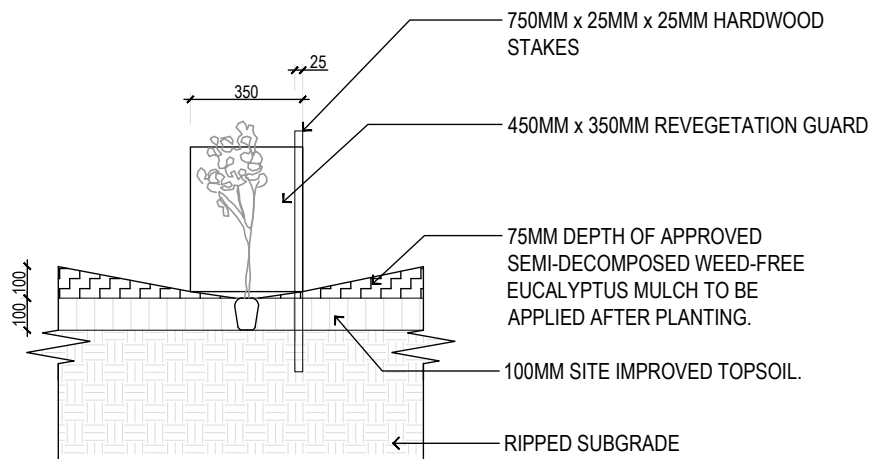


Figure 37: Tube stock planting detail (1:25 at A3)

TO PROMOTE LATERAL ROOT GROWTH THE PLANTING HOLE SHALL BE NO LESS THAN THREE (3) TIMES THE DIAMETER OF THE ROOT BALL. IF SPACE RESTRICTIONS EXIST STAKE SPACING SHALL BE REDUCED TO NO LESS THAN TWO (2) TIMES THE DIAMETER OF THE ROOT BALL. SLOPE ALL SIDES AT 45 DEGREES.

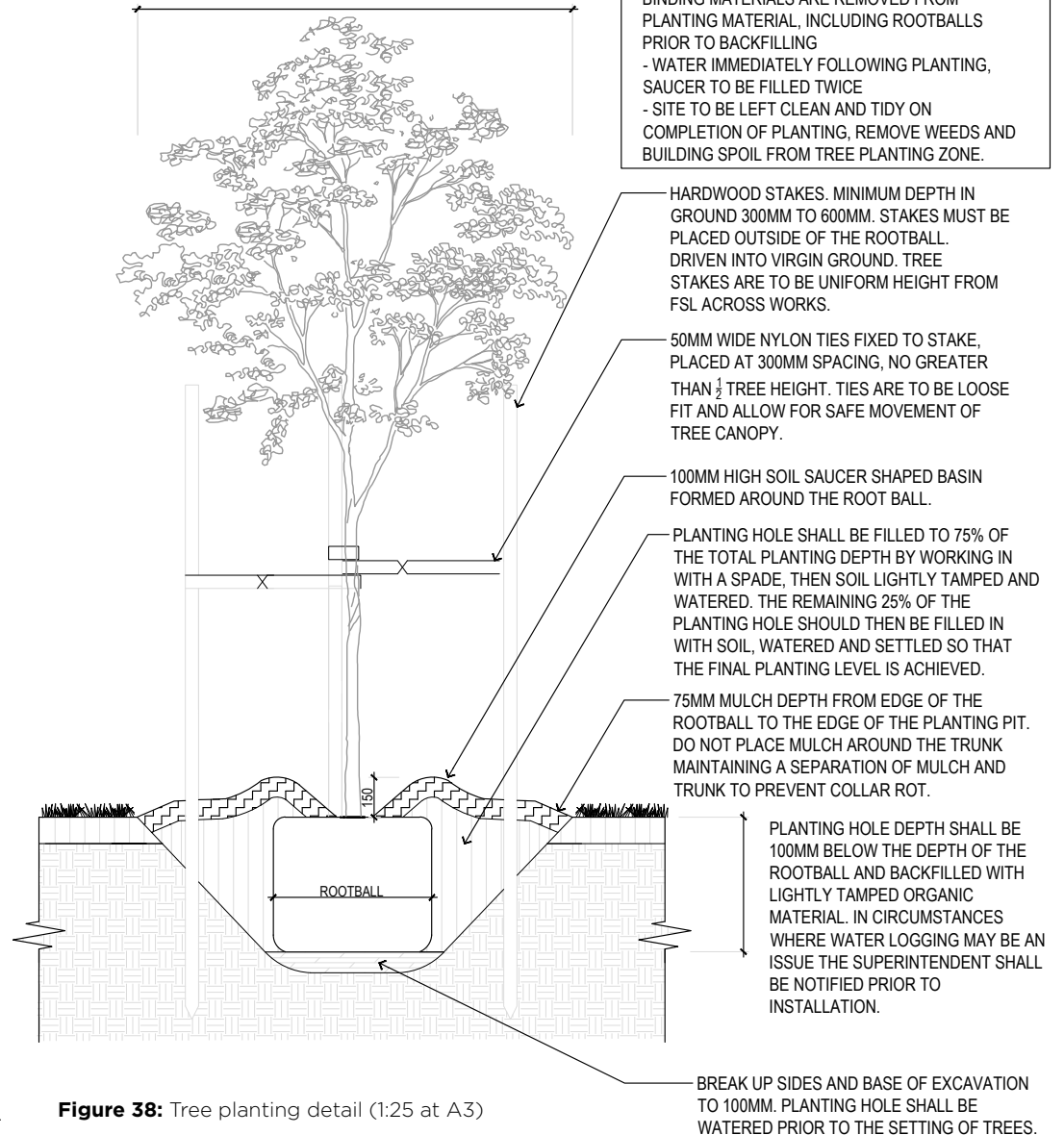


Figure 38: Tree planting detail (1:25 at A3)

TREE PLANTING NOTE:

- TREES SHALL HAVE A WELL DEVELOPED TAPER AND BE SELF SUPPORTING
- TREES SHALL BE OF GOOD HEALTH AND VIGOUR
- ENSURE ALL LABELS, WIRES, TWINE AND OTHER BINDING MATERIALS ARE REMOVED FROM PLANTING MATERIAL, INCLUDING ROOTBALLS PRIOR TO BACKFILLING
- WATER IMMEDIATELY FOLLOWING PLANTING, SAUCER TO BE FILLED TWICE
- SITE TO BE LEFT CLEAN AND TIDY ON COMPLETION OF PLANTING, REMOVE WEEDS AND BUILDING SPOIL FROM TREE PLANTING ZONE.



Planting palette

Trees palette

The tree palette was developed in collaboration with leading research and industry experts from the University of Western Sydney, Mt Annan Botanic Gardens, Campbelltown City Council forestry team and Urban Forestry Australia. An intensive workshop brought together research and knowledge to develop a tree palette which aims to find a balance between diversity, indigeneity, performance and aesthetics. This aims to increase the resilience of the future urban forest, cool the surrounding environment and create a sense of place for the local community.

Twenty-five species from 16 genus and 10 families have been selected. Many of the species are from the Myrtaceae family as they are commonly found in the Cumberland Plains bioregion and are ideal for the proposed Copperfield Drive growing conditions. Additional urban forest species diversity should be considered in the future when investigating surrounding tree planting projects.

The plant list is also based on performance – how the tree performs in a given soil type, soil volume and water availability. This is important

to increase tree health and increase potential canopy cover area and the additional benefits that trees bring.

Finally, aesthetics were considered. Based on the consultation with the Rosemeadow community certain traits were selected, specifically around foliage and flowers.

Trees will be planted out in different sizes, to introduce age diversity, economic viability and a natural aesthetic emulating successional growth patterns.

Material palette

For the first phase of the project, a simple palette of robust, economic and locally sourced materials have been selected. The functionality of concrete provides a base for the application of stone in more specialized locations like the drainage channel and tree pits. The fundamental approach is to facilitate efficient maintenance, support a sense of place and make the trees the hero.



Sandstone boulders for retaining walls and landscape features



Concrete footpath and kerb



Organic eucy-mulch



Ground cover palette

The ground cover planting palette is dominated by mowed grass for maintenance ease and familiarity. Pockets of tussock grasses, sedges and shrubs will be planted below discrete clumps of trees. These pockets will consist of species that feature in the Cumberland Plains as well as species with favourable aesthetic qualities, availability and longevity.



Sandstone screenings



Granitic gravel



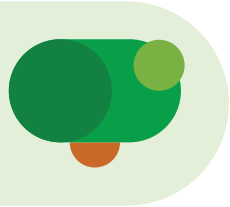


Table 2: Copperfield Drive concept plant species schedule.

Suggested Species		Maturity Size		Growth Rate			Seasonality		Species Mix	Comments	
Latin Name	Common Name	Family	Height	Width	Slow	Medium	Fast	Evergreen	Deciduous		%
Typology 1: Open Tree Pit											
Trees											
<i>Acer buergeranum</i>	Trident Maple	Sapindaceae	10	6		•			•	10%	
<i>Brachychiton acerifolius</i>	Illawarra Flame Tree	Malvaceae	10	6	•				•	10%	
<i>Cercis siliquastrum</i>	Judas Tree	Fabaceae	8	6	•				•	10%	
<i>Corymbia exima</i>	Yellow Bloodwood	Myrtaceae	15	8		•		•		20%	Shown good results locally
<i>Eucalyptus melanophloia</i>	Silver-leafed Ironbark	Myrtaceae	20	8		•		•		20%	Shown good results locally
<i>Eucalyptus sclerophylla</i>	Scribbly Gum	Myrtaceae	15	8		•		•		20%	Not good shade
<i>Malus floribunda</i>	Japanese Crabapple	Rosaceae	5	6		•			•	10%	
Ground Cover											
<i>Chrysocephalum apiculatum</i>	Common Everlasting	Asteraceae	0.2	1.0		•		•		10%	Colour
<i>Dianella longifolia</i>	Blue flax-lily	Asphodelaceae	0.8	0.6		•		•		20%	
<i>Eremophila debilis</i>	Winter Apple	Scrophulariaceae	0.5	2.0		•		•		20%	Cumberland Plains, scrambling
<i>Lomandra filiformis</i>	Wattle Mat-rush	Asparagaceae	0.5	0.5	•			•		10%	
<i>Lomandra longifolia</i> 'Verday'	Lomandra Verday	Asparagaceae	0.6	0.6		•		•		20%	
<i>Pultenaea villosa</i>	Hairy Bush-pea	Fabaceae	1.0	2.0		•		•		10%	
<i>Stypantra glauca</i>	Nodding Blue Lily	Asphodelaceae	1.0	1.0		•		•		10%	
Typology 2: Nature Strip											
Trees											
<i>Brachychiton populneus</i>	Kurrajong	Malvaceae	10	8		•		•		20%	Local native
<i>Calodendron capense</i>	Cape Chestnut	Rutaceae	10	6		•			•	20%	
<i>Lagerstroemia indica</i> x <i>L. fauriei</i>	Crepe Myrtle	Lythraceae	7	6		•			•	10%	
<i>Maclura pomifera</i>	Osage Orange	Rosaceae	10	8		•			•	20%	Male only
<i>Pistacia chinensis</i>	Chinese Pistachio	Anacardiaceae	10	8		•			•	20%	
Typology 3: Infiltration Trench											
Trees											
Upper Bank											
<i>Eucalyptus crebra</i>	Narrow-leaved Ironbark	Myrtaceae	25	25		•		•		30%	
<i>Eucalyptus fibrosa</i>	Red Ironbark	Myrtaceae	35	25				•		30%	
<i>Eucalyptus moluccana</i>	Grey Box	Myrtaceae	25	15			•	•		40%	

Suggested Species		Maturity Size		Growth Rate			Seasonality		Species Mix	Comments	
Latin Name	Common Name	Family	Height	Width	Slow	Medium	Fast	Evergreen	Deciduous		%
Typology 3: Infiltration Trench											
Trees											
Lower Bank											
<i>Casuarina glauca</i>	Swamp She-oak	Casuarinaceae	20	5			•	•		50%	Suckering and exploratory roots can cause maintenance issues
<i>Eucalyptus benthamii</i>	Camden White Gum	Myrtaceae	20	15		•		•		20%	Local native that has lost much of its range to development
<i>Eucalyptus longifolia</i>	Woollybutt	Myrtaceae	20	15		•		•		20%	Local native that has lost much of its range to development
<i>Eucalyptus robusta</i>	Swamp Mahogany	Myrtaceae	20	15		•		•		10%	Attractive to flying fox. Locate away from paths and school
Typology 4: Wet Soak											
Trees											
<i>Angophora subvelutina</i>	Broad-leaved Apple	Myrtaceae	18	15				•		10%	
<i>Eucalyptus amplifolia</i>	Cabbage Gum	Myrtaceae	30	15	•			•		10%	
<i>Melaleuca linariifolia</i>	Narrow-leaved Paperbark	Myrtaceae	6	7		•		•		60%	Roots may be invasive
<i>Melaleuca styphelioides</i>	Prickly-leaved Paperbark	Myrtaceae	10	8		•		•		20%	Roots may be invasive
Ground Cover											
<i>Carex appressa</i>	Tall Sedge	Cyperaceae	0.9	0.8		•		•		30%	
<i>Juncus usitatus</i>	Common Rush	Juncaceae	1.2	1.5		•		•		20%	
<i>Lachnagrostis aemula</i>	Blown Grass	Poaceae	0.8	0.2		•		•		10%	
<i>Schoenus melanostachys</i>	Black Bog-rush	Cyperaceae	1.2	1.5		•		•		30%	Weeping habit
<i>Xanthorrhoea minor</i>	Small Grass Tree	Asphodelaceae	1.0	1.0	•			•		10%	
Typology 5: Dry Soak											
Trees											
<i>Melaleuca decora</i>	White Feather Honeymyrtle	Myrtaceae	12	5		•		•		100%	
Ground Cover											
<i>Aristida ramosa</i>	Purple Wire-grass	Poaceae	0.8	0.8				•		20%	
<i>Austrostipa rudis</i>	Veined Spear-grass	Poaceae	1.0	0.5		•		•		20%	
<i>Indigofera australis</i>	Austral Indigo	Fabaceae	2.0	2.0			•	•		5%	
<i>Lepidosperma laterale</i>	Variable Swordsedge	Cyperaceae	0.4	0.6	•			•		10%	
<i>Microlaena stipoides</i>	Weeping Grass	Poaceae	0.2	indefinite			•	•		25%	
<i>Themida triandra</i>	Kangaro Grass	Poaceae	0.9	0.8		•		•		20%	
Typology 6: In-fill											
Trees											
<i>Acacia binervia</i>	Coastal Myall	Fabaceae	15	10			•	•		40%	Long lived acacia
<i>Allocasuarina littoralis</i>	Black Sheoak	Casuarinaceae	15	8	•			•		30%	Local sheoak
<i>Allocasuarina luehmannii</i>	Buloke	Casuarinaceae	15	8	•			•		10%	
<i>Callitris rhomboidea</i>	Port Jackson Pine	Cupressaceae	5	5			•	•		20%	



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