Street Trees in Challenging Spaces

May 2021

City of
West Torrens
Between the City and the Sea

Street Trees in Challenging Spaces

A shareable resource with a suite of solutions

City of West Torrens
Between the City and the Sea

JPE

JPE Design Studio Pty Ltd

Level 4
19 Gilles Street
Adelaide 5000
South Australia
Australia

Tel 08 8406 4000
Fax 08 8406 4007
design@jpe.com.au
www.jpe.com.au

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Contents

Introduction

Purpose

With population growth and the increased need for higher density housing, the decrease of tree numbers and decline in canopy cover is becoming evident. Tree planting to roadways provides demonstrated benefits beyond aesthetics such as improved biodiversity, contribution to community well-being, increase in property value and the cooling effect.

The cooling effect of trees in the urban landscape has been documented extensively, and as global warming increases the number of hot days in South Australia, more and more councils are implementing tree planting policies. In saying this, the costs of installation and maintenance of trees, as well as the potential damage they inflict on existing infrastructure and services, can be barriers to their installation. Situating trees in narrow or otherwise constrained locations is challenging and can result in poor tree growth and damage to surrounding infrastructure, increasing council maintenance costs long term.

To ensure an increase in tree planting and canopy cover, as well as an assurance of healthy tree growth whilst minimising conflicts with surrounding infrastructure, current traditional road planning and tree planting techniques need to be reviewed. The aim of this study is to address the quality of tree planting to maximise healthy tree growth and tree longevity, as opposed to promoting a larger quantity of tree planting which may be of a lower quality long term.

This study will provide the details and essential 'tool kit' for wider metropolitan councils to advocate for greater opportunities for tree plantings within areas which were once considered impractical. In addition, this study reviews the use of standard tree planting techniques and proposes design solutions for scenarios where traditionally conflicts would occur or poor tree canopy growth would be the result.

Tree conflicts with surrounding civil infrastructure can lead to the root system damaging bitumen and lifting concrete.

Tree species: Ulmus parvifolia
Mount Barker District Council

Quantity & Quality

The main focus within Local Government, and associated agencies in this discussion, is primarily concerned with the number of new trees being planted, and strategies for maximising this number. There appears to be little focus or critical review on survival rate, or how quickly, vibrantly and healthily these trees grow within their environments.

Similarly, gathering data on reduced life expectancy or inadequate growth of new tree planting due to seemingly common and arguably foreseeable factors such as infrastructure conflicts does not seem to be part of current conversation. Gathering data on tree health can also be challenging due to long life span of trees and logistical difficulties around coordinating long-term monitoring programs.

Given the shared goals of wanting to cool local environments and secure the benefits of tree planting from evapotranspiration, CO^2 sequestration and positive influence on amenity and mental health, we could ask the question: is maximising the *quantity* of planted trees truly the most significant factor in maximising the benefit of tree planting on the environment?

It could be proposed that planting fewer *successful* trees - established with supportive infrastructure and ground preparation and which grow at a much greater rate, vibrancy and volume and will last to a full life expectancy - is of many times greater value to the desired objective than multiple ‘standard’ tree installations which can suffer from shortened lives and stunted, unhealthy growth, and require increased maintenance inputs in their lifetime.

Constraints to healthy tree growth and mature canopy size including overhead services and proximity to properties.

Pyrus spp.
Mount barker

Guiding Principles

The below guiding principles have been developed following the research and consultation undertaken. These principles summarise the key factors which could lead to not only more successful tree planting outcomes, but also the implementation of more street tree planting.

‘The Roots get the Shoots’

Available soil volume is critical to success of trees. Encouraging root growth will result in thriving tree canopies.

Happy Trees Happy Infrastructure

Providing the needs of the tree results in reduced impact on surrounding infrastructure. Considered needs include space, oxygen, nutrients and water. If tree needs aren’t met, trees will seek space, water, nutrient elsewhere and by doing so may damage infrastructure.

Cost Efficient Solutions Maximise Implementation

Council budgets allow for asset renewal, new tree planting and tree maintenance yearly and the cost of standard tree planting needs to be responsive to these budgets. A number of designs have been prepared to suit a range of budgets, while considering long and short term cost investment.

The Right Tree for the Right Location

The selection of tree species needs to have consideration of their growing needs and how they might affect infrastructure.

Prioritise Trees

Trees increase street value, civic pride & well being, and can provide financial benefits to residents & council. Street trees provide landscape amenity, contribute to street & neighbourhood identity, & improve community stewardship. Considering trees as essential street infrastructure & prioritising them in the design & planning process ensures their success in the landscape and an overall benefit to the landscape and community.

An Integrated Approach

The best outcomes for all can be achieved through equal ownership, engagement and commitment between horticultural, engineering, infrastructure, asset management and other involved disciplines.

Successful Integrated Design

There are many factors affecting street tree planting success. Currently, Councils are finding tree canopy is being affected due to above and below ground restrictions and location of the tree as well as the selection of the tree, whereby the tree has either had to be removed, being planted too close to infrastructure, or severely pruned to minimise conflicts and thereby affecting overall tree canopy growth.

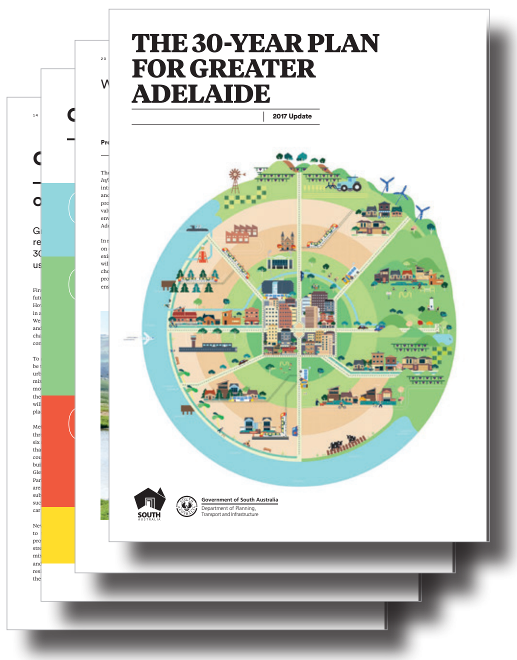
It is increasingly clear that if we continue to use traditional design for street tree planting, trees will not reach their full growth potential, surrounding streets will suffer damage and the urban canopy will continue to stagnate or decrease. In addition, strict requirements for existing and proposed services, equitable access and roadway design are resulting in fewer spaces where street trees are able to be installed.

This study examined these constraints holistically and provide innovative solutions that result in flourishing trees, minimal infrastructural damage and provide a more liveable and cooler environment for the future.

Strategic Context

This study sits within the context of other strategic plans for the City of West Torrens and greater Adelaide, and South Australian strategic documents, including:

- City of West Torrens Community Plan
- City of West Torrens Infrastructure and Asset Management Plans
- City of West Torrens Tree Strategy
- City of West Torrens Open Space and Public Place Plan
- City of West Torrens Public Realm Design Manual
- City of West Torrens Climate Change Adaptation Plan 'AdaptWest'
- City of West Torrens Public Health Plan
- SA Government - 30 Year Plan for Greater Adelaide
- SA Government - Greener Neighbourhoods program through Green Adelaide
- SA Government - Creating Greener Places for Healthy and Sustainable Communities
- Heart Foundation - Healthy by Design SA



The 30-Year Plan for Greater Adelaide

City of West Torrens Public Realm Design Manual

City of West Torrens Public Realm Design Manual - Street Typologies

The Public Realm Design Manual was recently developed, capturing a bespoke culture to the City of West Torrens public realm as well as providing a design guide for future Council developments. The manual outlines a level of hierarchy for Council streets. These include:

- Main
- Retail
- Neighbourhood
- Local
- Laneways

This study applies aspects of the manual, as outlined below:

Main street

- Significant street within the city
- Typically tree lined with a central median
- Large trees provide visual scale and sense of place
- On street parking
- Underground power supply where possible to utilise common service trenching and improve opportunities for street tree planting

Retail Street

- Typically service retail and civic uses
- Lower speeds allow for a more comfortable public environment
- Typically on street parking
- Tree planting to provide amenity and visual scale

Neighbourhood Street

- Disperse traffic locally
- Usually dedicated bike lane, footpaths and verges to both sides of road
- Typically with on street parking
- Incorporated WSUD where possible
- Tree planting incorporated to both sides of the road
- Underground electrical power supply where possible to utilise common service trenching and improve opportunities for street tree planting.

Local Street

- Narrower road reserve
- Provide distinctive street trees that contribute to local character
- May not include on street parking
- Support WSUD integration
- Support ‘verge gardening’
- Aim to reduce impact on infrastructure through the consolidation of services in common service trenches
- Consider protuberances to provide greater space for tree planting and WSUD integration

Laneways

- Narrow and located to the rear or sides of properties
- Typically no on street parking
- Accommodate provision for greening where possible, small tree planting or green walls
- Investigate opportunities to incorporate protuberances that provide greater space for tree planting and WSUD

The above dot points provide an understanding of street type hierarchy and terminology as per the City of West Torrens. This terminology will be referred to throughout this study.

City of West Torrens Public Realm Design Manual - Trees & Planting

The Public Realm Design Manual provides a 'Summary of Trees and Planting', and includes a selection of large, medium and small trees. The following aims and considerations from the Public Realm Design Manual to aid in the success of future tree planting are provided below;

- Suitable tree pit preparation,
- Selecting quality advanced tree stock exhibiting good growth and form,
- Suitable planting techniques,
- Providing irrigation, particularly during establishment,
- Suitable placement to avoid vehicle damage,
- Installation of water wells in street verges to water trees and guide roots away from infrastructure,
- Avoiding compaction around the base of the trees, and
- Incorporation of root control barriers to protect infrastructure and adjacent properties.

The Design Manual also outlines sustainable techniques to improve public realm environments;

- Improved tree canopy cover
- Improved tree planting arrangements
- Tree inlets and infiltration wells
- Swales
- Permeable footpaths, roads and carparks
- Rain Gardens
- Mulched verges
- Verge landscaping

These items are considered in the developed Design Guidelines which can be adopted within the overall Design Manual for the City of West Torrens.

Koelreutaria paniculata: **a common medium tree planted within the City of West Torrens and noted within the species list of the Public Realm Design Manual for a Neighbourhood Street.**

VOLUME 1

01. Desktop Study

South Australian Findings

Introduction

A desktop review was undertaken to identify approaches to tree planting, barriers to successful tree growth and any techniques being used to overcome challenges and to minimise damage to infrastructure. These precedents provide insight into street tree innovation projects undertaken in:

- South Australia,
- Australia (page 21), and
- Internationally (page 29).

A summary of relevant examples and studies are outlined in the following section.

South Australia

South Australia has a range of studies and reports that have been undertaken in the last 5 years as well as studies which are running concurrently with this study.

A review has been undertaken on the following reports;

- What's Happening to Adelaide Trees (Conservation Council of SA, June 2020)
- City of Adelaide, Greening the City
- Treenet Research Documents

> **“Trees help improve our mood, reduce our power bills and increase the value of our houses. In a warming climate, they are the single best investment we can make in keeping our cities cool, beautiful and liveable.”**

What's Happening to Adelaide's Trees?

This concise report by Conservation Council of SA questions why is it we are losing so many of our existing mature trees.

This report shows a trend in tree canopy reducation in South Australia over the last 10 years. Not only is there now increased pressure to boost tree planting numbers, but also there is dire need to keep what remaining tree cover we have left.

Ideas expressed within this report include the following;

- Involve qualified arborist to make informed decisions regarding tree plantings
- Capture the true worth of trees
- Give incentives to retain or plant new trees
- Inspire a love of trees through understanding the value and benefits of trees
- Change the law to increase tree protection

These issues will also help with an overall culture shift toward new ways of thinking when planting new trees.

This study will build on these findings with the aim that future tree plantings will yield a larger canopy within areas that may not have had the right tree planting technique or detailed applied.

> **"We must also stop the loss of mature trees across our suburbs if we have any chance of increasing our urban canopy cover."**

Greening the city, 2016

Your guide to greening with the Adelaide Design Manual

The City of Adelaide undertook a review of its street tree planting in a focused study about 'Greening' the Adelaide CBD. Key points which has guided their tree planting approach and tree selection are as follows;

- Mature height and canopy spread of the street tree and its spatial relationship with the street width.
- Successful performance and good growth rates in harsh urbanized environments.
- Trees that have a root system that is unlikely to lift kerbs and paving.
- Regular form and a high branching structure to create clear sight lines.
- Provision of shade for pedestrian amenity and cooler microclimate.
- Available at an advanced size which are less prone to vandalism and provide an immediate visual impact.
- No fruit, seed, spines, thorns
- Long lived, resists pests & disease

The first point is crucial to the success of tree growth and infrastructure longevity, and that is to understand the parameters of the street the tree will be installed and select an appropriate tree accordingly.

The third point suggests that there are certain tree species to avoid minimizing civil infrastructure lift.

Both points put emphasis on the tree species selection as a necessity for future tree growth success.

The City of Adelaide has also developed pilot projects which were largely based on where typical approaches *cannot* be applied and proposing solutions for these scenarios.

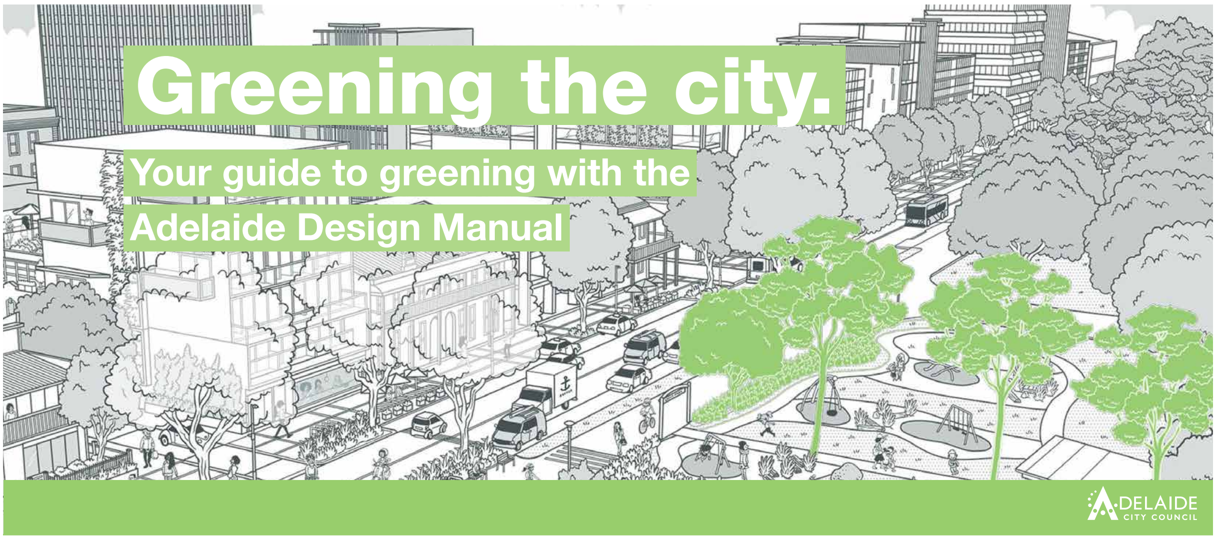
An exploration into the challenges and proposed solutions within Adelaide City Council can be found in this document, as well as the Adelaide Design Manual: Green Infrastructure Guidelines

Since this study was published, the City of Adelaide has refined its tree planting approach, partially in response to the on ground outcomes resulting from these recommendations.

The City of Adelaide is also undertaking a project looking into creating more space for trees, in collaboration with the University of Adelaide and Resilient East.

Key points for consideration within the context of this study are;

- Select tree species which mature at a height and canopy spread which is spatially appropriate within the context of the street.
- Select trees that have a non invasive root system and therefore less likely to lift kerbs and paving.



Treenet Research Documents

Treenet is a national urban tree research and education focused organisation. One of the aims of the Treenet organisation is to promote a much more systematic approach to the establishment of street trees.

There is a plethora of Treenet research undertaken which relate to this study. Key documents which have been reviewed are as follows;

- 2017, *Trees in Permeable Paving, Future Symbionts*, Tim Johnson, City of Mitcham & University of South Australia
- 2012, *Trees as essential infrastructure: Engineering and design considerations**, Simon Beecham, University of South Australia
- 2001, *Planting and Establishment of Trees on Difficult Sites*, Judy Fakes, Ryde College of TAFE, NSW

Trees in Permeable Paving: Future symbiots

Trials were undertaken within the City of Mitcham to determine the affect on street tree growth from the installation of permeable paving to the verge and nature strip. Conclusions as documented within this study found that permeable paving does provide benefit to trees as well as potential benefit to surrounding infrastructure. By installing a permeable pavement surface to the surround of the street tree, it may in fact recreate an environment to promote natural tree root growth and function.

> **“...more natural tree root growth and function can be engineered into our cities to achieve better performance of both the urban forest and the civil engineering.”**

In addition, the specification of permeable paving and installation technique is paramount to the success and effectiveness of permeable paving. Observations from this study suggest that the compaction of permeable paving sub-grade reduces infiltration capacity and therefore discourages the appropriate root growth.

It is also worth noting that these trials are suited to Adelaide climatic conditions where rainfall is low and opportunity to improve water absorption for improved tree growth is beneficial.

Key points to consider from this study;

- The use of permeable paving has a beneficial impact on tree root growth
- Water absorption encourages smaller, fibrous root growth (bio pores)
- Use of permeable paving will reduce conflicts with civil infrastructure with the improvement of a trees hydraulic performance and deeper root growth
- This study has been tested on silty clay loam soil type

Treenet Research Documents

Trees as Essential Infrastructure: Engineering and Design Considerations:

This study also reviews the effect of permeable paving types on the growth of street trees.

The installation and value of street trees often are associated with perceived maintenance costs. These costs relate to issues with infrastructure damage, potential risk of public injury and reduced tree health/ replacement costs. As per a study undertaken within the US, repair costs associated with street tree damage was an average of 25% of the total tree budget allocation. This figure affects future tree planting opportunities and investment.

This study suggests a lack of suitable soil conditions to promote appropriate tree growth is the most common cause of poor tree health. Soil and base course compaction due to surrounding pavements can cause root growth issues with the root growth seeking any available opportunity to grow. If access to water and nutrient is minimal, this will often result in poor tree health long term. In addition to this, some non-permeable pavement types can cause soil moisture to condense to the underside of the pavement due to temperature differences between soil and pavement. This moisture then attracts tree roots to the underside of the pavement with the result often leading to pavement lift or cracking from tree root growth.

Use of Structural Soils:

Generally, tree root growth in non-compacted soils have had better success, producing larger canopy trees, than compacted soils. Structural soils are used as alternatives to typical soils, containing larger aggregate, they are used for their weight holding capacity, whilst minimising compaction and maintaining soil porosity. Structural soils are typically used under footpaths and roadways where usual engineered compaction is required for pavement success.

Permeable Pavements:

As per the study undertaken by the City of Mitcham, permeable paving is recognised as a solution to improved tree growth and minimised infrastructure damage. Permeable paving increases the area in which a tree can collect stormwater, the pavement matrix of 20mm+ aggregate discourages larger root growth (as per previous study only smaller fibrous roots penetrated this zone) and therefore encourages deeper root growth and greater tree stability long term.

This study also defines trials undertaken within Adelaide using permeable paving and the depth of sub-base to each paving detail. One detail was labelled ‘perm-swale’ pavement, and is trialling an approach which has a central thicker aggregate base (i.e 250mm tapering to 380mm centrally), shaped into a swale. From early results, the ‘perm-swale’ has performed better with tree and root growth.

Key points to consider from this study;

- unsuitable soil conditions contribute to poor tree performance and infrastructure damage
- some non-permeable pavement types can cause moisture to collect to the underside whereby encourage unwanted root growth causing future pavement lift
- tree root growth performs better in non-compacted soils

Treenet Research Documents

Planting and Establishment of Trees on Difficult Sites:

This study looks at the current challenges facing planting and establishment of street trees. The paper identified common problems contributing to poor tree growth, such as;

- Inadequate planning
- Lack of site evaluation
- Poor quality tree stock
- Poor planting practices
- Anaerobic soil (soil with a lack of oxygen)
- Insufficient depth and volume of soil

A key problem with tree planting success, particularly within built up, high density areas, is lack of soil volume. This reduces the soils water holding capacity and water absorption. In urban environments, water is paramount for tree success. To supply a tree with enough water for any length of time, there must be a reasonable volume and depth of soil volume for adequate water storage. This paper recommends the following for adequate soil volume and water absorption (cited from Lindsay & Bassuk 1991);

- minimum soil depth of 600mm in the dripline area of the mature tree
- minimum soil volume for adequate tree growth from 7 – 8.5m3
- optimum soil volume up to 17m3, although this is almost impossible to achieve with current planting practices only reaching a volume of 1m3
- tree pit depth should be a minimum 450-500m and not exceed 600-900mm

The study also suggests opportunities to increase soil volume, such as;

- suspended pavements above larger planting pits of vaults
- linearly connected planting pits with drainage (tree trenches)
- structural soils

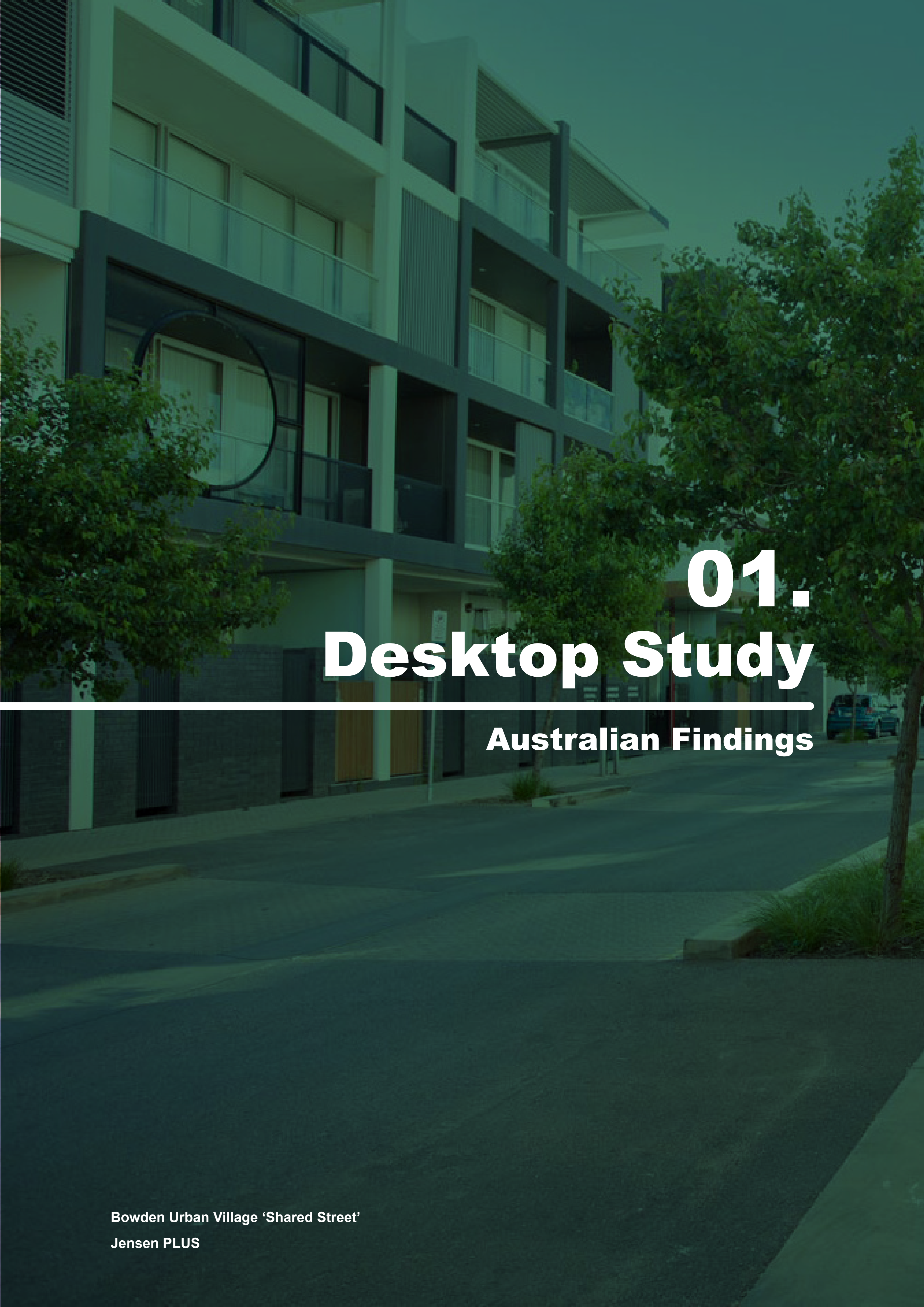
This paper recommends the following key points for future tree success;

- ensure the design meets the needs of the plant
- constructed environments need to be developed based on soil science and plant ecology
- thought needs to be given to the quality and quantity of growing medium such as volume, aeration, depth and organic matter
- record keeping determining future success of new tree plantings
- species should be selected which best suit poorer soils or restricted volumes
- use quality plants
- planting and establishment practices to best suit root establishment (appropriate irrigation)
- there is a need to communicate the basic needs of trees

> **“...seek advice and co-operation of soil scientists, landscape architects and even engineers if we are to create grand public tree plantings for the future in increasingly difficult urban environments.”**

01.
Desktop Study

Australian Findings



Bowden Urban Village ‘Shared Street’
Jensen PLUS

Introduction

Due to increasing urban development, finding space for trees is increasingly difficult not only in Adelaide, but around Australia and internationally. The findings presented here represent some innovative approaches being taken around Australia to ensure the health and success of trees in the urban realm.

These studies are as follows;

- City of Melbourne: Urban Forest Strategy - Making A Great City Greener 2012 - 2032.
- Cooperative Research Centre for Water Sensitive Cities: CRC for Water Sensitive Cities - Designing for a cool city
- Brisbane City Council: Brisbane. Clean, Green, Sustainable. 2017 - 2031

Where suitable, these findings influence the interventions and details presented as part of the Volume 2: Design Guidelines.

‘Urban Forest Strategy’

Making a Great City Greener 2012 - 2023, City of Melbourne

The City of Melbourne has developed the *Urban Forest Strategy: Making a Great City Greener 2012-2032*. Within this, Urban Forest Precinct Plans have been developed providing guidance to the future tree planting within the City of Melbourne’s streets and open space. The ultimate vision for the strategy is to ensure a future resilient and diverse urban forest, building on an already strong city character. The City of Melbourne’s Urban Forest Strategy makes key points relevant to our Adelaide study context, such as;

- Urban forests are not a new concept, however what is new is the shift in why urban trees are valuable. Rather than it solely and foremost being about aesthetic and recreational values, it is now seen as crucial for environmental sustainability, climate change adaptation and general community well-being.
- Water is the primary element needed for vegetation growth. Adequate available soil moisture is critical for healthy vegetation.

The strategy outlines key actions to improve vegetation health. Key actions most relevant to this study are;

- Implement best practice soil preparation before planting.
- Ensure the water needs of all vegetation are met, particularly during summer.
- Minimise conflict with above and below ground infrastructure.
- Improve soil structures to allow for oxygenation and water movement for the benefit of tree roots.
- Replace asphalt and concrete with porous surfaces such as porous asphalt, turf, garden beds and rain gardens to reduce heat retention and encourage soil moisture retention.

The success of gray infrastructure relies on the success of green infrastructure.

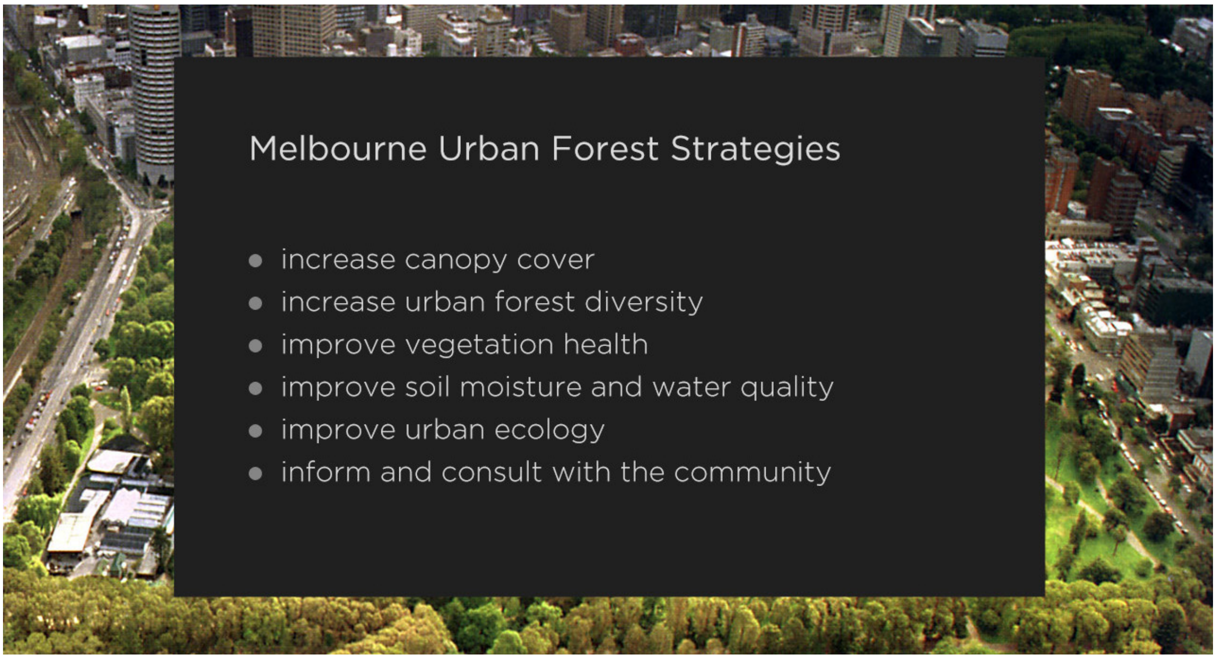
An integrated approach to planting, management and maintenance of street trees and surrounding infrastructure is key to the success of the urban forest. Implementation strategy and future planning is critical to ensure an overall increase in tree canopy.

Two key points can be applied to an Adelaide context;

1. Improve vegetation health,
2. Improve soil moisture and water quality.

Both strategies are essential to successful tree growth which collectively will create a resilient urban forest for Melbourne and Adelaide.


Melbourne Urban Forest


Melbourne Urban Forest Strategies
increase canopy cover
increase urban forest diversity
improve vegetation health
improve soil moisture and water quality
improve urban ecology
inform and consult with the community


Surface Temperature
Degrees Celcius
High : 28
Low : 20

The CRC for Water Sensitive Cities

Designing for a Cool City; Guidelines for Passively Irrigated Landscapes.

This guideline document outlines effective strategies for providing passive irrigation to urban planting.

> **"Adequate water is essential to the health of street trees, and passive irrigation benefits planting, stormwater infrastructure and the surrounding environment."**

Self-watered street trees / garden beds

Street trees and garden beds are typically planted into the verge or within protuberances into soils which have often become compacted due to the land uses and hard surfaces around them. Having a limited volume of good quality soil negatively impacts the growth and canopy cover of the tree in adulthood.

Similarly, in urban environments where there are surrounding impervious surfaces such as roads and pavement, there is limited opportunity for rainfall to penetrate soils and replenish soil moisture. Street trees are also typically disconnected from local water sources by the kerb and channel. Many street trees in urban areas therefore have stunted growth and never reach their full canopy potential. Passive irrigation can overcome this challenge by redirecting urban stormwater runoff to infiltrate into a volume of soil that is appropriately sized to nurture a healthy tree.

Passive irrigation can be used to benefit street tree planting by improving soil moisture to the tree roots and therefore assisting in the future health and growth of the tree.

The document also provides an outline of potential barriers when locating street trees. The potential barriers outlined below are not dissimilar to the barriers we face within an Adelaide context:

- Space – underground services and above ground infrastructure
- Proximity to Infrastructure
- Sightlines and safety
- Maintenance
- Costs

The document, whilst noting the importance of soil moisture, also notes the importance of soil volume which should be set by what is required by the tree for optimal growth. The document outlines design details which illustrate passive irrigation systems within a tree planting detail. The details most relevant to this study are as follows;

- Inlet system; infiltration well
- Tree pit is lower than the kerb invert level, open WSUD bed (i.e protuberances)
- Wicking bed composition and larger storage volume, open WSUD tree pit
- Structural cells, where pavement is required over tree pit

The document also catalogues engineered surface treatments more suited to permeability and water absorption. The items most relevant to this study are as follows;

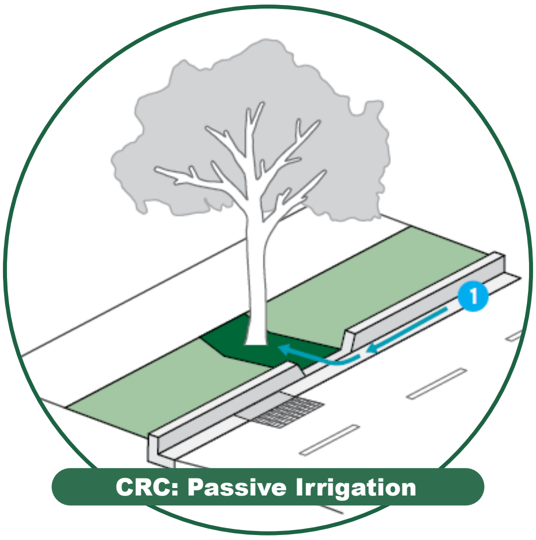
- Resin-Bound Gravel
- Porous asphalt, no-fines concrete
- Permeable pavement

In summary, this document provides insight into the benefits of passive irrigation to street trees as well as examples of design techniques that could be explored to better utilise stormwater for passive irrigation within the design solutions outlined in the Design Guidelines.

Key points relevant to this study;

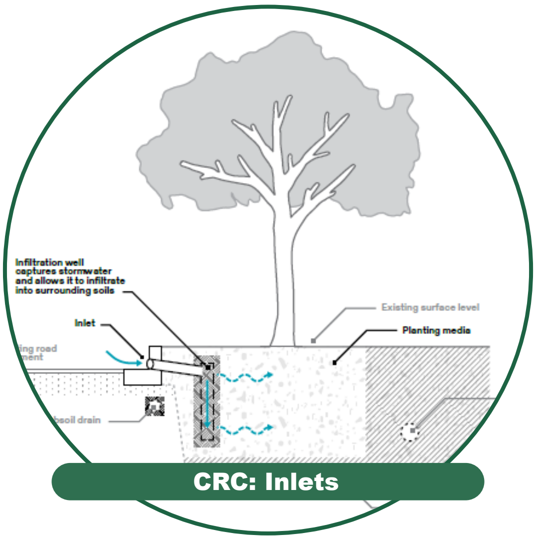
Trees with adequate soil volume and soil moisture have;

- Double growth rate,
- Increased lifespan,
- Reduced cost from pavement uplift and root intrusion, and
- Remove more air pollution.



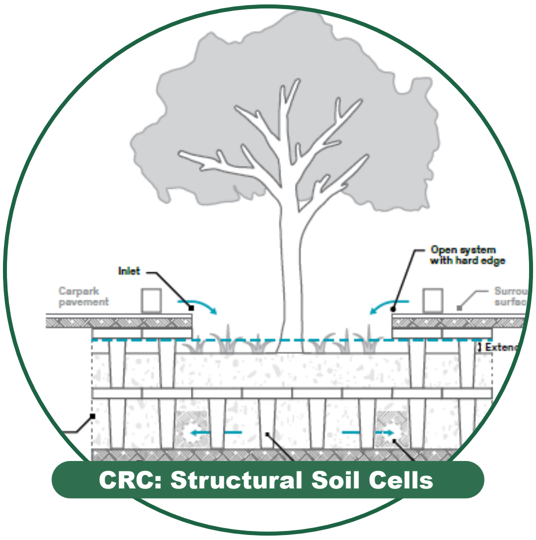
CRC: Passive Irrigation

CRC: Resin-Bound Gravel



CRC: Inlets

CRC: Porous Asphalt, no-fines concrete



CRC: Structural Soil Cells

CRC: Permeable Pavement

Brisbane City Council

Brisbane. Clean, Green, Sustainable 2017 - 2031

This document celebrates Brisbane's liveability due to their natural environment and value in sustainability. Within this document are key topics and associated goals, one of which is an improved Urban Forest with the goal; *Brisbane will value, nurture, and protect its urban forest.*

Within this document, priority actions are outlined, one of which is to 'Improve Councils Knowledge and Expertise in Urban Forest Management'. To do this, the City of Brisbane recommends to;

- **Determine the economic value of urban trees within Brisbane**
- **Embed water-smart planting techniques as 'business as usual' for street trees**

Brisbane Council estimates Brisbane's street trees return $1.67 million each year in air quality, rainfall interception, carbon storage and sequestration benefits. There is also $29.7 million in residential property value benefits.

> **"With this monetary return value set for Brisbane's street trees, the mental shift from being a 'nice to have' has changed and instead is seen as an investment for the future, returning not only social and environmental benefits, but future economic benefits."**

Healthy Land and Water

Waterwise Street Trees: Concept Design Catalogue, an Initiative of Healthy Land and Water

This guide examines the needs for stormwater infrastructure and street trees, proposing integrated solutions for both. By designing street tree pits as stormwater retention basins, both the street trees and stormwater infrastructure benefit.

Five basic types of water wise street trees are covered:

- Standard: street tree planting with no stormwater interventions
- + Soil Vol: street tree planting with larger than standard pits
- Brisbane City Council's Water Smart Street Tree
- Bioretention Street Tree
- Bioretention Street Tree with Saturated Zone

The case studies show clearly the correlation between healthy tree growth and access to stormwater, reinforcing the need for an integrated design solution.

The catalogue not only describes the installation types, but also provides some costs associated with each type.

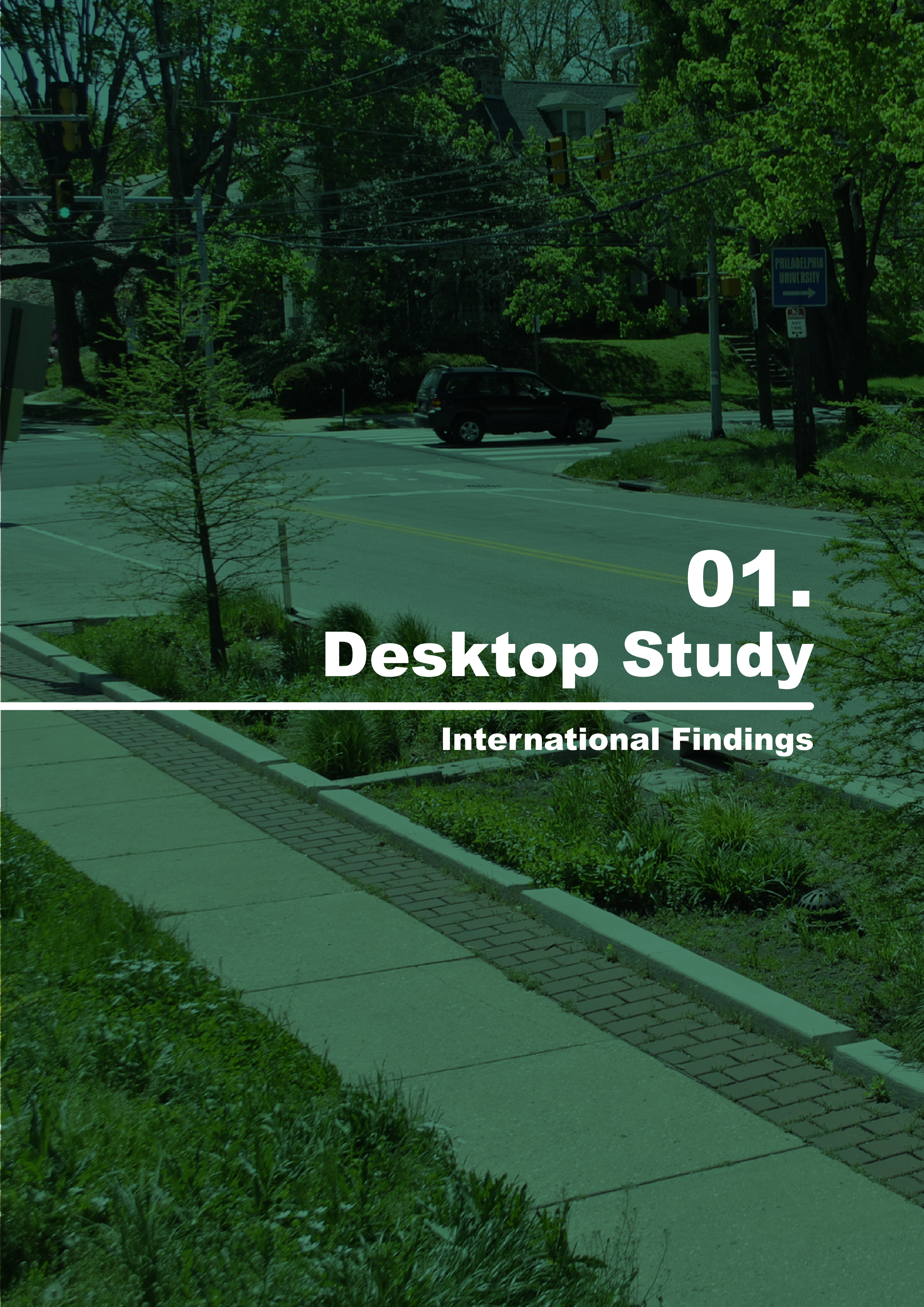
As well as describing street tree trials from around Queensland, this guide provides lessons learned from these and other projects nationally and internationally.

Lessons learned include in areas of stormwater inlets, pedestrian safety, and materials and aesthetics. For each of the failures a solution is proposed.

Outcomes from these trials have the potential to be integrated into this study to contribute to its success.

01.
Desktop Study

International Findings



Introduction

The following studies provide insight into practices occurring internationally, focusing on the improvement of tree canopy growth and tree success. These studies are as follows;

- City of San Francisco, Better Streets Plan: Streetscape Elements
- City of Toronto, Tree Planting Solutions in Hard Boulevard Surfaces: Best Practices Manual
- United States Environmental Protection Agency; Stormwater Trees Technical Memorandum
- Trees and Design Action Group: Trees in the Townscape: A Guide for Decision Makers & Trees in Hard Landscapes: A Guide for Delivery

City of San Francisco

Better Streets Plan: Streetscape Elements

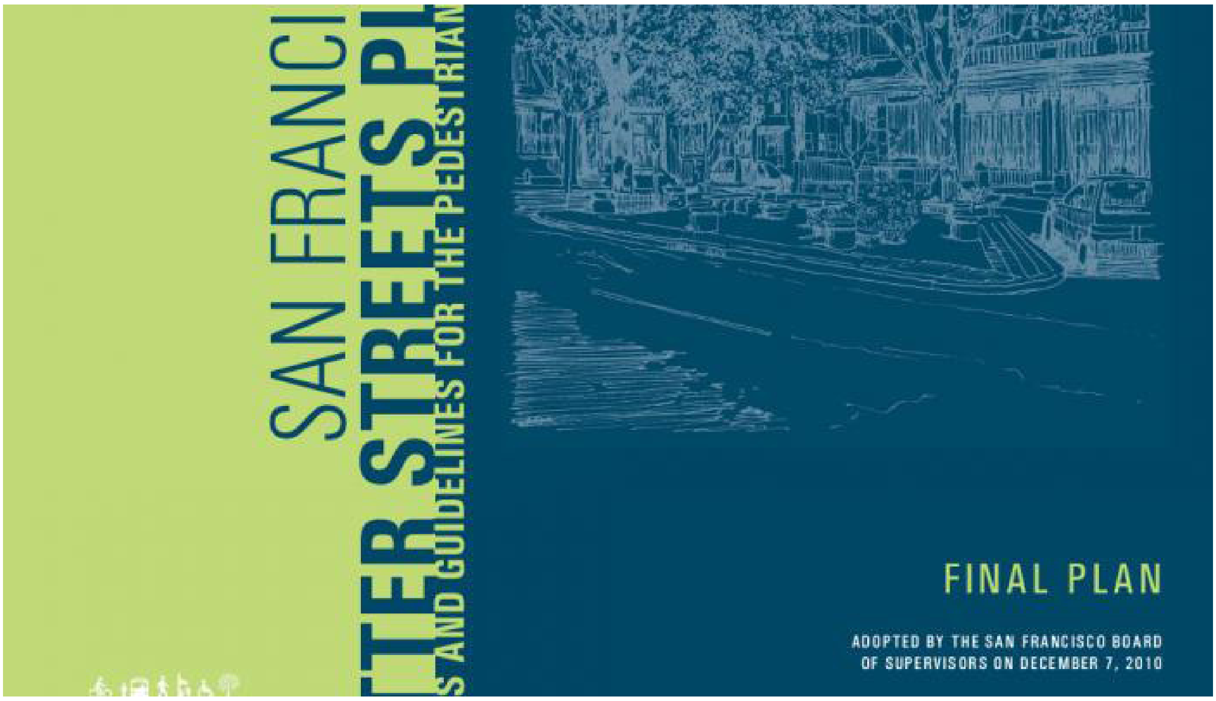
The better streets plan outlines a number of guidelines for street tree planting and stormwater treatment. A key policy to emerge from this document is Maximising Opportunities for street trees and other plantings. This is achieved by rethinking street design with trees as the first priority before siting other furnishings.

Design solutions to facilitate an increase in tree planting include narrowing the roadway with 'bulb-out' arrangements or parking lane planters, and reviewing tree proximity allowances in relation to services and intersections.

Proposed stormwater and planting solutions include:

- permeable paving,
- flow-through and infiltration planters,
- swales,
- rain gardens,
- channels and runnels,
- infiltration and soakage trench,
- infiltration boardwalks,
- vegetated gutters and vegetated buffer strips.

Many of these solutions are currently in place around Adelaide, with additional design solutions for consideration including sidewalk planters, infiltration boardwalks and parking lane planters.



City of Toronto

Tree Planting Solutions in Hard Boulevard Surfaces: Best Practices Manual

This manual proposes four guiding principles, and details to provide optimal street tree growing conditions without sacrificing path or amenity space. The manual covers topics including tree selection, water infiltration, soil volume, tree growth requirements, pavement types, tree protection, tree selection and installation.

Guiding Principles:

- More soil yields larger, healthier trees
- Larger pavement openings yield larger, healthier trees
- Integrating utilities into tree root zones increases soil volume
- Strategic, cost-efficient design yields larger, healthier trees

The proposed solutions to provide optimal growing conditions include:

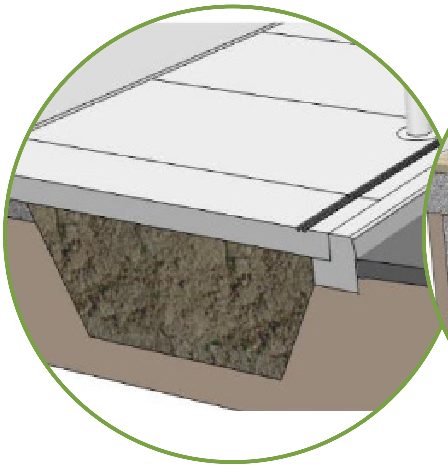
- Pavement bridge system
- Soil cells system
- Open planter system
- Hybrid solutions and retrofits
- Sub-standard sidewalk conditions

The key lessons from this manual include:

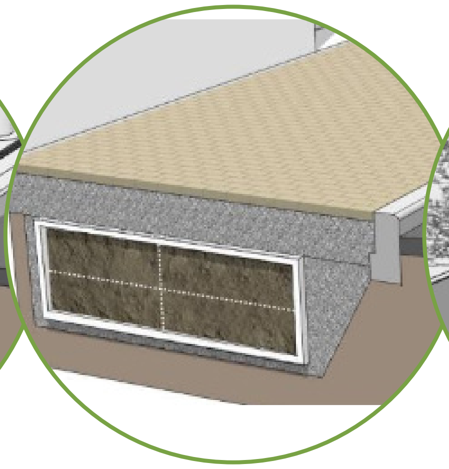
- Optimal growing soil volume is recommended as 20-30m^3 per tree
- Optimal pavement opening size is recommended to be at least 1.5mx1.5m
- There may be scope to review underground services proximity to root balls
- Low cost options can be implemented in certain locations to offset cost in difficult situations
- Installing fewer trees with adequate soil volume is preferable to more trees with inadequate soil volume
- Design for tree success depends on the tree pit and surrounding infrastructure and soil details, including adjacent subsoil associated with pavement

Some of the solutions proposed here could be applied in Adelaide, including structural ‘bridge’ footpath in lieu of structural soil or cells.

“Installing fewer trees with adequate soil volume is preferable to more trees with inadequate soil volume.”



City of Toronto Detail Pavement Bridge System



City of Toronto Detail Soil Cell System

City of Toronto Detail Open Planter System

United States Environmental Protection Agency (EPA)

Stormwater Trees Technical Memorandum

The Stormwater Trees Technical memorandum outlines benefits of trees, challenges to establishing trees, site constraints and issues leading to tree failures.

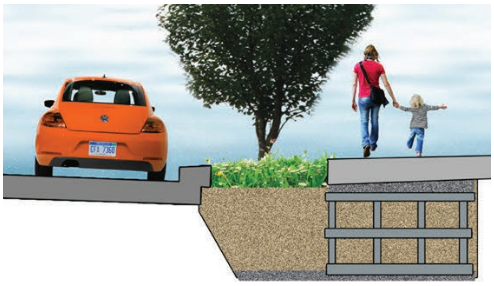
The surface opening is also critical to tree health, allowing adequate access to water and oxygen.

The recommended opening at surface level is proposed as 2.2sqm (24sq ft)

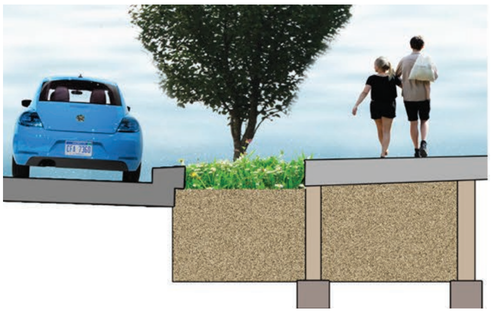
Some solutions put forward to meet these requirements for healthy trees include Structural Cells, Suspended Sidewalks and Structural Soils, in conjunction with Stormwater Tree Pits/Trenches, and Permeable Pavement.

The typical site constraints include:

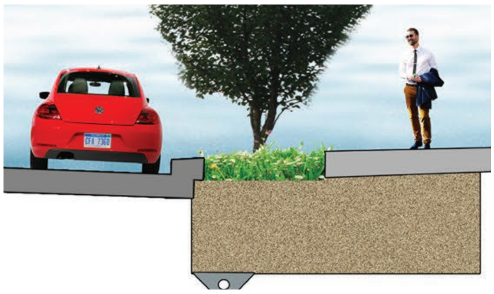
- space requirements
- soil quality & texture
- steep slopes
- overhead and underground utilities
- pavement and other impervious surfaces
- proximity to structures



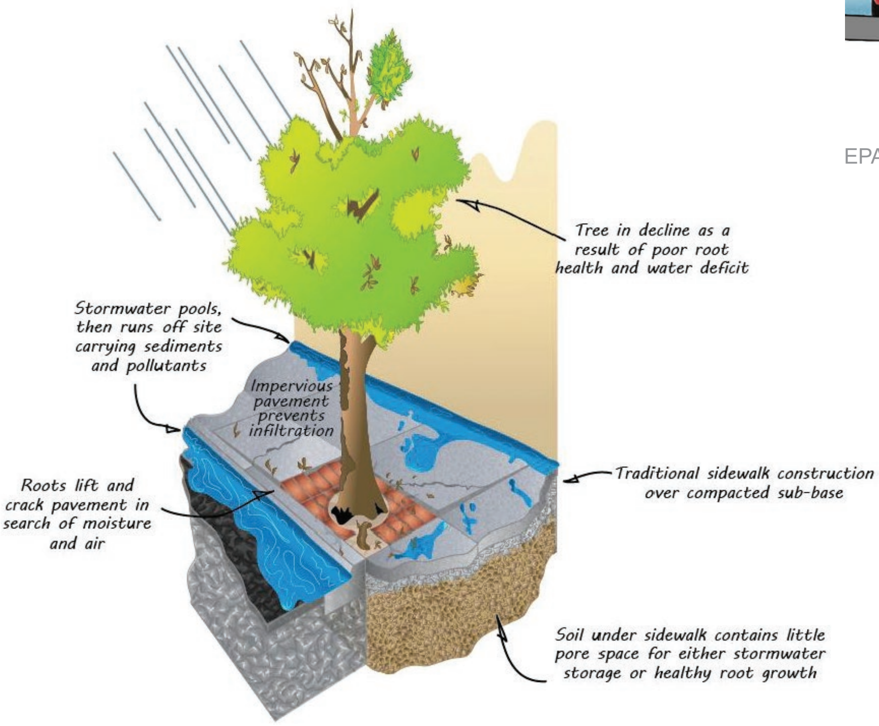
EPA: Structural Cells



EPA: Suspended Sidewalk



EPA: Structural Soil



Typical street tree challenges (image from EPA 2013)

One of the key issues identified is the lack of adequate soil volume. As part of this memo, the EPA sets forward the following preferred soil volumes:

- Small Tree: 17m3 (600cu ft)
- Medium Tree: 28m3 (1000 cu ft)
- Large Tree: 42m3 (1500 cu ft)
- Multiple trees: 2.4m length x 0.9m depth (8ft x 3ft)
- Minimum soil volume per tree: 14m3 (500 cu ft)

Trees and Design Action Group (TDAG), UK

Trees in the Townscape: A Guide for Decision Makers & Trees in Hard Landscapes: A Guide for Delivery

Trees in the Townscape proposes twelve principles to guide the success of trees in the urban, 21st century context. The principles are as follows:

1. Know Your Tree Resource
2. Have a Comprehensive Tree Strategy
3. Embed Trees into Policy and Other Plans
4. Make Tree-friendly Places
5. Pick the Right Trees
6. Seek Multiple Benefits
7. Procure a Healthy Tree
8. Provide Soil, Air and Water
9. Create Stakeholders
10. Take an Asset Management Approach
11. Be Risk Aware (Rather than Risk Averse)
12. Adjust Management to Needs

Each of these principles are supported by objectives, benefits and actions grounded in real-world practicality, and feature case studies outlining their implementation.

This document is not only beneficial to on-ground installers and designers, it also provides tools to guide policy and responds to the strategic barriers that are often faced in relation to tree planting.

Following from the principles established in Trees in the Townscape, Trees in Hard Landscapes proposes practical tools for successful delivery of the identified objectives. Covering a much broader scope than this study, this document provides a working guide for delivery of tree planting as part of sustainable integrated infrastructure. This strategy of approaching tree failure, stormwater failure and infrastructure failure as inextricably linked allows a more cohesive and mutually beneficial solution.

The delivery of the objectives set out in the previous document are explored through:

- Collaboration and the key players required from inception to delivery
- Design choices that will ensure trees best contribute to project objectives
- Technical solutions, mostly below-ground, to avoid conflicts between trees and the surrounding infrastructure
- A framework for selecting and obtaining the ‘right’ tree(s)

TDAG: Trees for the Greater Bristol Bus Network Case Study

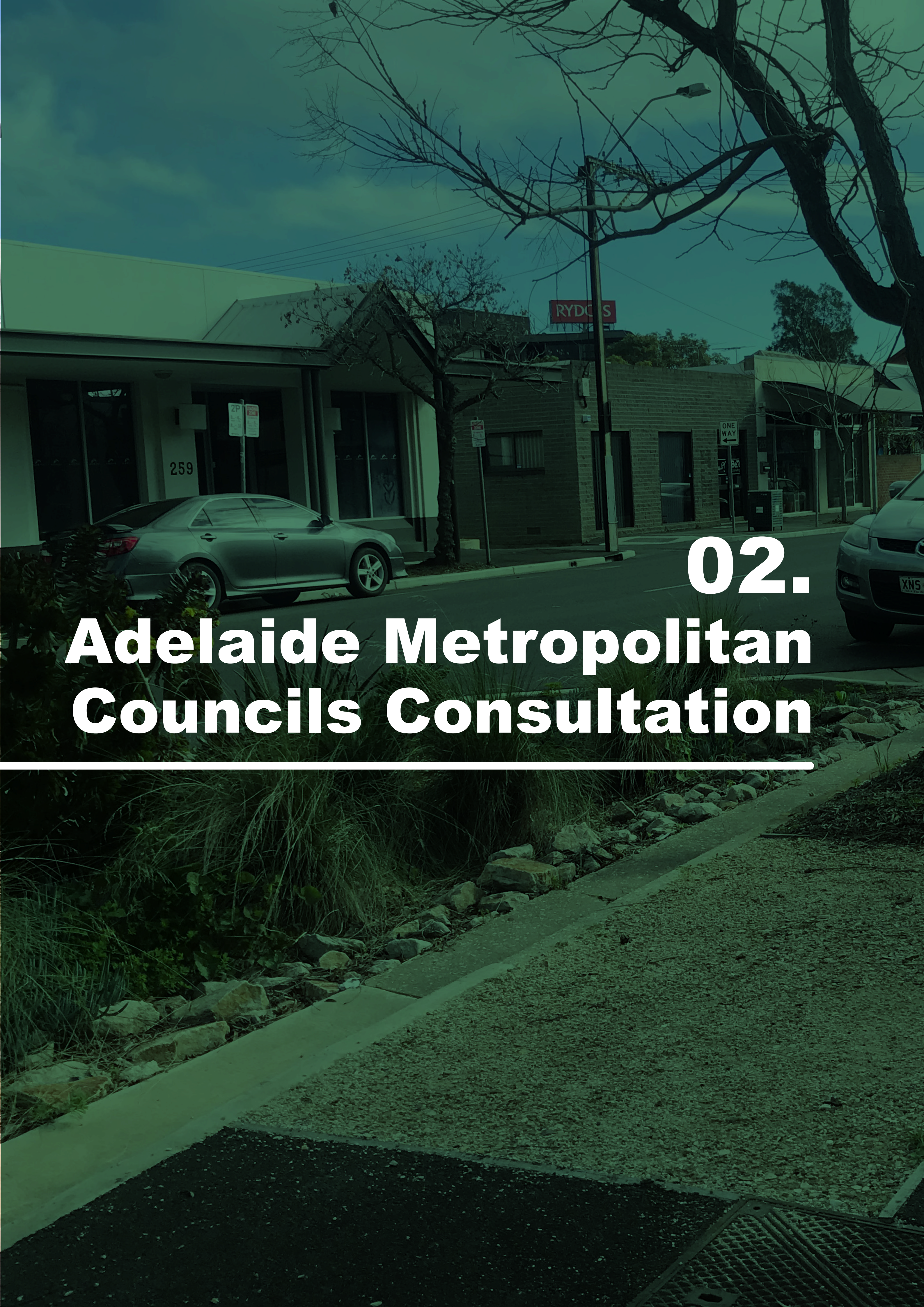
TDAG: Hong Kong Green Master Plan Case Study

TDAG: RAF Bomber Command Memorial Case Study

Summary of Learnings

This research reviews key documents from a range of backgrounds; locally, nationally and internationally. This is summarised into the following key findings we can apply to this study;

- Tree selection is important to the future success of the tree and surrounding infrastructure. Choose species that are less likely to lift kerbs and paving.
- The success of grey infrastructure is reliant of the success of green infrastructure
- A tree needs soil volume to survive and flourish.
    - The American EPA states an average tree size of 5-10m requires a volume of soil of 14m3.
    - Other studies have recognised that current practices are only achieving an average of 1m3 of soil volume and with an increase in challenging spaces for trees to grow, a more achievable target is 7m3
- A tree requires access to water to establish appropriately and survive.
    - A recommended surface opening for appropriate water absorption which will improve tree growth within urban environments is 2.2m2
    - Trials of permeable paving adjacent tree pits have found improved tree root growth and potential for minimised infrastructure damage
- It is important to determine the economic benefit for each tree, ensuring street trees as an asset and investment for the future



02.
Adelaide Metropolitan Councils Consultation

Introduction

As part of this study a survey and trial review was undertaken.

The survey was developed and distributed to various councils around metropolitan Adelaide. The survey aimed to gain an understanding of the challenges facing these council and any measures they are undertaking to ensure the success of tree planting.

A site by site review of key tree planting locations was undertaken to explore challenging space scenarios and their impact on tree growth and street infrastructure, as well as any trials being undertaken which vary from standard tree planting techniques. This was undertaken within the City of West Torrens and the Mount Barker District Council.

The following section is broken down into the following key parts;

- Surveys
- Trials
- Typical Details Review
- Findings summary

Metropolitan Adelaide Councils Surveys

A range of metropolitan Councils were contacted to seek involvement in a study survey to capture current Council street tree planting challenges. These Councils represent a range of landscapes and built forms. The following section provides a summary of these responses.

The results of this survey indicate that the main limiting factor for planting street trees is the lack of space such as narrow nature strip planting, followed by conflicts with infrastructure and underground and overhead services.

Another factor which was not included on the original survey but mentioned by a number of Council's is public perception. Street tree planting is one of the most visible representations of council in public space, and can create conflict between the council and residents due to perceived potential property damage, expenditure, and maintenance requirements.

The consequences of unsuitable tree planting is most commonly characterised by lifting pavement, followed by damage to other infrastructure and the tree itself.

Many councils are addressing these issues through the use of passive irrigation inlets, permeable paving and careful selection of tree species.

A copy of the distributed survey is pictured adjacent.

A summary of responses is illustrated on the following pages.

Trees in Challenging Spaces

Council Survey

In order to provide meaningful and practical solutions for installing trees in challenging spaces, we're seeking to understand existing tree planting challenges and details across Adelaide. A challenging space is a space which limits appropriate tree growth or prevents installation of trees.

What challenges are commonly faced when situating trees within your council?

- Lack of space within verge for tree growth
- Proximity to overhead wires
- Proximity to civil infrastructure
- DPTI setout requirements
- Proximity to underground services
- Cost of installation

Any others, or further comments on the above:

What are common consequences of unsuitable tree planting within your council?

- Lifting pavement
- Damage to surrounding infrastructure
- Damage to services
- Tree damage (poor growth, death, requires severe pruning)

Any others, or further comments on the above:

What measures are your council currently providing for successful tree growth in challenging spaces?

- Root protection barriers
- Strata Cells
- Permeable paving
- Passive irrigation inlets

Any others, or further comments on the above:

Is your council trialling any non-standard tree planting details designed to promote better tree growth and reduce impact on surrounding infrastructure?

- Yes, we have trial sites
- No, we're not developing alternative details
- Yes, we're developing details

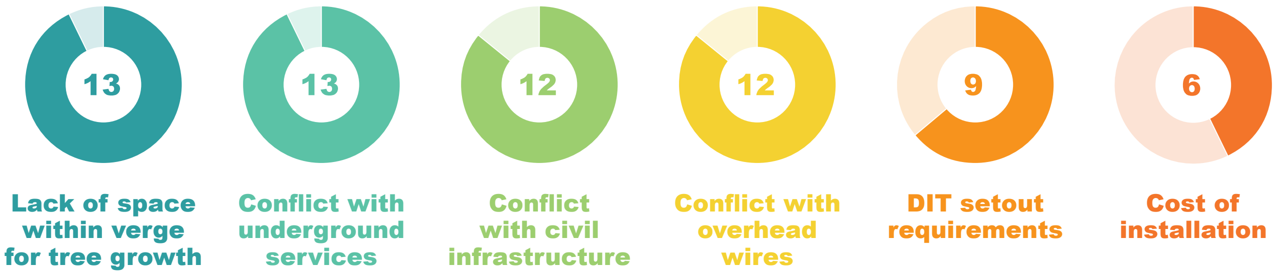
Would you be willing to share any trial successes and failures with this study?	Yes	No
Would you be willing to share standard Council details with this study?	Yes	No
Would you be willing to share non-standard details with this study?	Yes	No

Have you found success with particular tree species within your council? Have any tree species exhibited unexpected success in certain locations?

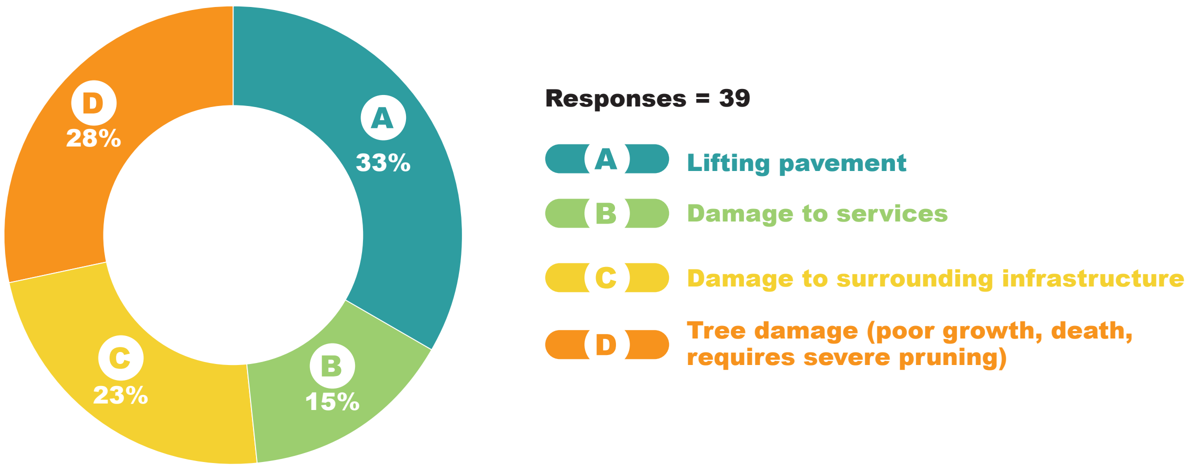
- I would be interested in giving feedback on the draft document
- I am interested in participating in future workshops
- I would be available to further discuss these responses

Thank you for your input

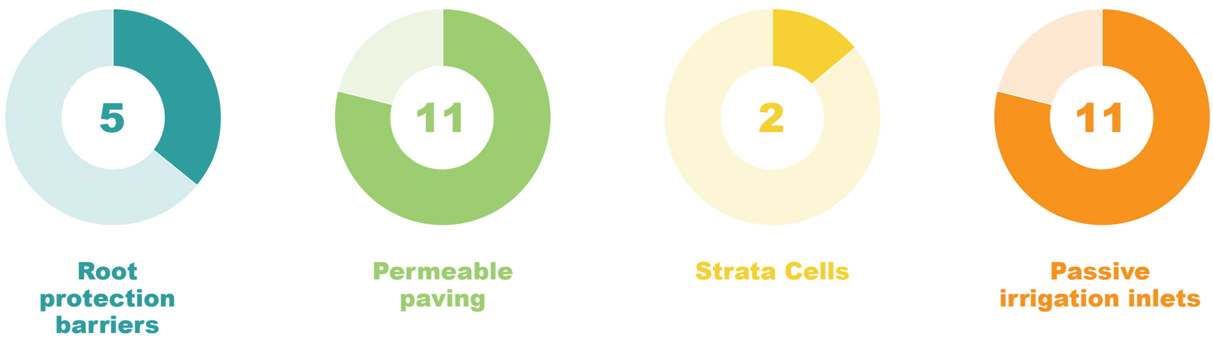
What challenges are commonly faced when situating trees within your council?



What are common consequences of unsuitable tree planting within your council?



What measures are your council currently providing for successful tree growth in challenging spaces?



Additional Responses:

Some residents don't want a tree in 'their' verge.

- City of Onkaparinga

Using species suitable to locations prevents these issues

- City of Campbelltown

Variable soil profiles, poor quality soils and compaction

- City of Onkaparinga

Streets are so tight these days that developers need to carefully plan and install underground services and infrastructure to ensure that there is a designated place for a tree to be planted in the verge.

- City of Onkaparinga

Community expectation of anti tree is a challenge, as they value manicured lawn over tree and the greater benefit. Council planting guidelines which outlines planting offsets, are becoming more of an issue with urban infill development.

- City of Salisbury

Additional Responses:

Lifting pavement & damage to services are relatively minor issues but perceived as major by some

- City of Onkaparinga

It is more likely that the infrastructure is unsuitable. If trees were considered during the urban design process and infrastructure was designed and built to accommodate trees then most of the common issues would be avoided.

- City of Mitcham

This varies greatly between location within the City and soil conditions (eg, shallow rock). There is also the resident concern that states a tree has damaged private infrastructure, which is found to have failed prior to tree impact.

- City of Salisbury

Planting an appropriate tree for the situation as well as installation of permeable paving in footpaths (and roads in some cases), root barriers and Treenet inlets will help minimize these conflicts.

- City of Onkaparinga

Additional Responses:

Avoiding compaction of engineering subgrades as much as possible ... this allows for soil movement around the roots rather than root expansion lifting the consolidated (i.e. strong, inflexible) mass of soil and causing infrastructure damage. The standard engineering approach of 95% or 98% maximum bulk density to achieve subgrade strength is excessive and unnecessary (how much strength is required? Why not specify the strength required rather than the soil density... this is unnecessary, expensive and harmful to delivering an integrated solution.

- City of Mitcham

Plant small trees

- City of Campbelltown

We have moved away from root barriers and specify larger holes/ volumes or trees to allow for root development. Sometimes this excavation needs to be long & narrow to fit between the kerb and footpath.

- City of Onkaparinga

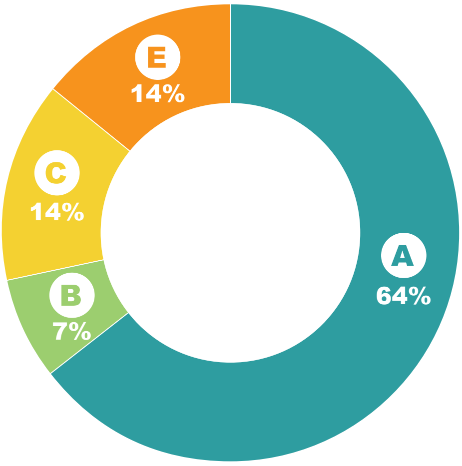
Root Barrier is being installed with new development works and is being considered for capital project works

- City of Salisbury

We have also used 'structural soils'. The use of Strata Cell and permeable paving only in limited places.

- City of Onkaparinga

In consideration to footpath and kerb assets, what percentage of 'written off' value each year do you believe is due to tree conflicts?



Response group size = 14

- A 0-25% (9)
- B 25%-50% (1)
- C 50%-75% (2)
- D 75%-100% (0)
- E No Response (2)

Additional Responses:

Impermeable paving can be written off in 10 - 20 years by tree roots, whereas permeable paving is likely to achieve its full life expectancy.

- City of Mitcham

More flexible asphalt formed kerbs are put in to replace damaged concrete kerbs near trees.

- City of Onkaparinga

Tree damage is generally minor and does create maintenance but usually has little affect on timing of asset renewal.

- City of Norwood, Payneham & St Peters

Summary of Survey Findings

From our consultation with Councils the following dot points summarise the key findings;

- Permeable paving and passive irrigation are the most common technique used to improve street tree growth
- The most common challenge facing councils when planting street trees is a lack of space within the verge for appropriate tree growth
- The most common consequence of unsuitable tree planting is lifting and damage of surrounding infrastructure
- Almost all Councils have had past conflict with civil infrastructure however the majority stating an average asset renewal cost of less than 25% per annum

Trial Sites:
City of West Torrens

Within the City of West Torrens ten sites were reviewed. Each site provided a varied technique to tree planting (new and existing) and civil infrastructure management/ replacement due to tree conflicts. Some examples include:

Permeable Paving

In association with full replacement as well as maintenance replacement of footpath projects, the City of West Torrens encourages the use of permeable and pervious paving to each street tree planting, particularly where new street trees are also being established in conjunction with the works. This approach is being utilised under the understanding that the combination of water infiltration (during wet days) and heat transfer (during warm days) provided by the permeable paving work to encourage deep root development and discourage shallower root development which in turn could lift and conflict with the footpath infrastructure.

West Torrens Detail Type 1: Permeable Paving

Irrigation Well and Inlet

Infiltration Wells and Inlets are being utilised to collect passing stormwater flows from the street kerbing and direct to adjacent infiltration wells established within proximity to new or existing street trees. One trial, associated within a complete road upgrade, includes the establishment of approximately 50 new street trees. Half of these new trees have had an Infiltration Well and Inlet installed adjacent to the tree to provide supplementary irrigation, whilst the other half have been provided with a conventional ground level dripper pipe potable irrigation system. The trial is hope to provide information in relation to comparative growth patterns of the two sets of trees, as well as observe any typical variance in nature of future infrastructure conflicts.

West Torrens Detail Type 2: Tree Inlet

WSUD Pits

Developed in the 2010, the City of West Torrens installed Bio-Filtration RainGardens (with trees). Although the use of Raingardens are considered a common Water Sensitive Urban Design (WSUD) approach, the inclusion of trees within them is far less common or understood. Raingardens collect and filter ‘first flush flows’ of stormwater off of roadways, saturating the soil profile, with underdrainage in the bottom of the installation to deliver excess water to Council stormwater infrastructure. These installations (each measuring around 2m long x1.5m wide x1m deep) which have been planted with trees and understorey plantings have had reasonable, but mixed success. Most of the trees experienced excellent early growth and vitality, with some experiencing signs of pH imbalance a few years ago.

West Torrens Detail Type 3: WSUD Pits

Mount Barker District Council

Within the Mount Barker District Council four sites were examined as examples of tree planting techniques that challenged conventional tree planting standards and encouraged as much soil volume potential as possible.

Natural Earth Trench

A key tree planting principle used by the Mount Barker District Council is a natural earth trench, also known as 'roots get the shoots', meaning an increase in below ground root volume provides a greater chance for above ground canopy growth. Examples of tree trenches varied in size, some narrow but deep, some shallow but wide, but all examples demonstrated an increase in soil volume for tree root growth.

The tree planting details being trialled by council have focused on best possible tree planting technique, consideration of civil infrastructure parameters, and ensuring required stabilisation is achieved. It is also worth noting that the details being trialled by Mount Barker District Council are a higher cost per tree to plant. In saying this, if a reduction of infrastructure conflicts is a continual outcome for these trials, it may be considered a sound investment and a valuable tree planting approach.

In summary, both Mount Barker and West Torrens have used a range of techniques to increase opportunity for improved tree health and canopy cover. These techniques involve applying a greater amount of soil for root growth, or providing an increase in permeable surface area for improved water catchment and absorption. These are two key principles which will require consideration in developing future tree planting details.

Mount Barker: Tree within trench

Council Typical Tree Planting Details Review

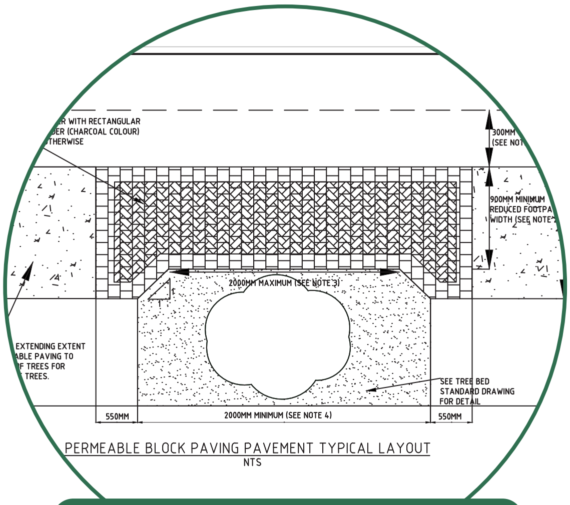
City of West Torrens, Permeable Footpath Detail:

This detail allows for both installation to a new streetscape construction as well as retrofitting within an existing streetscape.

The indented pathway width gives an increased permeable area to the tree pit as well as the opportunity to increase tree volume. Typical permeable pavement width is 1350mm (can be narrowed to 900mm for a maximum of 2m length) and length is 3100mm, in addition to the tree pit permeable space.

Permeable Surface: approx. 7 m^2 (varies to each nature strip width and application)

This detail is very similar to the trailed details as referenced within the Treenet document *(Tim Johnson, Trees and Permeable Paving: Future Symbionts)*.



Permeable Footpath Detail

01 Tree Bed Typical Detail (for new tree and roadway construction – for smaller spaces):

This detail is applied to new verge and roadway construction.

Tree pit depth:

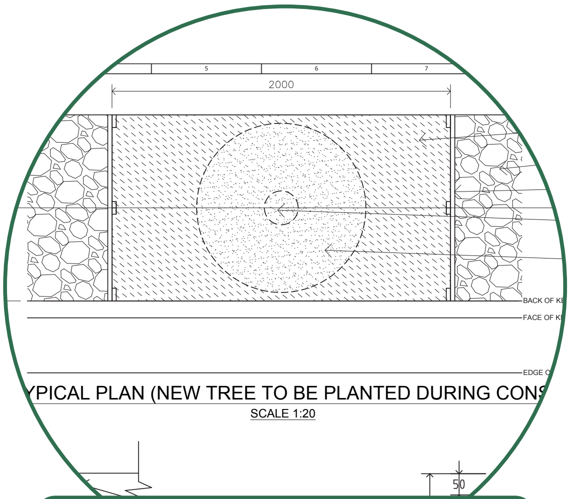
1000mm from top of rootball with two types of imported soil, one with a level of organics (to the top 400mm) and the other with no organics and with light compaction to aid in the rootball settlement (to the bottom 600mm). (CWT use imported soil over site soil due to the poor quality of soils found within the CWT region)

Tree pit width:

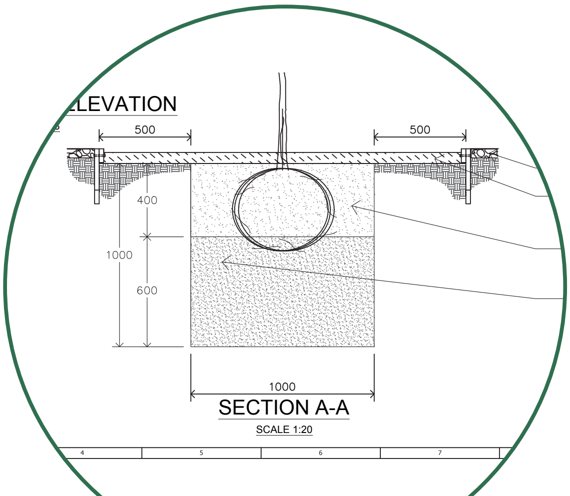
1000mm diameter hole, with 500mm either side mulch garden, total width of mulched zone 2000mm x width of nature strip (typically 1400mm).

Permeable surface: 2.4 m^2 (assumed average nature strip width of 1.2m)

Soil volume: 0.79 m^3



01 Tree Bed Typical Detail: PLAN



01 Tree Bed Typical Detail: SECTION

Council Typical Tree Planting Details Review

02 Tree Bed Typical Detail (for new tree and roadway construction for minimum 1.4m nature strip width):

This detail is applied to new verge and roadway construction.

Tree pit depth:

1000mm from top of rootball with two types of imported soil, one with a level of organics (to the top 400mm) and the other with no organics and with light compaction to aid in the rootball settlement (to the bottom 600mm). (CWT use imported soil over site soil due to the poor quality of soils found within the CWT region).

Tree pit width:

1400mm x 2000mm desired width, with 2500 mulched zone

Permeable surface: 3.5m^2

Soil volume: 2.16 m^3

City of Norwood Payneham and St Peters, Tree Planting in Verge Detail

This detail is applied to all verge plantings, retrofitting existing verge treatments and new verge construction.

Tree pit depth:

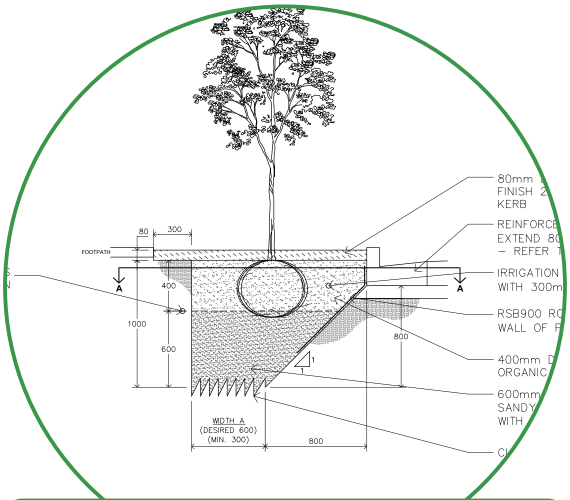
Dependant on depth of rootball. Based on a 75L tree size, the rootball height is 500mm and therefore depth of tree pit is 500mm. It is NPSP's direction to create the planting hole depth to the same height as the rootball. This is to avoid settlement over time and sinking of the rootball. NPSP support the reuse of site soil and backfilling site soil to the tree pit.

Tree pit width (based on an average 1.2m nature strip width) :

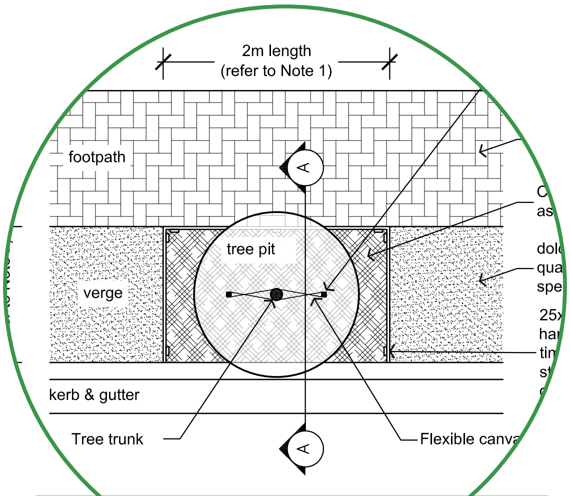
2000mm x 1200mm, excavated pit, back filled with site soil.

Permeable surface: 2.4m^2

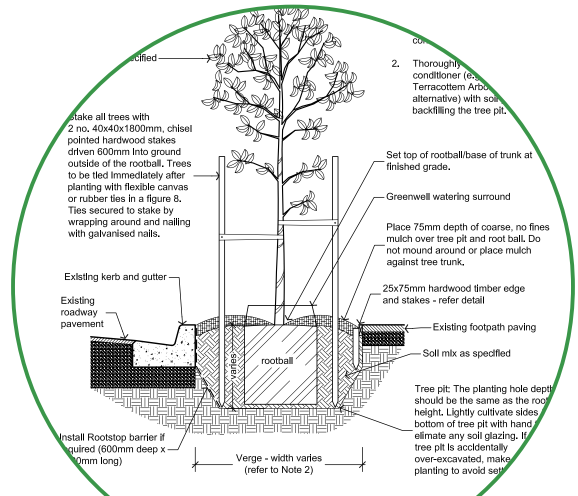
Soil volume: 1.2m^3



02 Tree Bed Typical Detail: SECTION



NPSP Tree Planting in Verge: PLAN



NPSP Tree Planting in Verge: SECTION

Summary of Findings

From our consultation with Councils the following dot points summarise the key findings;

- Permeable paving and passive irrigation are the most common technique used to improve street tree growth
- The most common challenge facing councils when planting street trees is a lack of space within the verge for appropriate tree growth
- The most common consequence of unsuitable tree planting is lifting and damage of surrounding infrastructure
- Almost all Councils have had past conflict with civil infrastructure however the majority stating an average asset renewal cost of less than 25% per annum
- There are inexpensive techniques currently being trialled with City of West Torrens which retrofit damaged infrastructure around established street trees
- Trials within Mount Barker are exploring the use of larger aggregate (ballast) as a form of structural soil to support pedestrian pavements whilst minimising soil compaction for tree root growth
- Standard details shared from Councils provide an average cubic metre soil volume of $1.5m^3$

The above findings will support solutions explored within Volume 2 Design Guidelines.

03. Defining Challenging Spaces

Introduction

This section summarises the challenges our Adelaide Metropolitan Councils are facing when planting new street trees. The key challenges determined by the consultation phase are as follows;

Infrastructure and Space Constraints;

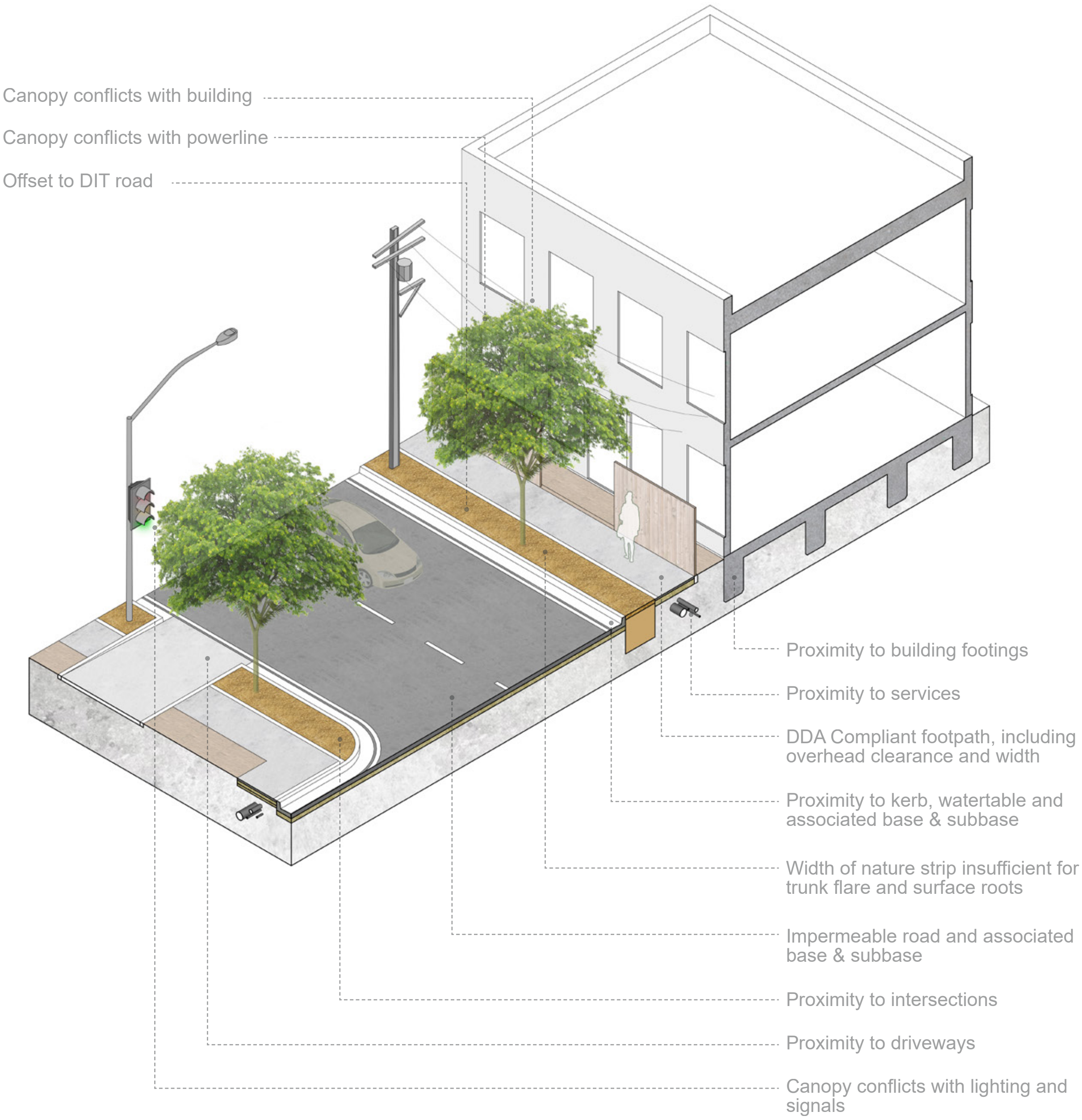
- Narrow Street and Verge
- Increased Building Densities

Tree Growth Requirements and Species Selection

- Soil Volume
- Water Absorption
- Tree Planting Standards
- Appropriate Tree Selection

Infrastructure & Space Constraints

The following section examines common space constraints faced when planting new trees. The below diagram illustrates these constraints as well as represents how challenging it is to achieve healthy street tree planting within the streetscape fabric.



Narrow Streets & Verge

A hierarchy of street types which present parameters for tree planting are defined as follows;

- Main Street
- Local Street
- Laneway

Each street type presents their own parameters for consideration when planting new trees.

Main Street

A main street within a Council region is often a DIT asset and therefore there are parameters set within DIT to be considered.

DIT requires certain offset distances from its roads. The offsets vary depending on the adjacent road layout.

In addition to these road offset requirements, there are also sightline distance requirements to traffic control infrastructure such as street signs and traffic lanterns. These setout specifications can greatly reduce the available street tree planting locations.

The issue of sightline envelopes may be alleviated by the use of traffic lantern outreach arms. This is a solution that requires an integrated multidisciplinary approach across a project and a council intention to prioritise tree inclusion.

Local Street

A local street is a local suburban road primarily with footpaths on either side, and smaller verges.

Current parameters which hinder the future growth as well as installation of tree planting are as follows;

- Minimum offset from back of kerb of 500mm
- Minimum offset from light poles 6m
- Nature strip width varies and can often sit below 1m in width
- Tree selection restrictions with the risk of minimal canopy growth

These parameters can equate to trees being planted in spaces which are too restricted and result in infrastructure damage and poor tree growth.

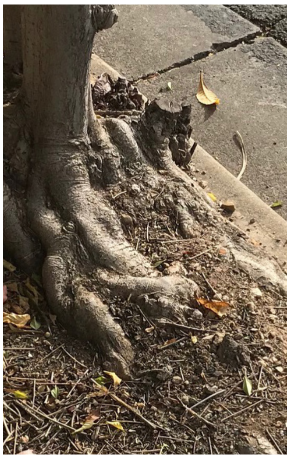
Laneway

A laneway is a narrow road, generally without a verge, often associated with rear access to dwellings or businesses.

Current parameters which hinder the future growth as well as installation of tree planting are as follows;

- narrow road widths mean no verges for adequate tree planting
- costly design solutions often sought and therefore can deter tree planting investment
- car parking within laneways puts further pressure on tree planting and successful outcomes due to conflict with car spaces

These parameters often mean little to no tree planting occurs to laneways.



Increased Building Densities

Typically, tree placement requires a minimum offset from building footings. This minimum offset is generally determined by the mature height of the tree species.

Not enough emphasis is being placed during development on the retention and encouragement of installation of new trees. The current infill development trend is resulting in one allotment being subdivided into two or more houses, and these dwellings are occupying more of the land, leaving little or no space for tree planting. There is reduced area for tree planting in private land, putting greater importance on tree planting to public streetscapes.

In addition to an increase in building densities, there are narrower street corridors and more underground services, driveways and infrastructure. The spaces need to be planned to allow for street tree planting where tree success and larger canopies are built into the desired outcomes for the development.

Utilities Constraints

Utilities refer to the following authorities which require consultation when planting new trees, as conflicts with underground and overhead services are a common occurrence.

- APA (Gas)
- SA Office of Technical Regulator
- SAPN
- SA Water
- Telstra
- NBN

Most of these authorities have developed standards around allowable tree planting within the proximity of their services assets (these are included for reference within the appendices of this document). The increasing density of services assets within streetscapes, and increased expected offset requirements, has led to the decreasing area available for tree planting.

Authority standards for tree planting are in some cases legislated (eg. SA Water and APA). However, given the increasing difficulty to include trees adjacent to existing services, where possible, unlegislated standards should be reviewed on a case by case or project by project basis. As part of any project, the relevant authorities should be contacted and the proposed tree planting locations and details reviewed by relevant parties.

In summary, utilities should be consulted to achieve the following;

- A better outcome for each tree planting scenario.
- An understanding not every offset can be achieved all the time, compromises can be made to suit all parties.

A study is currently being undertaken, led by the City of Adelaide in partnership with Resilient East, reviewing all service requirements and offsets. This document is hoping to be used to find opportunities to work with service providers to ensure the best result and more tree planting.

Soil Volume

As raised within the EPA's *Stormwater Trees Technical Memorandum*, the US EPA recommends certain soil volumes based on the expected fully grown size of the tree species. These categories are divided as follows:

- Small Tree: 17m^3 (600cu ft)
- Medium Tree: 28m^3 (1000 cu ft)
- Large Tree: 42m^3 (1500 cu ft)
- Multiple trees: 2.4m length x 0.9m depth (8ft x 3ft)
- Minimum soil volume per tree: 14m^3 (500 cu ft)

The soil volume calculation method adopted by this study has been sourced from Trees Impact Group (see references) and incorporates calculations from NATSPEC, Australian Standard 2303:2015 and the Field Size Index (FSI).

The formula is as follows:

$$\text{Required Soil Volume (m}^3\text{)} = \frac{\text{Field Size Index (FSI)}}{100}$$

$$\text{FSI} = \text{Height in metres} \times \text{Diameter at Breast Height (DBH) in mm}$$

The above formula represents the 'available' soil volume that a tree should ideally have access to over its lifetime. It is considered that a smaller 'prepared' soil volume is necessary to support healthy, vibrant early establishment growth.

This calculation technique takes into account not only the expected mature size of the tree (as per the USA standard) but also the trunk size (DBH), and is able to be applied to any tree regardless of definition of mature size as small, medium or large.

In addition to the above, further research and review of Fakes Treenet Document *"Planting and Establishment of Trees on Difficult Sites"* finds that a minimum reasonable soil volume within a challenging scenario suggests 7m^3 is more achievable, acknowledging current typical tree planting techniques only reach 1m^3 of soil volume.

If soils are not conductive to healthy tree growth, the volume of soil replacement in association with tree establishment needs to be substantially greater by importing soil or by improving the existing soil.

Tree Growth Requirements and Species Selection

For optimum tree growth requirements trees need the following key inputs;

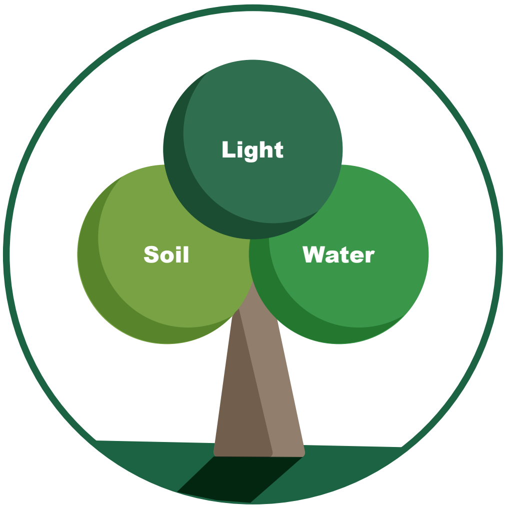
- Appropriate soil volume (varies dependent on tree species)
- Access to water
- Access to natural light
- Access to sufficient nutrients in the soil

In addition to these key inputs, tree health is also affected by:

- Drainage of excess water
- Sufficient space to allow for root taper and trunk flare (SRZ)
- Quality nursery stock supply
- Sufficient space for appropriate canopy growth

Assurance of successful tree planting rely on the following processes;

- Appropriate tree planting details can affect soil volume, space for root taper, water absorption and drainage,
- Specifications will affect quality of nursery stock supply, access to sufficient nutrients, and
- Tree planning and location will affect access to natural light and sufficient space for appropriate canopy growth.



This study focuses on factors that are more easily controllable within a limited space: appropriate soil volume and access to water.

When selecting the tree specimen, use the following table as a guide for the minimum standard and characteristics.

Typical Tree Sizes and Rootball for Street Tree Planting					
SIZE	TRUNK CALIPER	TREE HEIGHT	TREE SPREAD	ROOTBALL DIAMETER	ROOTBALL HEIGHT
45L	15-25mm	1.5-2m	0.6-1m	420mm	350mm
75L	25-35mm	2-2.5m	1m	465mm	500mm
100L	40-50mm	2.5-3.5m	1-2m	520mm	560mm
200L	60-70mm	3.5-4.5m	1.5-3m	700mm	625mm

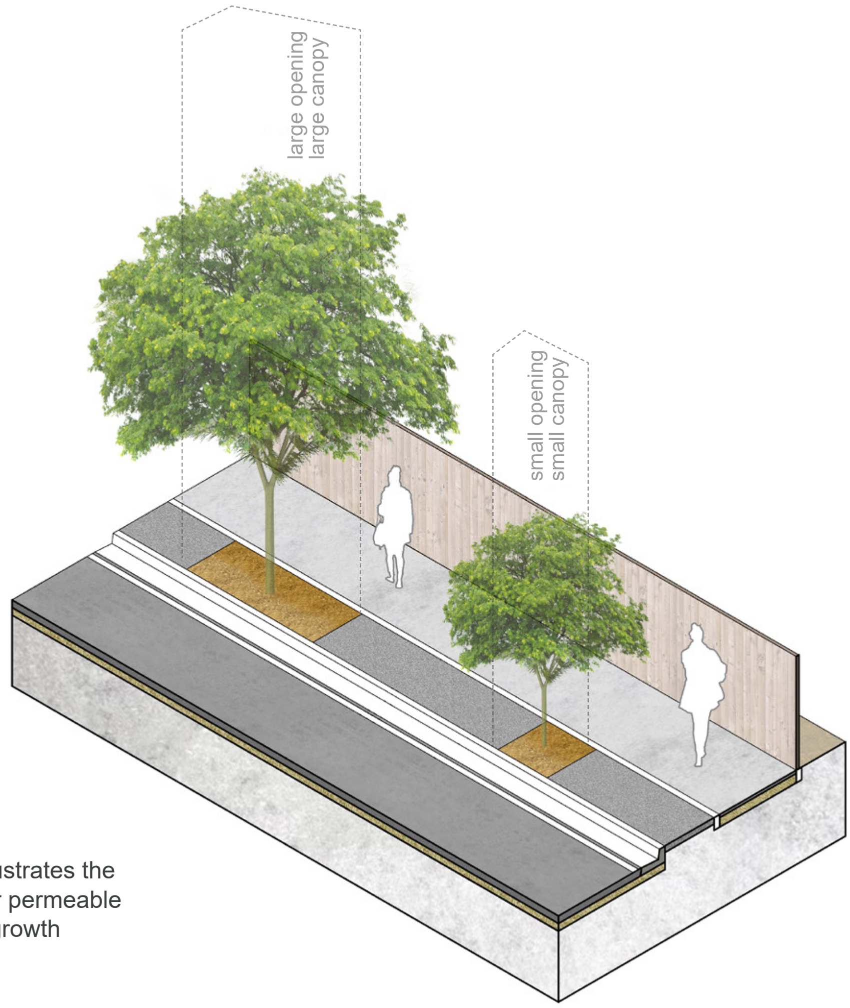
Water Absorption

As density of housing and hard surface infrastructure increases throughout the metropolitan area, access to bare earth / permeable surfaces in which rainfall can permeate to tree roots is reduced.

Not only this, but as hard surfaces increase, so does the heat island affect, which can contribute to increased evapotranspiration and ultimate increased loss in water absorption.

The US EPA recommends that the permeable area at surface level should be 2.2sqm and similarly supported within the Treenet document by Fakes, the surface opening is a recommended minimum of 2m^2 .

As part of this study, various solutions are presented to provide trees with access to water, not only by increasing the availability of water at the surface level, but also by providing additional water sources to tree planting.



This diagram illustrates the effect of a larger permeable surface to tree growth

Standard Tree Planting Detail

This tree planting detail illustrates standard tree planting practice as per the national organisation 'Arboriculture Australia'.

This detail illustrates the following:

Tree pit depth: depth of rootball = depth of tree pit

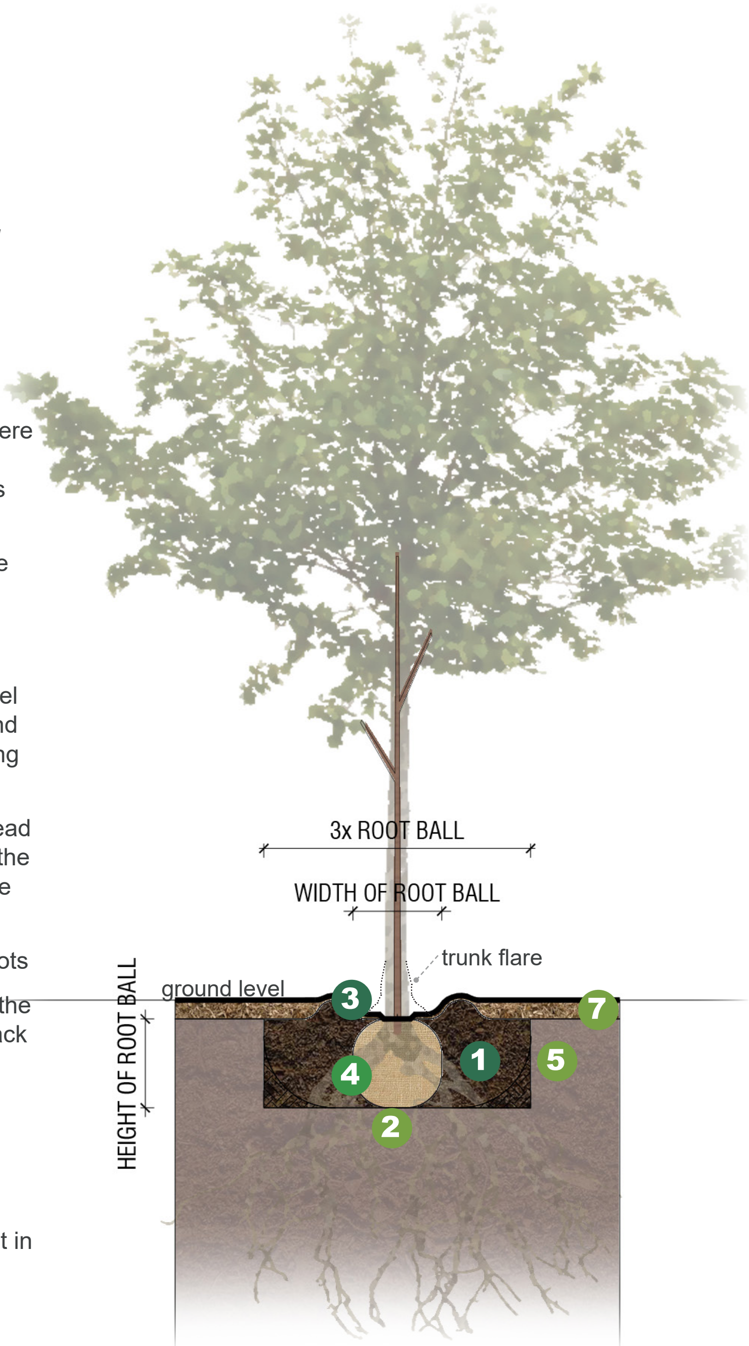
For reference, the adjacent table is per Norwood Payneham and St Peters *'Typical Tree and Rootball Sizes for Street Tree Planting'*

Tree pit width: 3 x width of rootball

Appropriate Tree Planting Technique

As per the Guidelines developed by Arboriculture Australia and the 'National Urban Forest Alliance' there are standard processes which a recommended to follow to aid in the successful planting of a tree. This process is as follows;

1. Dig a bowl-shaped hole at least two to three times wider than the plant's root ball
2. Keep the base of the hole firm and to the maximum depth of the root ball to mitigate settlement of the root ball below ground level – trees planted too deep will grow slowly and develop poorly due to the lack of air reaching the roots
3. Ensure the trunk flare (where the roots spread out from the trunk) is at the finish height of the hole. the potting soil level and the trunk flare must be at ground level.
4. Inspect the root ball for circling/spiralling roots
5. Fill the hole with site soil. Pack soil around the base of the root ball to stabilise it. Firmly pack the soil around the root ball to eliminate air pockets
6. Water whilst backfilling, water once a week while establishing (if not raining) and water during hot dry months
7. Apply mulch to the base of the tree to assist in moisture retention to the tree pit



The above notes from the *'Arboriculture Australia: National Urban Forest Alliance Tree Planting Guide' nufa.com.au*

Tree Selection

Selecting the right tree for the right location is fundamental to the future success of a tree. There are various scales of tree suited to various scales of infrastructure and street type.

As per the research findings, tree species should be selected based on;

- Canopy size and relationship with the scale of the streetscape
- Root growth and required tree pit detail suited to each tree planting scenario
- Soil type and micro-climate

Common species used throughout the Adelaide Metropolitan are shown below, divided into appropriate scale of application;

L

Large Tree - Main Street, wider verges, larger tree pits


Angophora costata


Jacaranda mimosifolia


Zelkova serrata 'Green Vase'


Eucalyptus leucoxylon


Platanus x acerifolia

M

Medium Tree - Local street, mid-size verges, mid-size tree pits


Tristaniopsis laurina


Ginkgo biloba


Corymbia ficifolia


Pyrus calleryana 'Capital'


Ulmus parvifolia

S

Small Tree - Local street/Laneway, smaller verges, smaller tree pits


Lagerstromia indica 'Tuscarora'


Koelreuteria paniculata

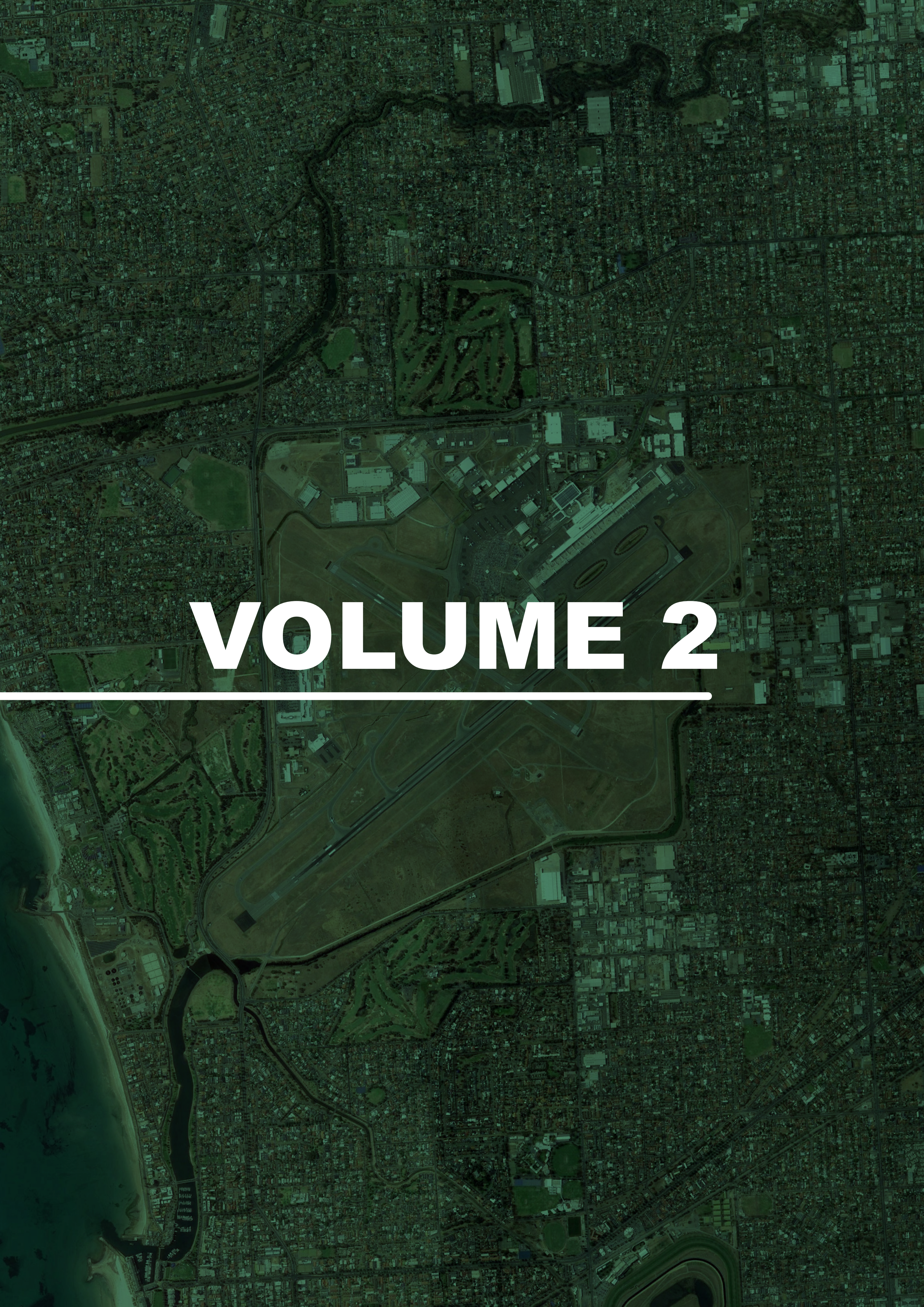

Pistacia chinensis


Sapium sebiferum


Cercis canadensis 'Forest Pansy'

For a comprehensive list of tree species, type, size and recommended tree pit volume refer to the appendix.

VOLUME 2



Design Guidelines

Introduction

The following section outlines the following;

- **Summary of Vol. 1 Key Findings**
- **Guiding Principals**
- **Challenging Scenarios**
- **Illustrated Glossary**
- **Support Infrastructure**
- **Scenarios & Design Solutions**
- **Technical Details**

How to use the Design Guidelines:

Following an assessment of the challenging space, identify street elements that are able to be amended to align with applicable guide documents and design standards.

This guide outlines various solutions that can be applied to these individual elements in order to allow for successful tree planting. Multiple solution details can be combined to create an overall design solution for a given scenario.

Summary of Vol 1. Key Findings

To meet appropriate street tree requirements within challenging streetscape environments, whilst minimising infrastructure damage, the study has found that future design solutions need to address the following points determined from our findings thus far;

Tree Selection:

- Choose tree species which are the right shape and scale for the street type.
- Select the right tree for the right location

Soil Volume:

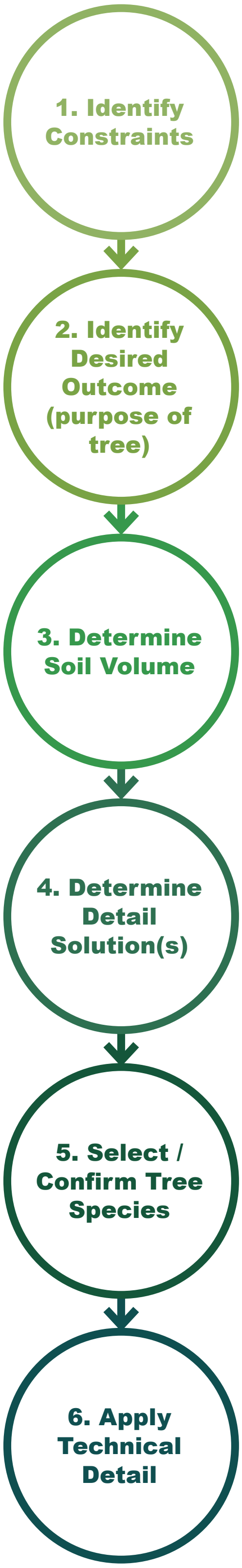
- Understand in situ soil profile and soil type
- A tree needs soil volume for the tree root system to appropriately establish, survive and flourish. 'The roots get the shoots'.
- It is recognised that current street tree planting practices are only achieving an average of 1m3 or less of prepared soil volume per tree.
- An increase in prepared soil volume greater than 1m3 will improve the success of the tree growth and future tree resilience.

Water Absorption:

- A tree requires access to water to establish effectively and survive.
- A recommended surface opening for appropriate water absorption which will improve tree growth is 2.2m2
- Currently permeable paving and passive irrigation are the most common technique used to improve street tree growth amongst Adelaide metropolitan councils.

Street Tree Value:

- The success of grey infrastructure is reliant of the success of green infrastructure
- It is important to determine the economic benefit and return for each tree, ensuring street trees as a valued asset and investment for the future



Guiding Principles

The below guiding principles have been developed following the research and consultation undertaken. These principles summarise the key factors which could lead to not only more successful tree planting outcomes, but also the implementation of more street tree planting.

‘The Roots get the Shoots’

Available soil volume is critical to success of trees. Encouraging root growth will result is thriving tree canopies.

The Right Tree for the Right Location

A better understanding of appropriate tree species and which species are most likely to impact on infrastructure compared to others is crucial when selecting trees.

Happy Trees Happy Infrastructure

Providing the needs of the tree results in reduced impact on surrounding infrastructure. Considered needs include space, oxygen, nutrients and water. If tree needs aren’t met, trees will seek space, water, nutrient elsewhere and by doing so damage infrastructure.

Prioritise Trees

Trees increase street value, civic pride & well being, and can provide financial benefits to residents & council. Street Trees provide landscape amenity, contribute to street & neighbourhood identity, & improve community stewardship. Considering trees as essential street infrastructure & prioritising them in the design & planning process ensures their success in the landscape and an overall benefit to the landscape and community.

Cost Efficient Solutions Maximise Implementation

Council budgets allow for asset renewal, new tree planting and tree maintenance yearly and the cost of standard tree planting needs to be responsive to these budgets. The final details will provide tools to plant trees for a range of budgets, while considering long and short term cost investment.

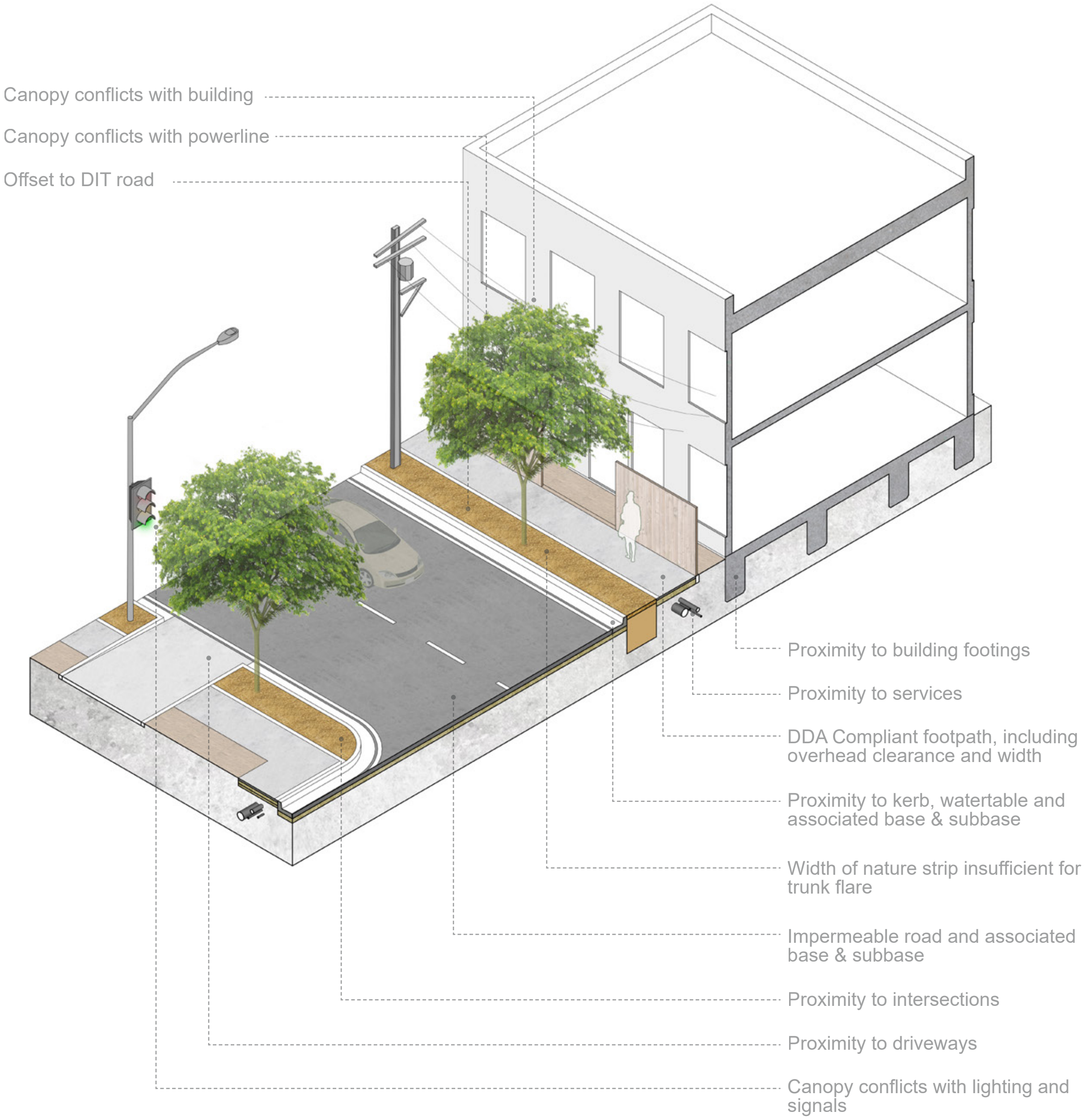
An Integrated Approach

The best outcomes for all can be achieved through equal ownership, engagement and commitment between horticultural, engineering, infrastructure, asset management and other involved disciplines.

Challenging Scenarios

The following diagram illustrates many conflicts that can create or contribute to a challenging scenario for tree planting and subsequent tree growth and health.

Some challenges are able to be addressed through localised details, while others are only able to be addressed through a bigger picture approach to the site, street and wider precinct.



Illustrated Glossary

The following diagram illustrates the terminology used throughout the following document.

Support Infrastructure

There are multiple support 'treatments' and 'infrastructure' to aid in the improvement of ongoing tree health and reduction in infrastructure damage. These treatments are as follows;

- Porous Pavements
- Passive Irrigation
- Soil Infrastructure

Porous Pavements:

Porous pavements allow for water infiltration beyond the edges of the tree pit. It allows for a more trafficable, pedestrian friendly application, whilst encouraging tree root growth downward, away from surrounding infrastructure, minimising uplift of pavements and kerbs. There are currently a range of porous pavement types. These are as follows;

Tree grates

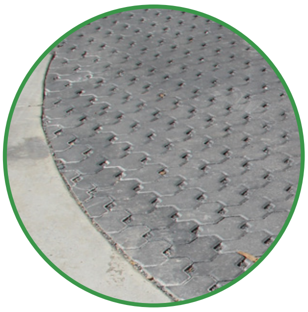
pro: customisable to suit multiple applications, whilst being pedestrian trafficable

con: high cost per unit for material and installation. Typically only used in high amenity and high pedestrian utilisation situations.

Permeable asphalt

pro: seamless surface transition from standard asphalt to porous asphalt

con: emerging product with limited typical industry understanding of the product, which can result in the unjustified perception of excessive cost and risk of blockage when using the product.



Permeable unit paving

pro: can be retrofitted into existing streetscape. Considered to also provide stormwater benefits as well as landscape support. Can be cost competitive to conventional finishes, if detailed appropriately.

con: Lack of typical industry understanding of the product, which can result in the unjustified perception of excessive cost and risk of blockage when using the product.

Compacted quarry sand/fines

pro: inexpensive whilst still providing a somewhat pedestrian trafficable surface

con: not well suited to highly trafficked (pedestrian and / or vehicle) installations due to vulnerability to water damage.

Resin-bound gravel

pro: aesthetic and hard wearing product, more robust and long lasting than compacted sand

con: higher cost finish. Typically only used in high amenity and high pedestrian utilisation situations.
Tree root lift causes an ongoing maintenance issue

Support Infrastructure

Passive Irrigation

Elements which assist in the collection of stormwater to the tree pit are a valuable contribution to tree pit detailing. Passive irrigation is a key contributor to successful tree growth, as well as may help reduce infrastructure damage with the reduced risk of tree roots seeking out water. The following items could be retro fitted to existing kerbs and existing verge infrastructure.

Stormwater inlets

pro: can be retrofitted into any kerb and water table situation

con: relies on street sweeping to assist with efficient operation of the inlet

Ag pipe connections

pro: inexpensive application, whilst encouraging water to penetrate to the rootball

con: requires hand/ manual watering to encourage best outcome

Bio-filtration Raingardens

pro: adaptable design options, which provide the added benefits of stormwater quality improvement, as well as supporting improved urban cooling, biodiversity and greening. Option for sealed system design which completely eliminates moisture impacts on adjacent infrastructure.

con: higher cost installation. Unique design, construction and ongoing maintenance requirements resulting in specialist personnel and processes being required in these areas.

Slotted Kerb / Surface Stormwater Diversion

pro: inexpensive and subtle exercise to direct stormwater into tree beds

con: will require the reconstruction of a kerb or protuberance therefore can be expensive. Difficult to retrofit around existing established landscaping. Can run the risk of compromising landscape through oversaturation and waterlogging of soil profile. Higher risk of moisture impacts on adjacent infrastructure.

Support Infrastructure

Soil Infrastructure

There are items in the market which help stabilise pavements for certain loads - varying from pedestrian to heavy vehicle load bearing - whilst maintaining minimal soil compaction. By minimising soil compaction around the tree root zone, the tree root system can grow without much to hinder adequate root growth. The following elements require implementation at the beginning of a new street planting project, however they can achieve greater volumes of usable soil for tree root growth.

Structural soil

pro: inexpensive whilst minimising compaction and encouraging root growth

con: weight bearing capacity is limited to pedestrian only

Moisture and Root Barrier

pro: minimising root interference with adjacent street and private property infrastructure

con: may have detrimental impacts on long term tree growth. Moderate cost increase to installation.

Ballast growing material

pro: inexpensive whilst minimising compaction and encouraging root growth

con: still in trial, likely to be limited to pedestrian only areas

Soil cells

pro: very effective and proven success for achieving non compacted soils

con: expensive application, therefore unlikely it would be applied to many scenarios as well as limited use under roads

Scenarios & Design Solutions

The following section outlines the key elements that create a challenging scenario;

1. Limited space below ground
2. Limited space above ground
3. Lack of access to water

Multiple design solutions respond to the above challenges and provide options which may best suit individual requirements.

Elements to address space constraints below and above the ground for tree pit and growth:

- Verge
- Parking Lane
- Road Corridor
- Footpath
- Relationship with Services

Elements to address access to water

- Kerb & Watertable
- Surface Treatment
- Other Passive Irrigation

Design Solutions

ELEMENT	DETAIL	
NATURE STRIP	SN1	MINIMUM NATURE STRIP
	SN2	PREFERRED NATURE STRIP
	SN3	TREE TRENCH
PARKING LANE	SP1	PROTUBERANCE
	SP2	PLANTING BED
ROADWAY	SR1	SLOW POINT
	SR2	STRUCTURAL SOIL
FOOTPATH	SF1	INDENTED TREE PIT
	SF2	STRUCTURAL SOIL
	SF3	SOIL CELL
SOLUTIONS FOR ACCESS TO WATER		
KERB & WATER TABLE	WK1	SLOTTED KERB
	WK2	LEAKY WELL
SURFACE TREATMENT	WS1	PERMEABLE PAVING
	WS2	TREE GRATE
PASSIVE IRRIGATION	WP1	RAINGARDEN
	WP2	AG PIPE CONNECTION

KEY:

Easy to retrofit detail

S Detail suitable for small trees

M Detail suitable for medium trees

L Detail suitable for large trees

Notes for design solutions:

Tree pit excavation depth
Site soil conditions will determine depth of tree pit excavation.

Where existing site soil is of a suitable structure, tree pit is to be excavated only to depth of root ball.

Where existing site soil is of an unsuitable structure, tree pit is to be excavated to a depth of 1m and lightly compacted below root ball.

Soils
Retaining site soil is preferable where existing soils are suitable within tree pit.

Where soils are unsuitable for tree planting, imported soil is to be installed within tree pit.

Typical Footpath width (measured obstruction to obstruction):

Preferred width:	1350mm
Min. Width for length of <2m:	900mm
Min. Width for length of >2m:	1000mm

Soil Volume
While many of these details do not meet the guidelines discussed in the research document (i.e optimal soil volume), they represent vast improvement over the current practices while remaining achievable.

Applications

POTENTIAL APPLICATIONS OF DESIGN SOLUTIONS TO CHALLENGING SCENARIOS

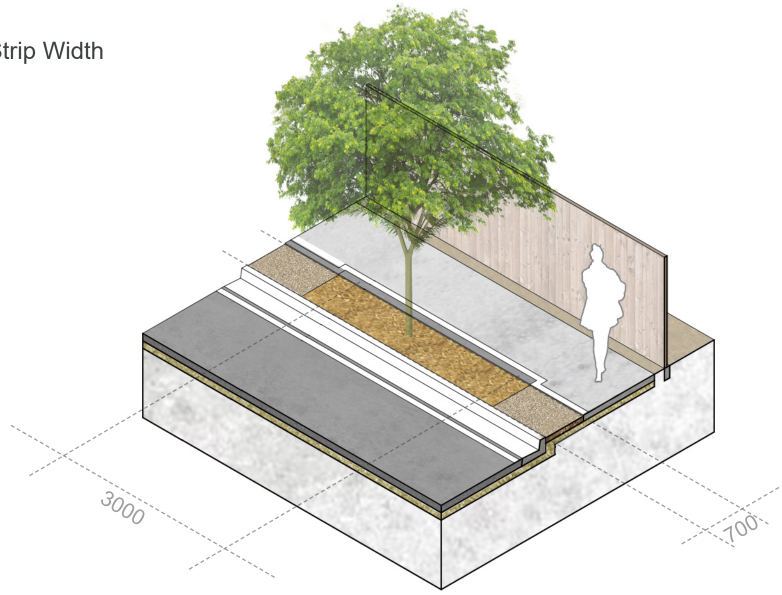
	MINIMUM NATURE STRIP	PREFERRED NATURE STRIP	TREE TRENCH	PROTUBERANCE	PLANTING BED	SLOW POINT	STRUCTURAL SOIL	INDENTED TREE PIT	STRUCTURAL SOIL	SOIL CELL	SLOTTED KERB	LEAKY WELL	PERMEABLE PAVING	TREE GRATE	RAINGARDEN	AG PIPE CONNECTION
CHALLENGING SCENARIO	**SN1**	**SN2**	**SN3**	**SP1**	**SP2**	**SR1**	**SR2**	**SF1**	**SF2**	**SF3**	**WK1**	**WK2**	**WS1**	**WS2**	**WP1**	**WP2**
Canopy conflicts with building		●		●	●	●										
Canopy conflicts with powerline	●	●		●	●	●			●	●						
Offset to DIT road		●	●		●			●								
Proximity to building footings		●		●	●	●										
Proximity to services		●			●	●		●								
DDA Compliant footpath, including overhead clearance and width	●	●	●	●	●	●	●	●	●	●						
Proximity to kerb, watertable and associated base & subbase	●	●	●	●	●	●	●	●	●	●						
Width of nature strip insufficient for trunk flare		●		●	●	●		●	●	●						
Impermeable road and associated base & subbase							●		●	●			●			
Proximity to intersections					●			●								
Proximity to driveways					●	●		●								
Canopy conflicts with lighting and signals		●														
Access to Surface Water			●										●	●		
Additional Water Intake				●		●					●	●			●	●

Detail Solution SN1

Solutions for space constraints:

Nature Strip:

SN1: Minimum Nature Strip Width



Pros:

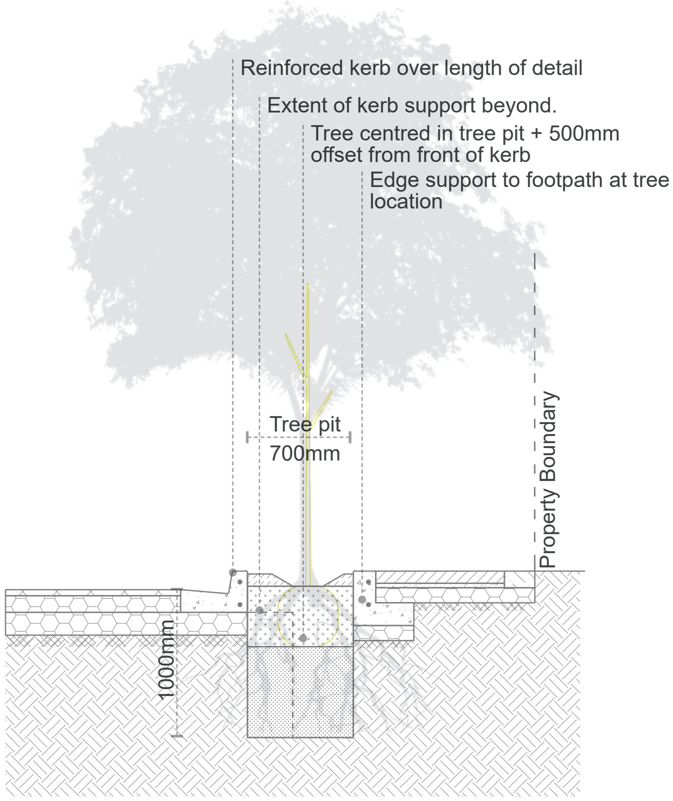
- Minimal Nature Strip width
- Sufficient kerb and footpath support
- Sufficient permeable area per tree
- Retains opportunity for uncompromised footpath width

Cons:

- Reinforcing to kerb adds cost and time
- Footpath edge detail adds cost and time
- Limited offset from adjacent properties

Suitable Applications:

- Laneways and very narrow streets
- Unsuitable for DIT roads or streets with high volumes of traffic or heavy vehicle traffic anticipated close to road edge



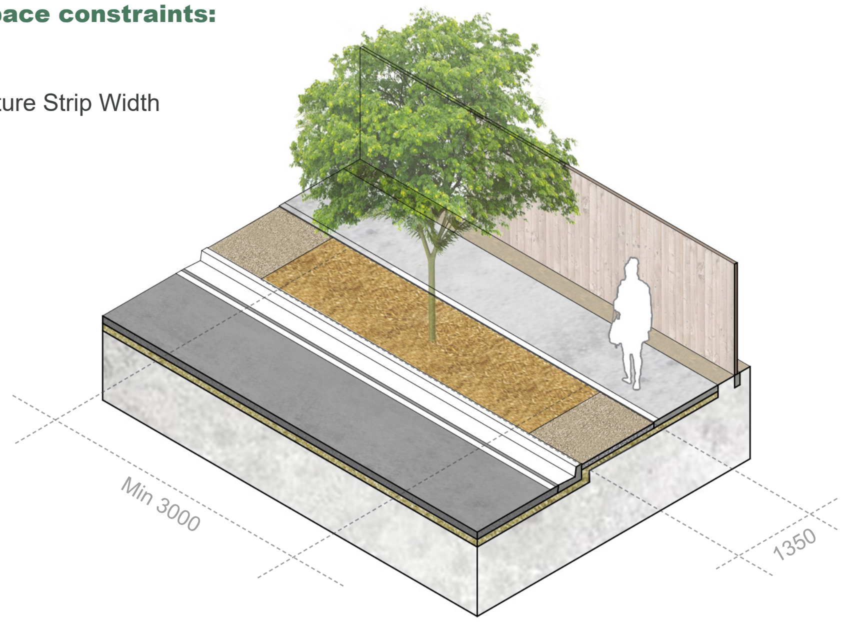
Section Detail
1:50 @ A4
Soil Volume Achieved: 1.6m3
Permeable Surface: 2.1m2

Detail Solution SN2

Solutions for space constraints:

Nature Strip:

SN2: Preferred Nature Strip Width



Pros:

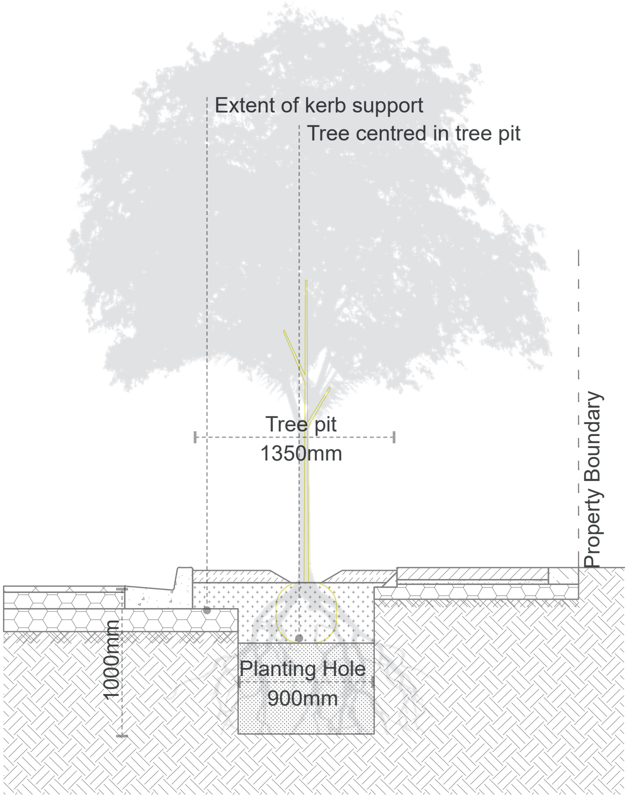
- Easy install nature strip
- Sufficient kerb and footpath support
- Sufficient permeable area per tree

Cons:

- Larger area of excavation than traditional tree pit
- Requires sufficient street width

Suitable Application:

- General streets



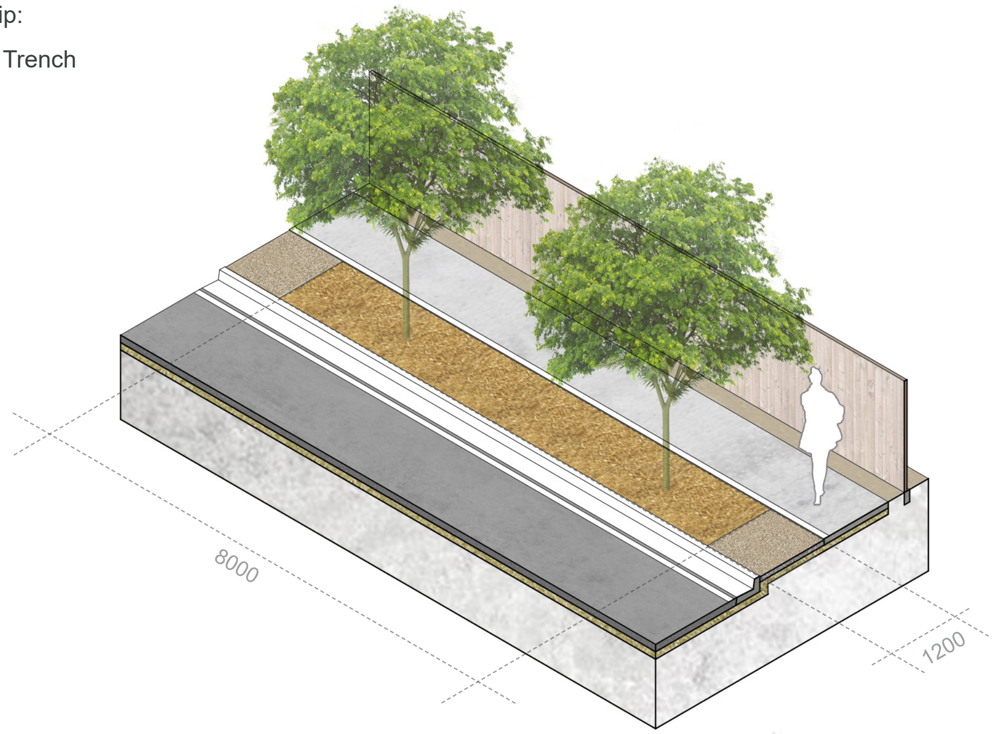
Section Detail
1:50 @ A4
Soil Volume Achieved: 2.83m3+
Permeable Surface: 4.86m2+

Detail Solution SN3

Solutions for space constraints:

Nature Strip:

SN3: Tree Trench



Pros:

- Minimal Nature Strip width
- Sufficient kerb and footpath support
- Sufficient permeable area per tree
- Shared nature strip equates to larger soil volume per tree
- Trafficable surface along street
- Retains uncompromised footpath width

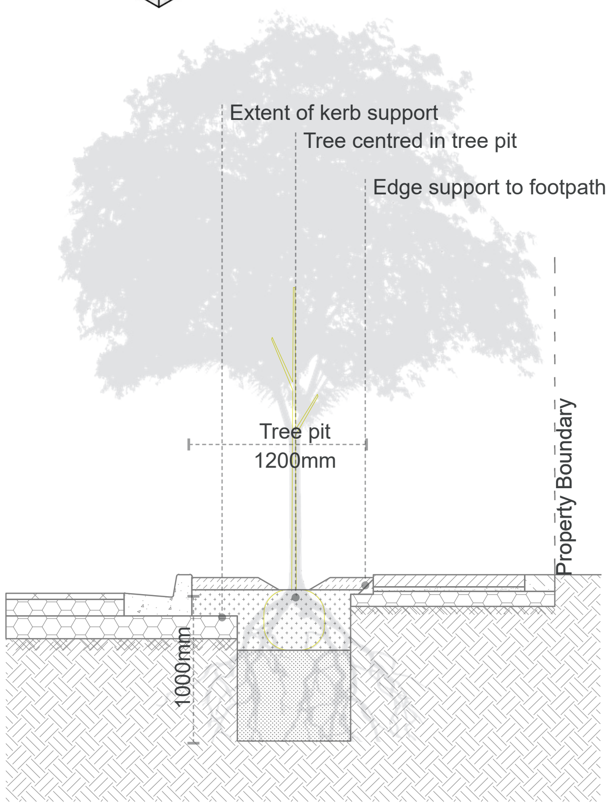
Cons:

- Compacted soil beneath sand less suitable for trees
- Increased cost due to excavation and materials

Suitable Application:

- Laneways and narrow streets

S M L



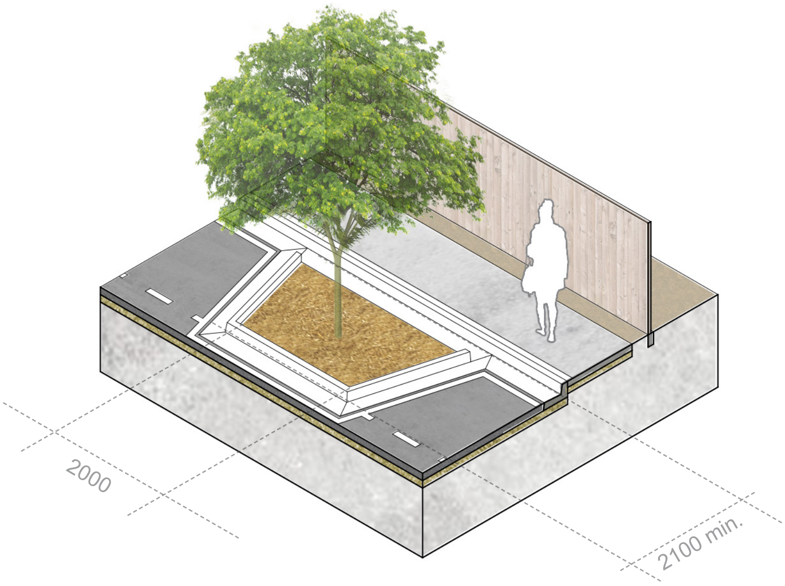
Section Detail
1:50 @ A4
Soil Volume Achieved: 5.9m3
Permeable Surface: 9.6m2

Detail Solution SP1

Solutions for space constraints:

Parking Lane:

SP1: Protuberance



Pros:

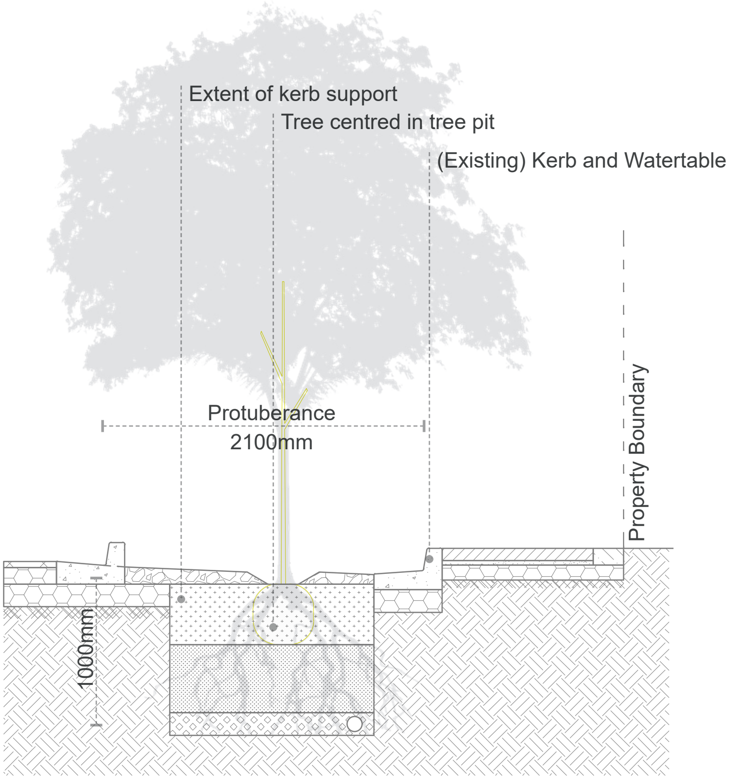
- Opportunity for passive irrigation
- Sufficient permeable area per tree
- No change to pedestrian circulation
- Increased tree offset from buildings and adjacent properties
- Potential traffic calming benefits

Cons:

- Can impact on parking numbers
- Significant change to street layout

Suitable Application:

- Streets with existing parking lane



Section Detail

1:50 @ A4

Soil Volume Achieved: 2.7m3

Permeable Surface: 4.1m2

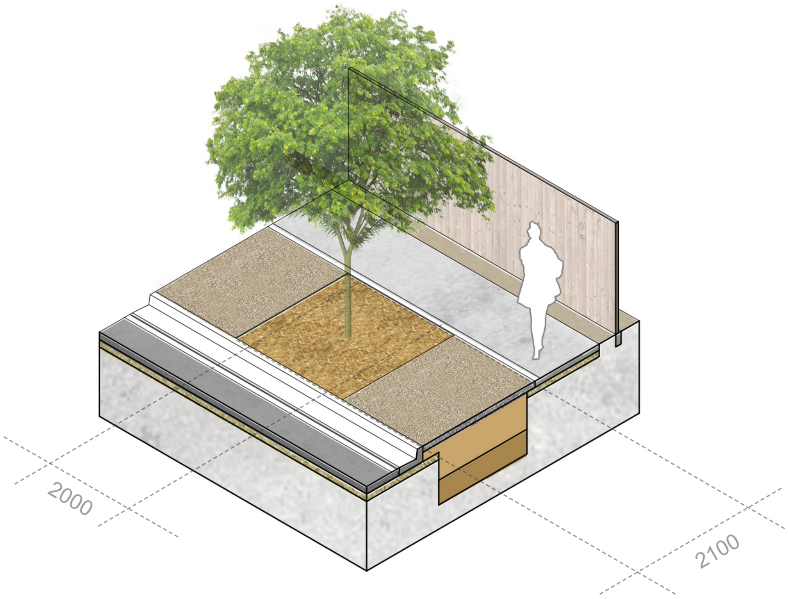
S M L

Detail Solution SP2

Solutions for space constraints:

Road Narrowing or Parking Lane Removal:

SP2: Planting Bed



Pros:

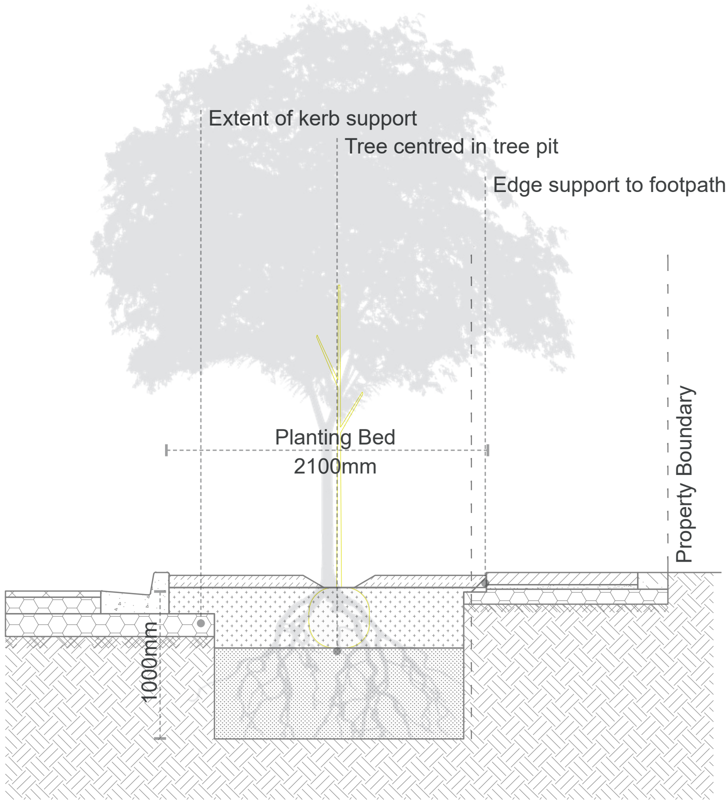
- Large nature strip width
- Opportunity for supplementary garden bed planting
- Sufficient permeable area per tree
- Increased tree offset from buildings and adjacent properties
- Sufficient room for trunk flare growth

Cons:

- Could result in reduced parking
- Substantial change to road cross section - scale of work

Suitable Application:

- Wide streets
- Areas where parking can be reduced



Section Detail
1:50 @ A4
Soil Volume Achieved: 3.4m3
Permeable Surface: 4.2m2

Detail Solution SR1

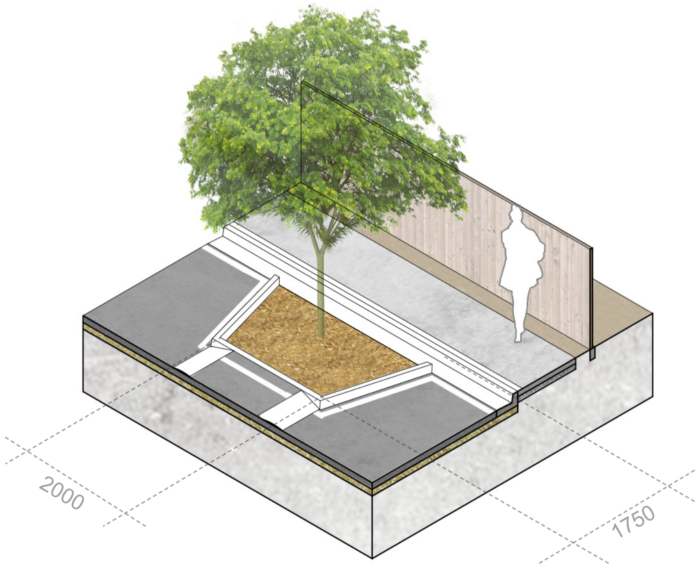
Solutions for space constraints:

Roadway:

SR1: Slow Point

Pros:

- Large soil volume
- Sufficient kerb and footpath support
- Sufficient permeable area per tree
- Retains uncompromised footpath width

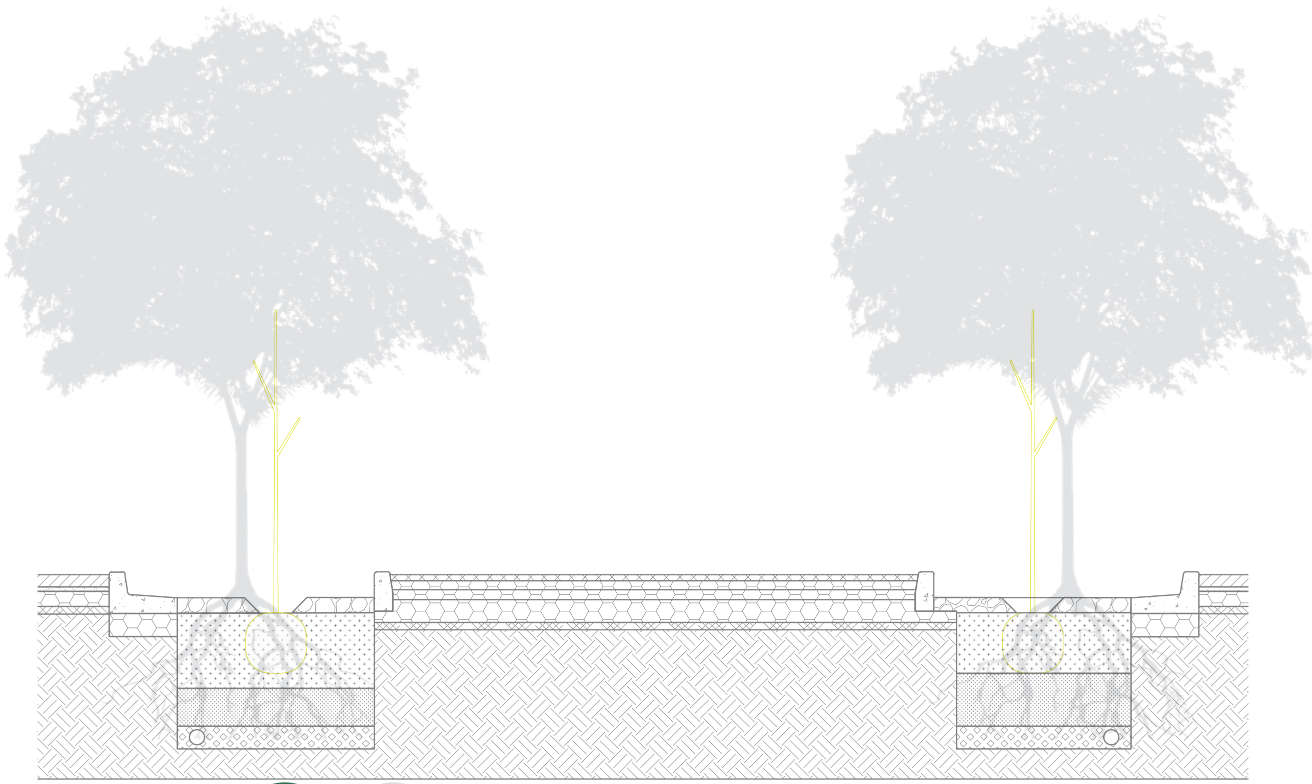


Cons:

- Can impact on parking numbers
- Significant change to street layout

Suitable Application:

- Streets with existing parking lane



S M L

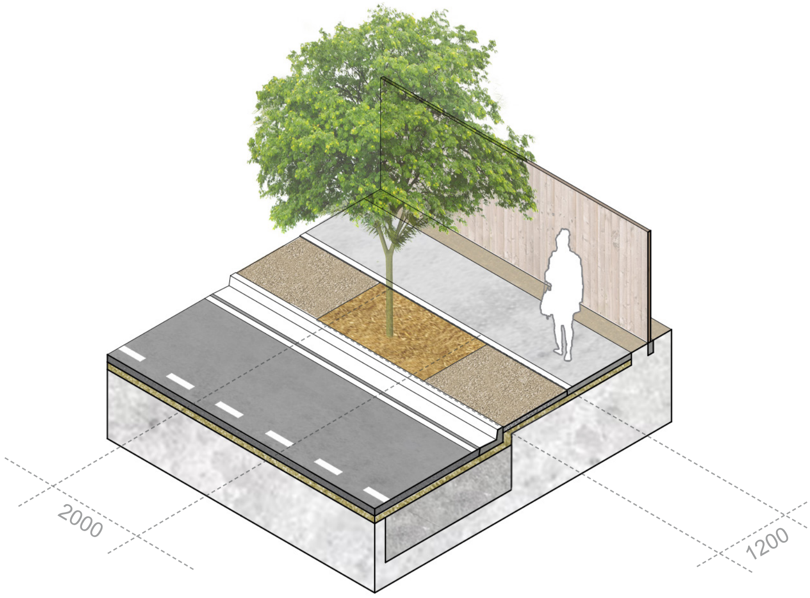
Section Detail
1:50 @ A4
Soil Volume Achieved: 3.29m3
Permeable Surface: 4.38m2

Detail Solution SR2

Solutions for space constraints:

Roadway:

SR2: Structural Soil



Pros:

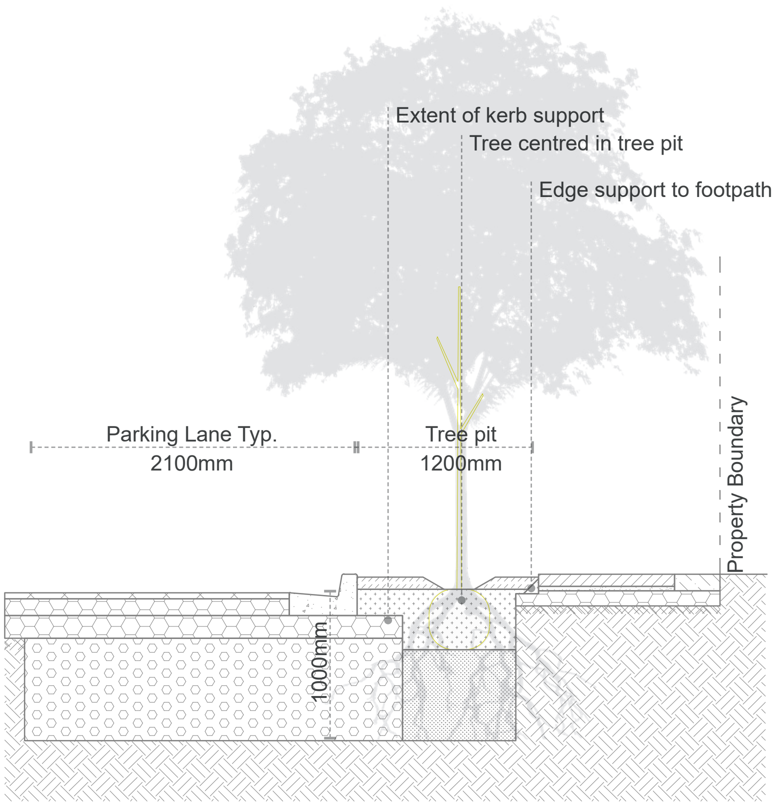
- Large soil volume
- Sufficient kerb and footpath support
- Sufficient permeable area per tree
- Retains uncompromised footpath width

Cons:

- Structural soil and additional excavation adds cost

Suitable Application:

- Streets with parking lanes



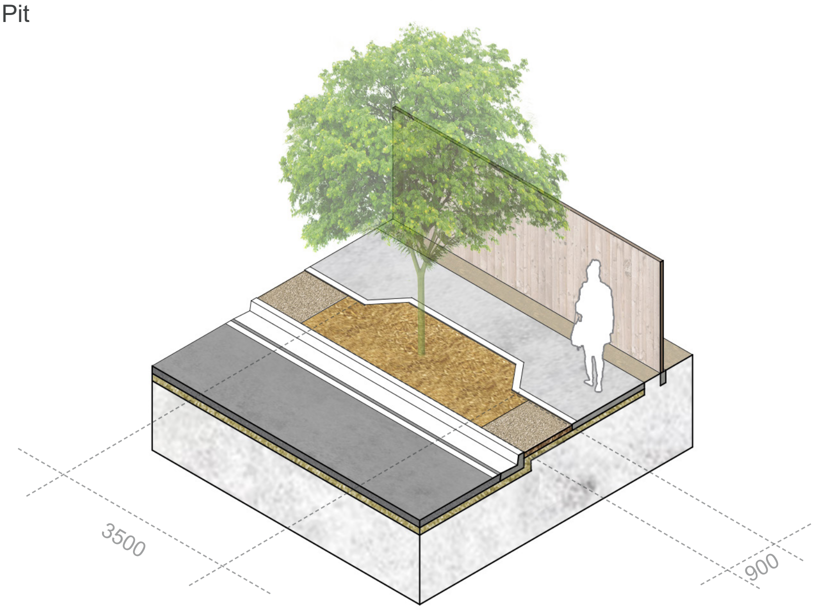
Section Detail
1:50 @ A4
Soil Volume Achieved: 5m3
Permeable Surface: 2.4m2

Detail Solution SF1

Solutions for space constraints:

Footpath:

SF1: Indented Tree Pit



Pros:

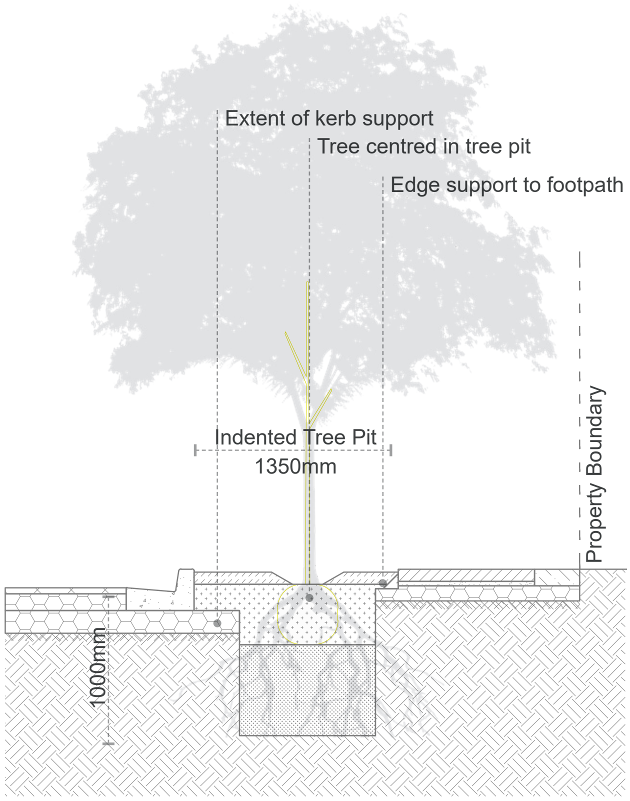
- Minimal nature strip width
- Sufficient permeable area per tree
- Potential for combination with permeable paving

Cons:

- Reduced footpath width
- Non-standard excavation layout

Suitable Application:

- Low pedestrian volume streets



Section Detail
1:50 @ A4
Soil Volume Achieved: 2.8m3
Permeable Surface: 4.2m2

S M L

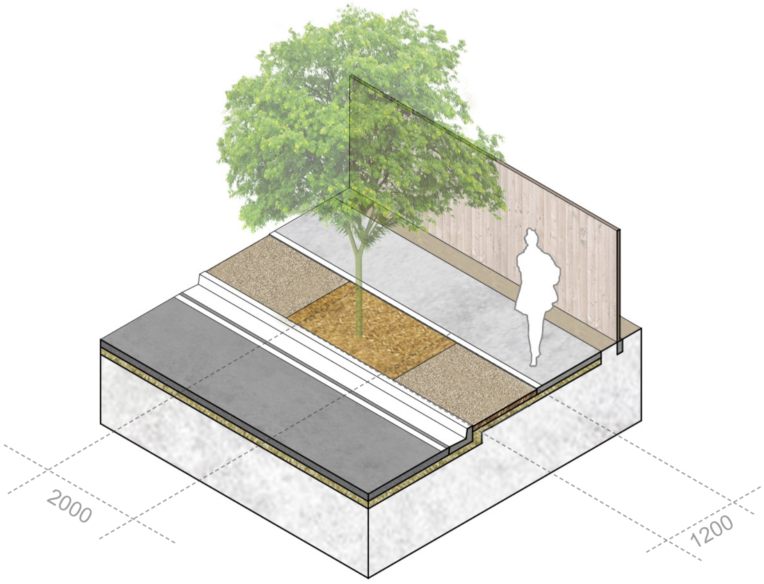
Detail Solution SF2

NOTE: Structural soil should be offset 300mm minimum from adjoining properties. Further investigation should be undertaken where nearby structures exist or are proposed.

Solutions for space constraints:

Footpath:

SF2: Structural Soil



Pros:

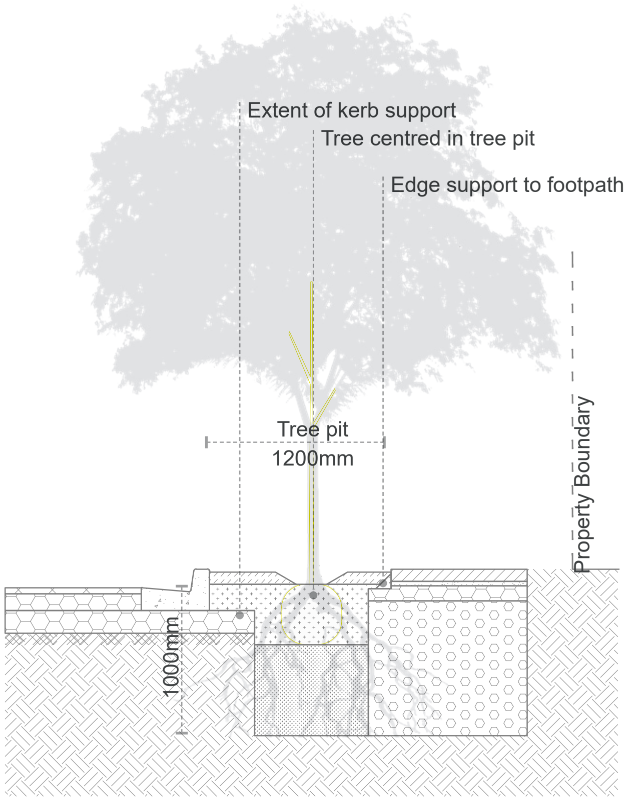
- Minimal Nature Strip width
- Sufficient kerb and footpath support
- Sufficient permeable area per tree
- Larger soil volume per tree

Cons:

- Structural soil and excavation adds cost
- Less available volume than loose soil
- Difficult to retrofit

Suitable Application:

- Pedestrian only footpaths



Section Detail
1:50 @ A4
Soil Volume Achieved: 4m3
Permeable Surface: 2.4m2

S M L

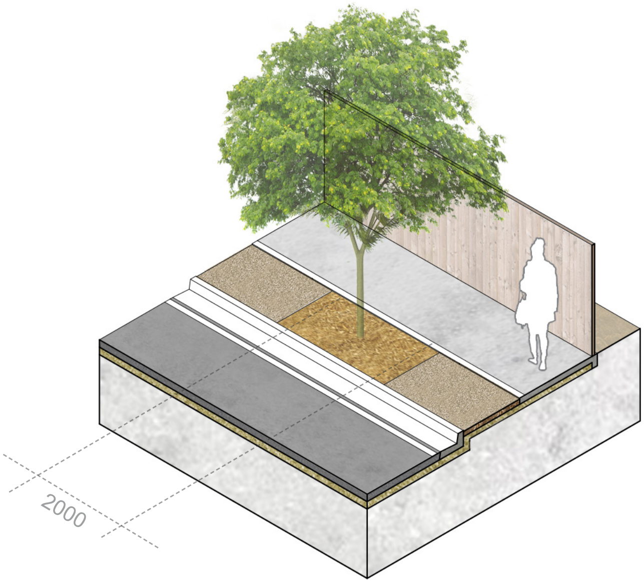
Detail Solution SF3

NOTE: Soil cells should be offset 300mm minimum from adjoining properties. Further investigation should be undertaken where nearby structures exist or are proposed.

Solutions for space constraints:

Footpath:

SF3: Soil Cell



Pros:

- Minimal Nature Strip width
- Sufficient kerb and footpath support
- Sufficient permeable area per tree
- Larger soil volume per tree

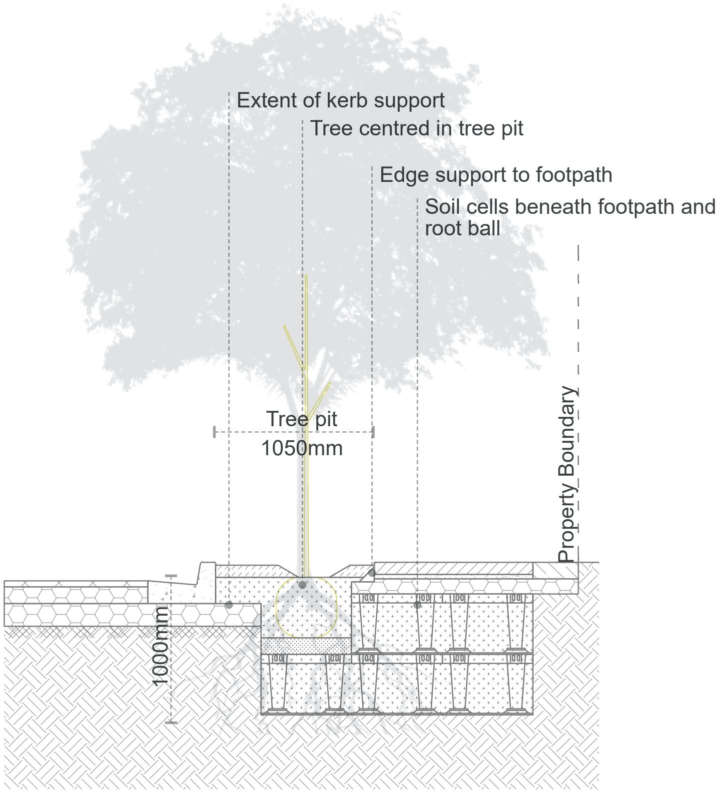
Cons:

- Soil cell and excavation adds cost
- Less available volume than loose soil
- Difficult to retrofit

Suitable Application:

- Pedestrian only footpaths

S M L



Section Detail

1:50 @ A4

Soil Volume Achieved: 3.1m3

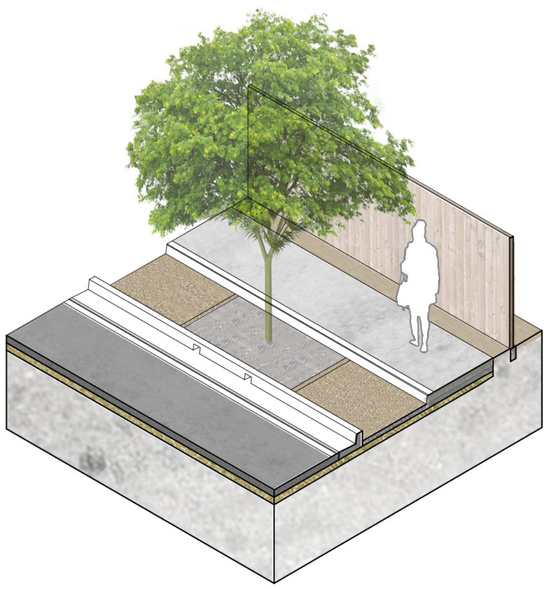
Permeable Surface: 2.1m2

Detail Solution WK1

Solutions for access to water:

Kerb & Watertable:

WK1: Slotted Kerb



Pros:

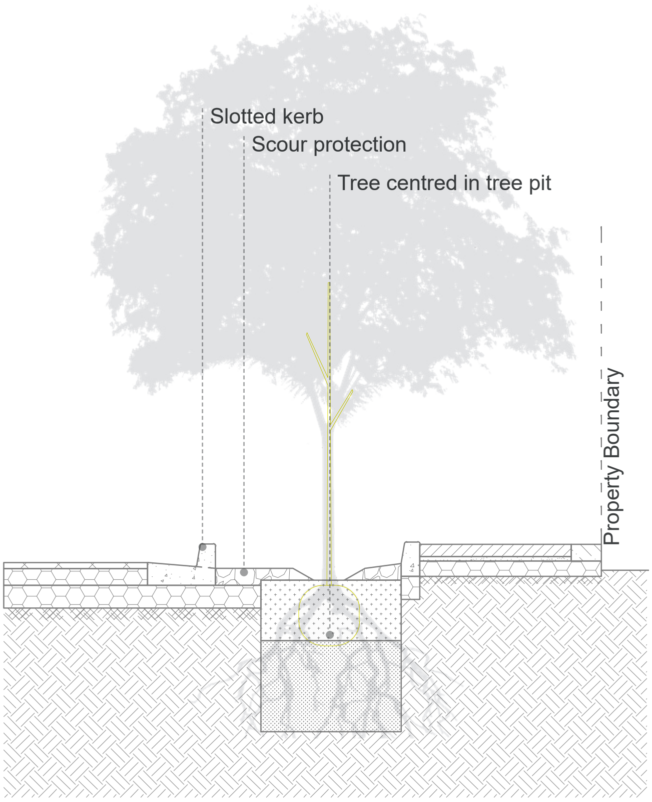
- Low cost to retrofit where suitable

Cons:

- Tree bed unable to detain water - infiltration during flow events only.
- Increased potential for moisture inundation to infrastructure
- Potential for soil volume around tree to become waterlogged during prolong wet periods, leading to compromised tree health

Suitable Application:

- All



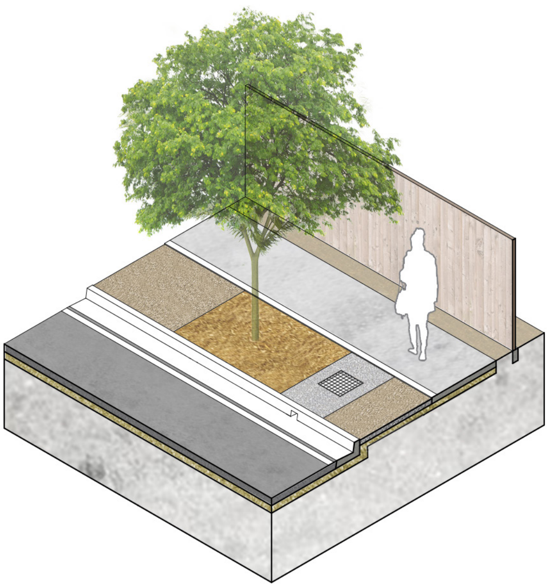
Section Detail
1:50 @ A4
Infiltration Area: Varies with Detail
Additional Catchment: Road Runoff

Detail Solution WK2

Solutions for access to water:

Kerb & Watertable:

WK2: Leaky Well



Pros:

- Minimal Nature Strip width
- Suitable for retrofit
- Sufficient permeable area per tree
- Infiltration pit provides water detention
- Low comparative cost per installation

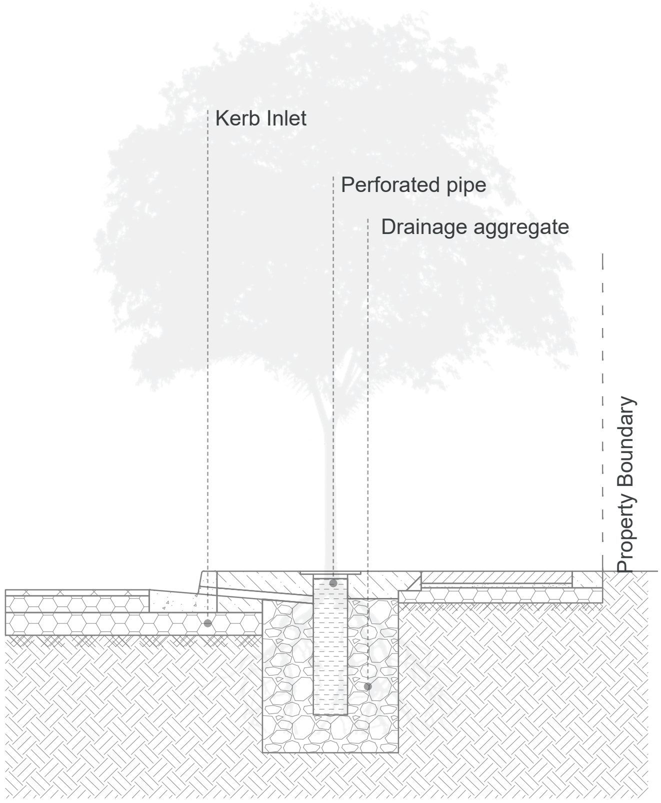
Cons:

- Relies on street sweepers and hand clearing maintenance for efficient operation

Suitable Application:

- Most situations

S M L



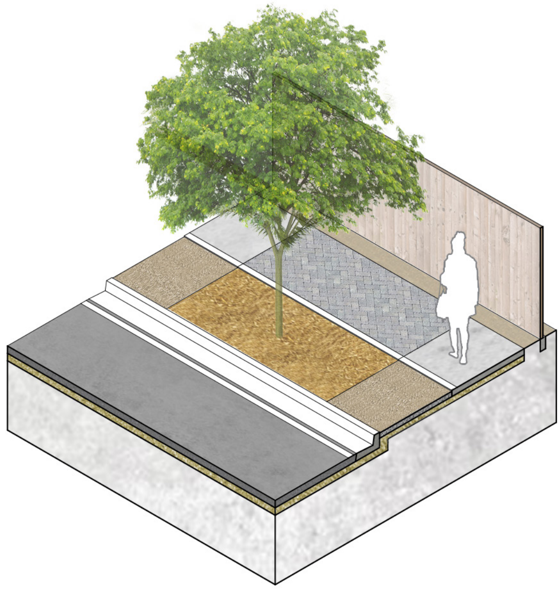
Section Detail
1:50 @ A4
Infiltration Area: Varies with Detail
Additional Catchment: Road Runoff

Detail Solution WS1

Solutions for access to water:

Surface Treatment:

WS1: Permeable Paving



Pros:

- Reduces root development directly below footpath and hence reduces ongoing potential for future footpath damage from tree roots
- Minimal nature strip width
- Makes more secondary soil volume available
- Large permeable area per tree
- Minimal additional cost

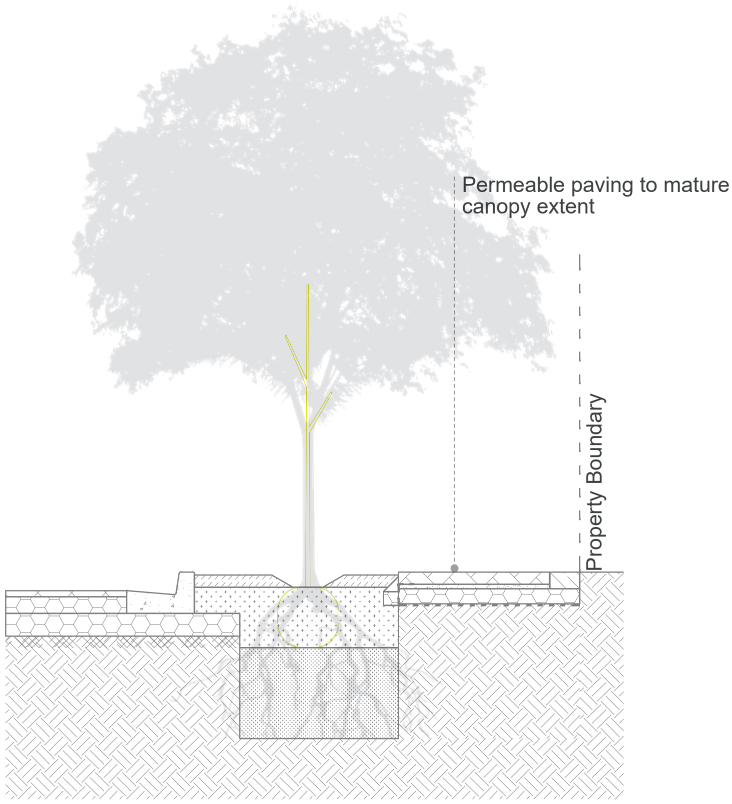
Cons:

- Due to the current low utilisation of this product within the market, there is the necessity to seek suitably qualified designers and contractors to get quality and efficient outcomes

Suitable Application:

- New tree planting

S M L



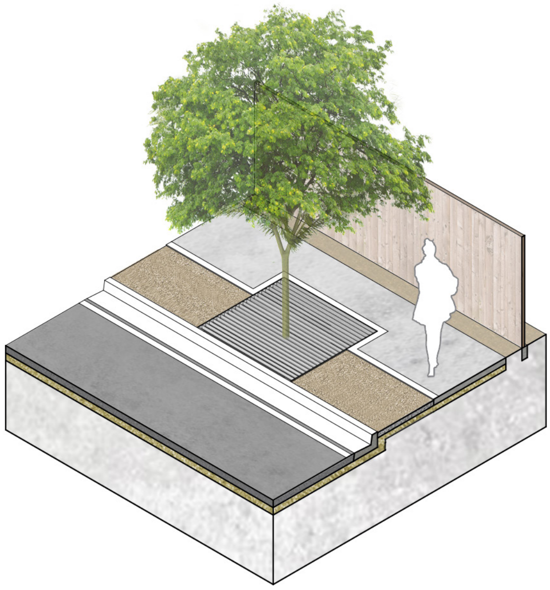
Section Detail
1:50 @ A4
Infiltration Area: Additional 1.8m2+
Additional Catchment: Footpath

Detail Solution WS2

Solutions for access to water:

Surface Treatment:

WS2: Tree Grate



Pros:

- Minimal nature strip width
- Sufficient circulation space around tree
- Sufficient permeable area per tree

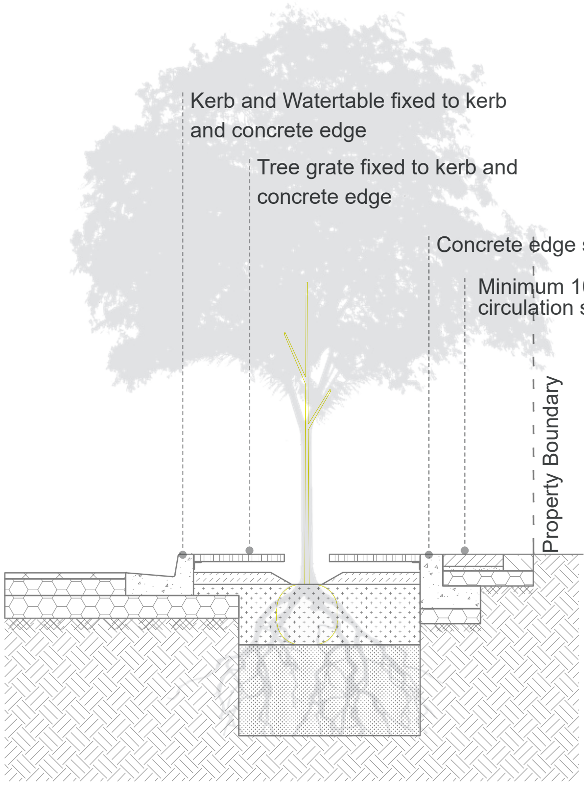
Cons:

- Small primary soil volume achieved
- Increased cost for concrete support and tree grate

Suitable Application:

- High pedestrian traffic, high amenity situations, very narrow streets

S M L



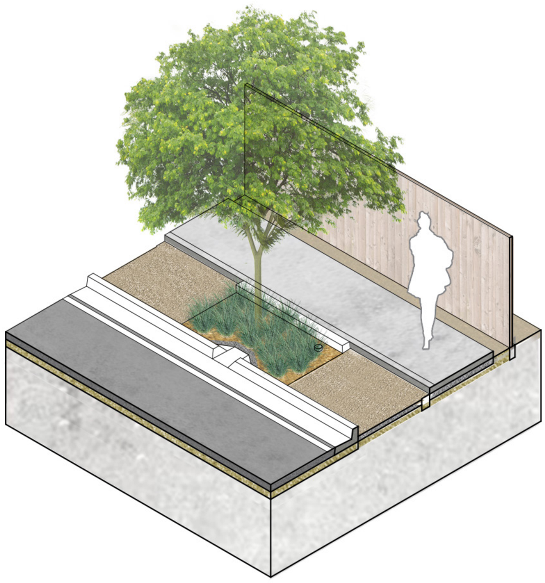
Section Detail
1:50 @ A4
Infiltration Area: 2.25m2+
Additional Catchment: N/A

Detail Solution WP1

Solutions for access to water:

Passive Irrigation:

WP1: Raingarden



Pros:

- Large volume of water passing through for passive irrigation and nutrient supply
- Multiple benefits including stormwater quality and quantity, increase growth and viability of vegetation, increased urban cooling through increased water cycle
- Scalable and can be used in close proximity to sensitive infrastructure

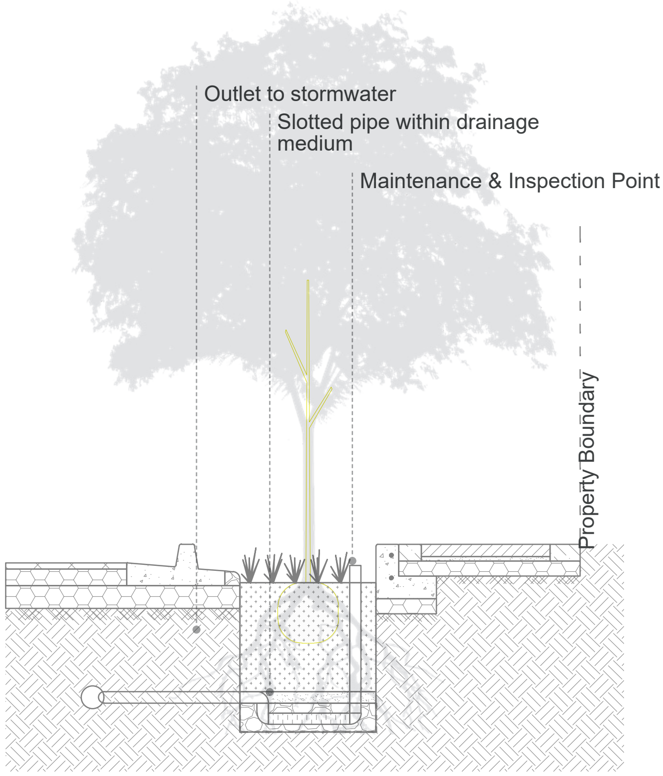
Cons:

- Limitations in the vegetation which can be utilised within a Raingarden
- High cost installation
- Requires provision of underground stormwater drainage along the street where technique is to be utilised
- Requires experienced skillset in design, construction and maintenance to achieve best results

Suitable Application:

- Wide streets, medium pedestrian traffic

S M L



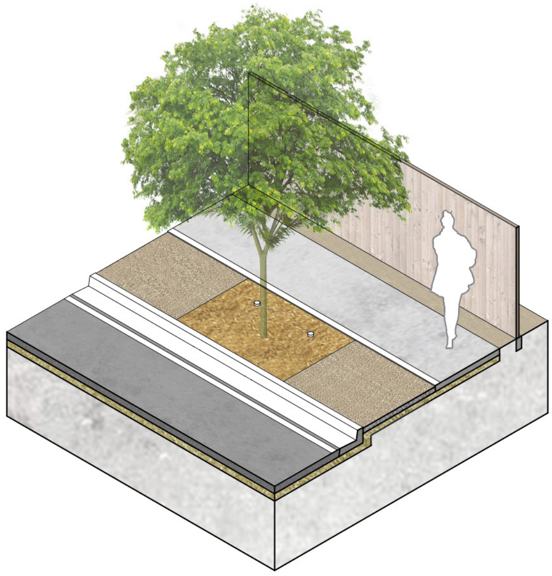
Section Detail
1:50 @ A4
Infiltration Area: Varies with Detail
Additional Catchment: Road Runoff

Detail Solution WP2

Solutions for access to water:

Passive Irrigation:

WP2: Ag Pipe Connection



Pros:

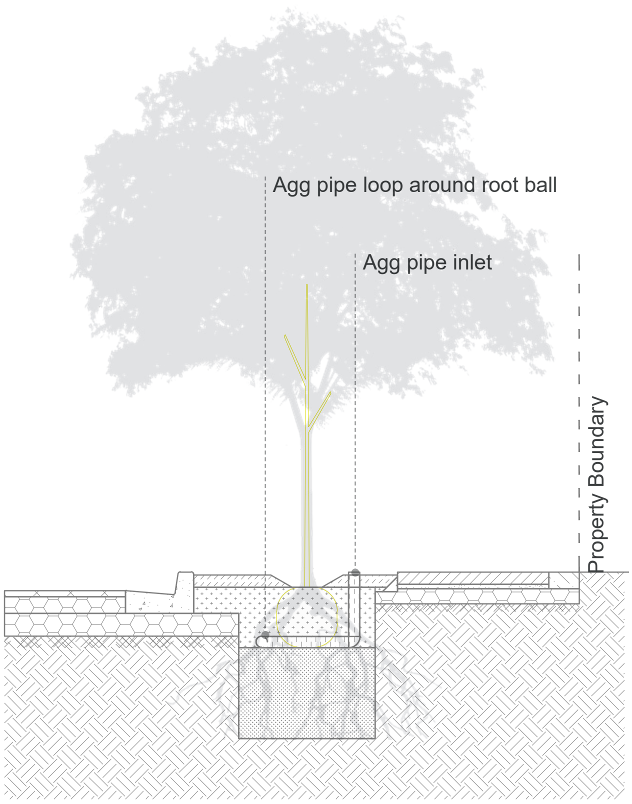
- Easier application of water
- Low cost installation

Cons:

- Requires hand / manual irrigation

Suitable Application:

- All or any trees



Section Detail
1:50 @ A4
Infiltration Area: Varies with Detail
Additional Catchment: Per Watering Schedule

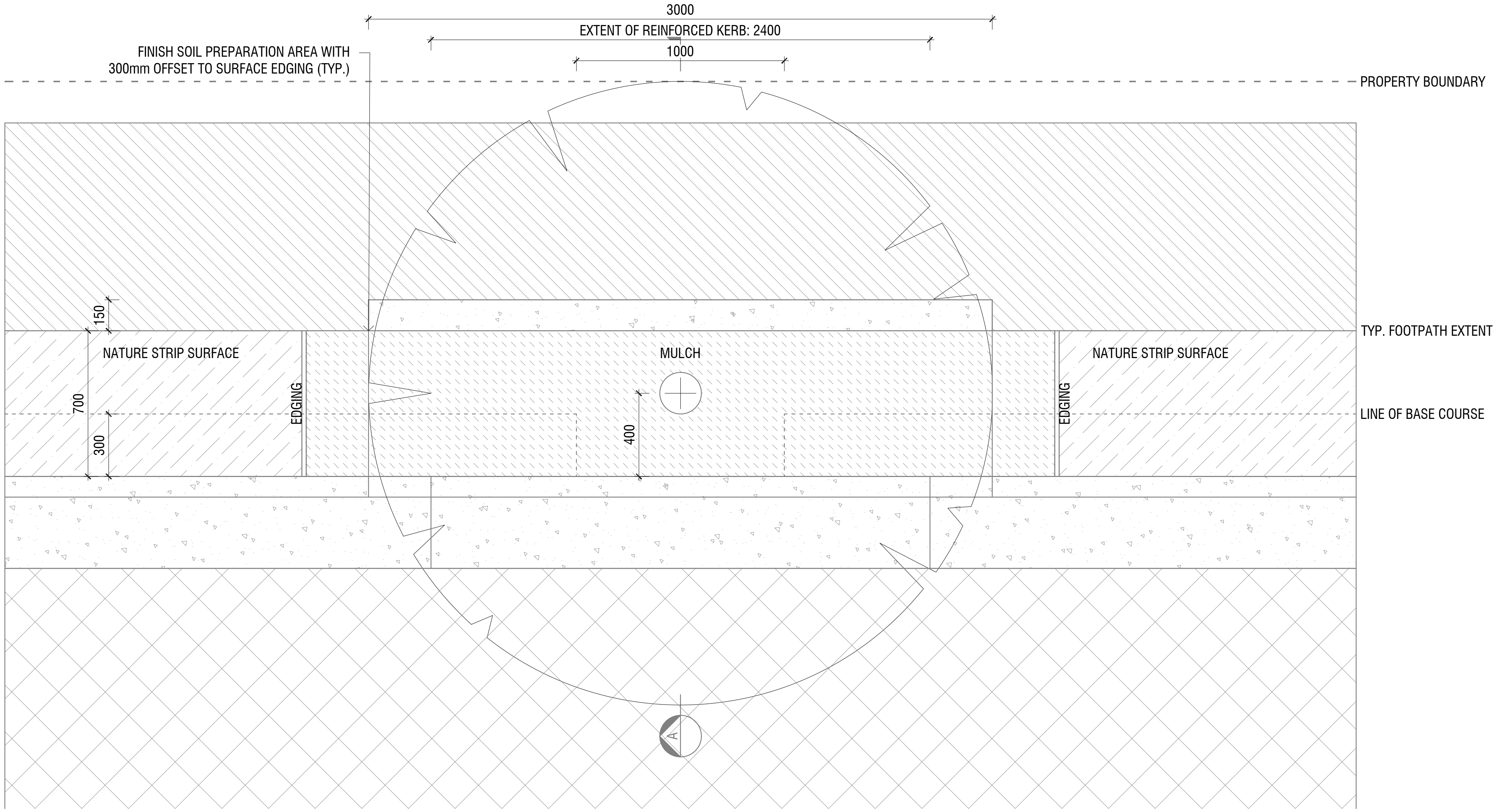
Technical Details

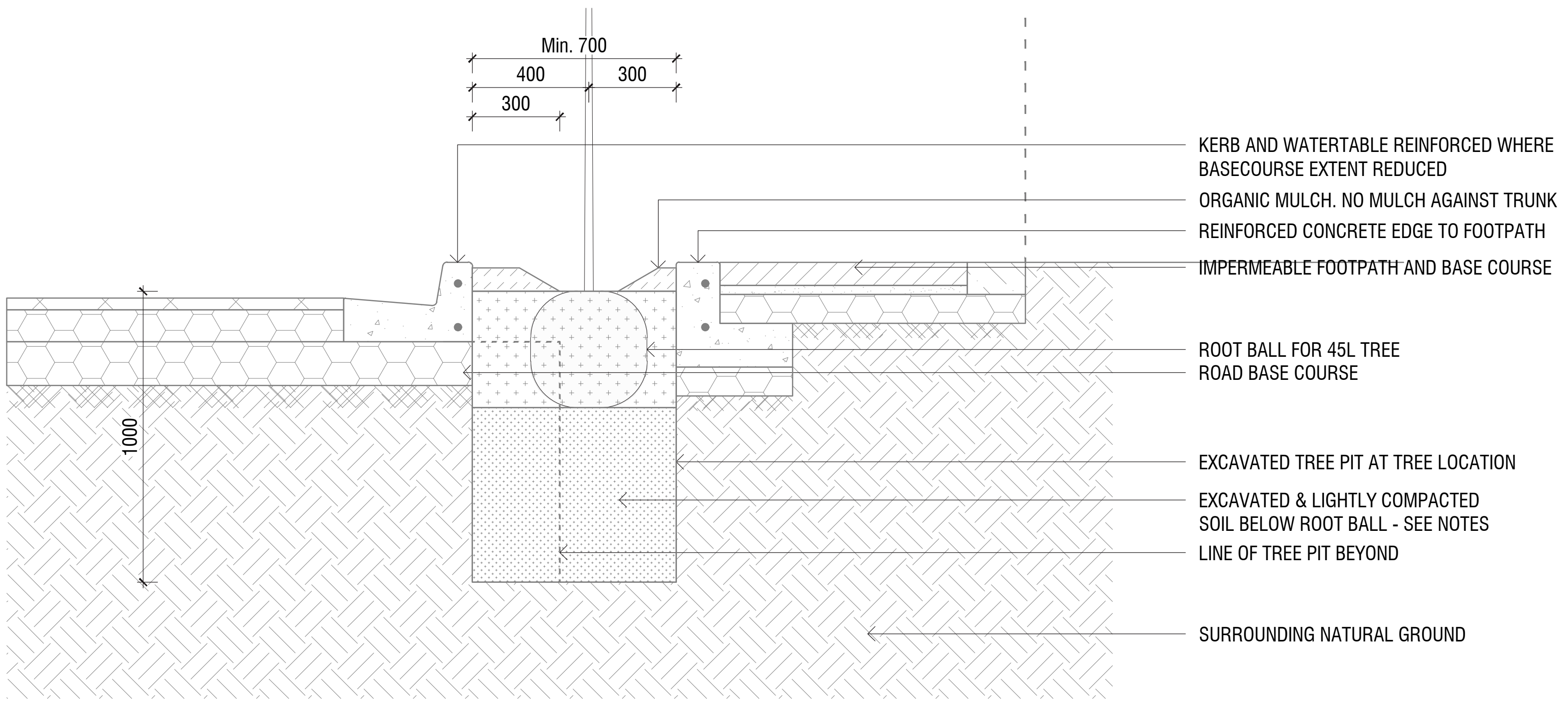
Introduction

The following technical details have been developed as practical solutions for tree planting in challenging spaces. They are generic, typical details that should be approached as a starting point, to be adapted to various situtations as they arise in tree planting projects.

Amendments:

Rev.	Date	Amendments	Initial





1 SN1: MINIMUM NATURE STRIP

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 2.5M3
INFILTRATION: 3.5M2

NOTES:

TREE PIT EXCAVATION DEPTH

SITE SOIL CONDITIONS WILL DETERMINE DEPTH OF TREE PIT EXCAVATION.

WHERE EXISTING SITE SOIL IS OF A SUITABLE STRUCTURE, TREE PIT IS TO BE EXCAVATED ONLY TO DEPTH OF ROOT BALL.

WHERE EXISTING SITE SOIL IS OF AN UNSUITABLE STRUCTURE, TREE PIT IS TO BE EXCAVATED TO A DEPTH OF 1m AND LIGHTLY COMPACTED BELOW ROOT BALL.

SOILS

RETAINING SITE SOIL IS PREFERABLE WHERE EXISTING SOILS ARE SUITABLE WITHIN TREE PIT. WHERE SOILS ARE UNSUITABLE FOR TREE PLANTING, IMPORTED SOIL IS TO BE INSTALLED WITHIN TREE PIT. TO BE CONFIRMED WITH COUNCIL ARBORIST.

FOOTPATH WIDTH:

PREFERRED WIDTH:	1350mm
MIN. WIDTH FOR LENGTH OF <2m:	900mm
MIN. WIDTH FOR LENGTH OF >2m:	1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

ALL DIMENSIONS SHOWN ARE MINIMUMS, UNLESS OTHERWISE SPECIFIED

JPE Design Studio

JPE Design Studio
ABN 97 007 776 249

Level 4,
19 Gilles Street
Adelaide 5000
PO Box 6401
Halifax Street
SA 5000

Tel 08 8406 4000
Fax 08 8406 4007
www.jpe.com.au
design@jpe.com.au

Project: Street Trees in Challenging Spaces
City of West Torrens

Title: TREE PLANTING DETAILS
SPACE CONSTRAINTS
NATURE STRIP

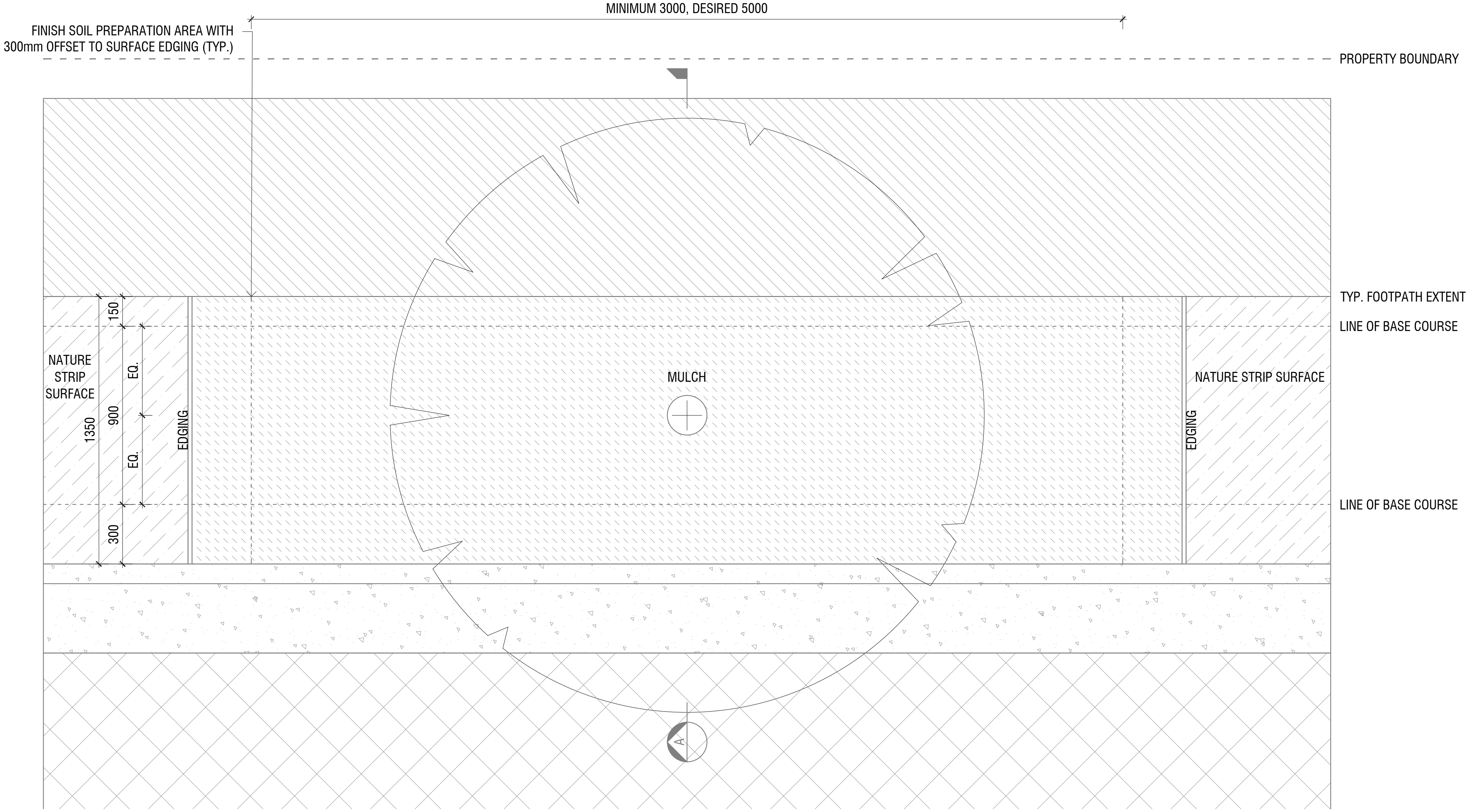
Scale: 1:25 @ A3

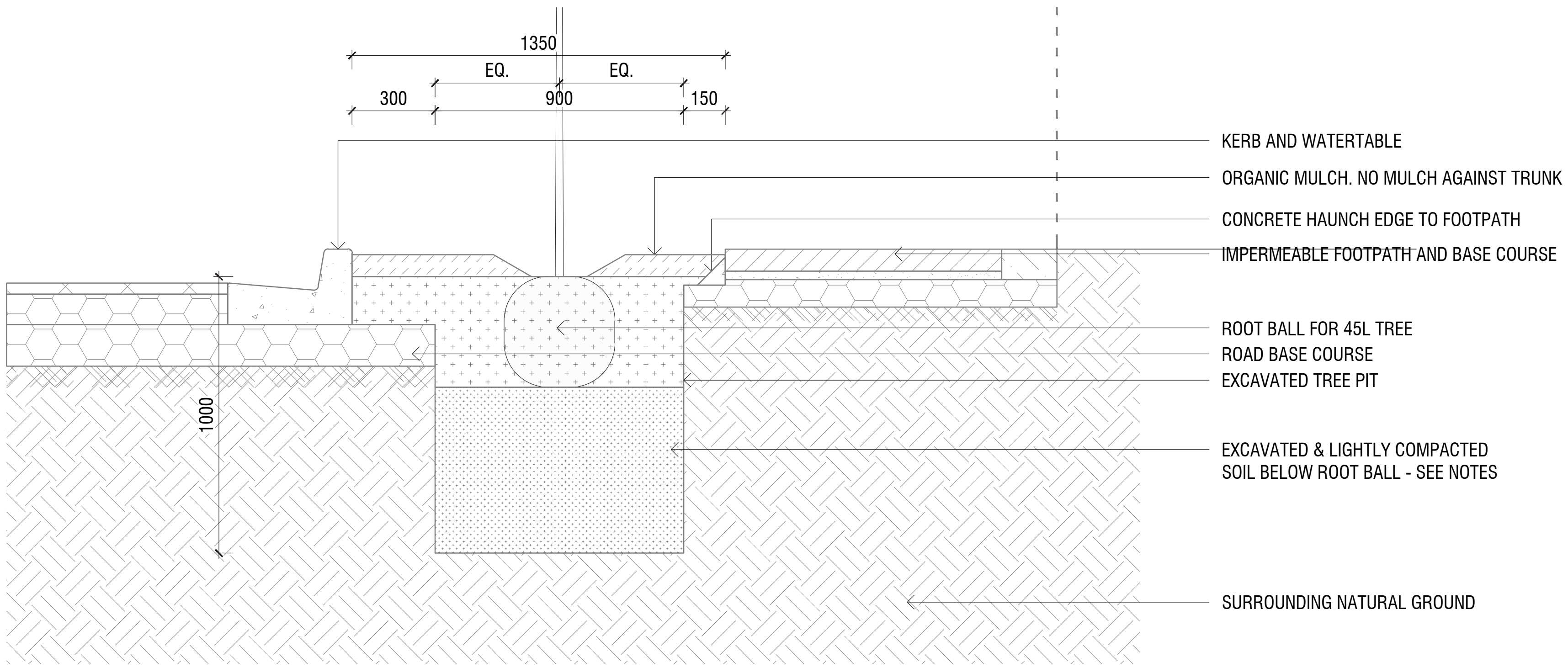
Date: Aug 20

Project No: 01520

Drawing No: SN1

Status: PRELIMINARY





1 SN2: PREFERRED NATURE STRIP

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 4.8M3
INFILTRATION: 6.7M2

Amendments:

Rev.	Date	Amendments	Initial

NOTES:

TREE PIT EXCAVATION DEPTH
SITE SOIL CONDITIONS WILL DETERMINE DEPTH OF TREE PIT EXCAVATION.

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SOILS
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FOOTPATH WIDTH:

PREFERRED WIDTH:	1350mm
MIN. WIDTH FOR LENGTH OF <2m:	900mm
MIN. WIDTH FOR LENGTH OF >2m:	1000mm

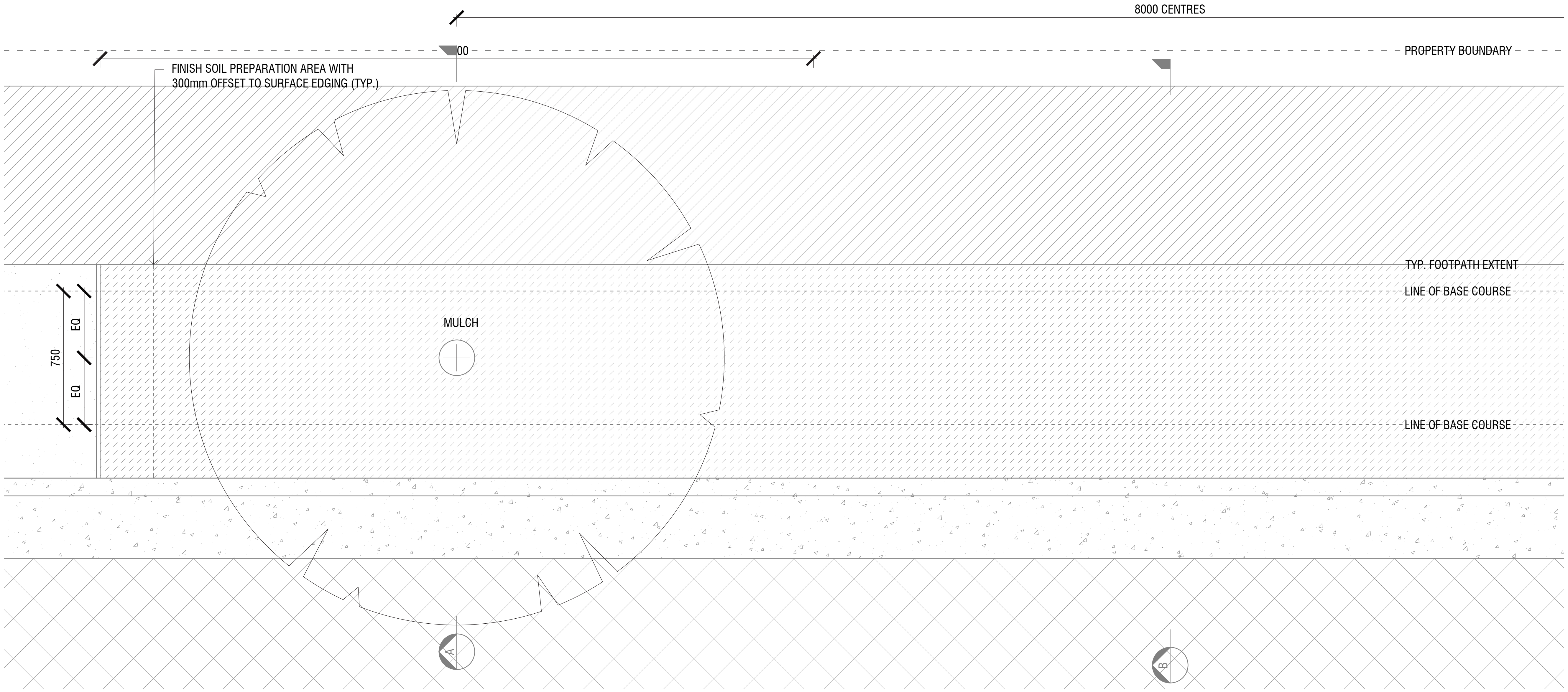
MINIMUM TREE OFFSET TO KERB: 400mm

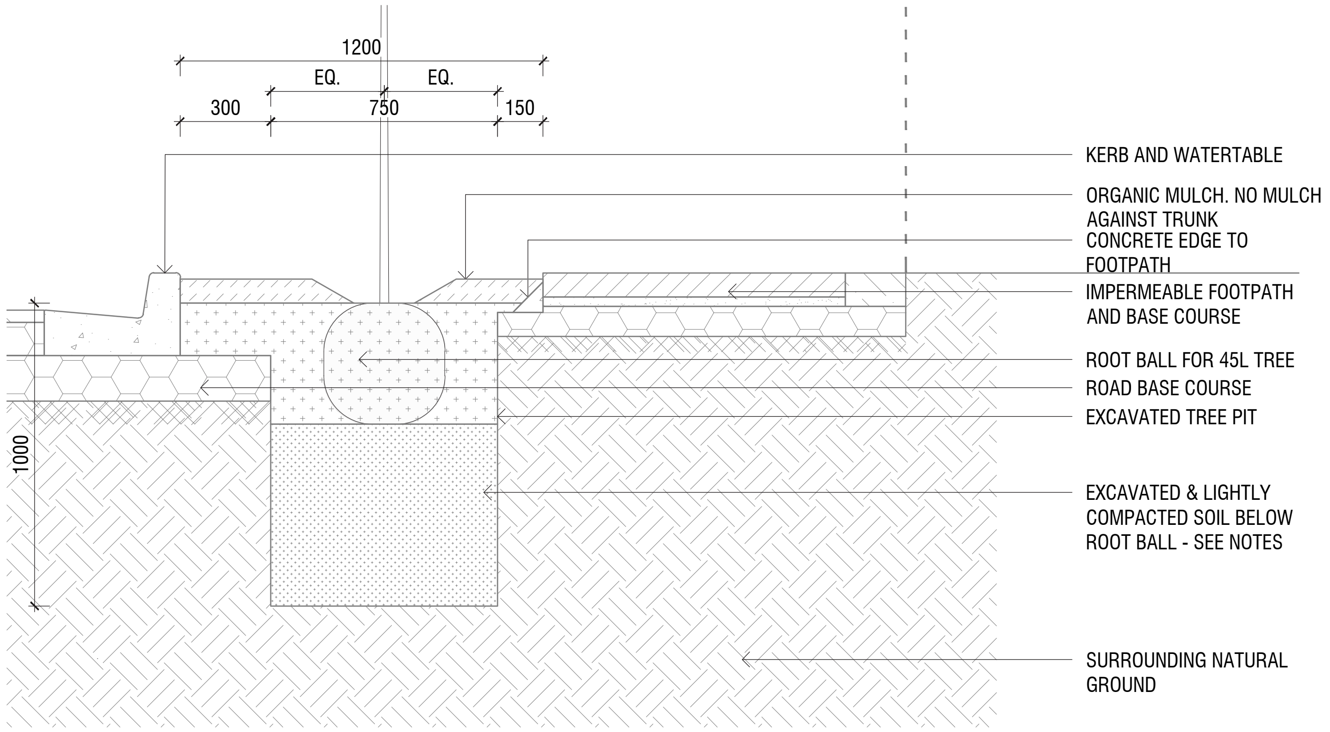
ALL DIMENSIONS SHOWN ARE MINIMUMS, UNLESS OTHERWISE SPECIFIED

JPE Design Studio

JPE Design Studio ABN 97 007 776 249
Level 4, 19 Gilles Street Adelaide 5000 PO Box 6401 Halifax Street SA 5000
Tel 08 8406 4000 Fax 08 8406 4007 www.jpe.com.au design@jpe.com.au

Project:	Street Trees in Challenging Spaces City of West Torrens
Title:	TREE PLANTING DETAILS SPACE CONSTRAINTS NATURE STRIP
Scale:	1:25 @ A3
Date:	Aug 20
Project No:	01520
Drawing No:	SN2
Status:	PRELIMINARY





1 | SN3: TREE TRENCH

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 5.9M3
INFILTRATION: 4.8M2

Amendments:

Rev.	Date	Amendments	Initial

NOTES:

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FOOTPATH WIDTH:

PREFERRED WIDTH:	1350mm
MIN. WIDTH FOR LENGTH OF <2m:	900mm
MIN. WIDTH FOR LENGTH OF >2m:	1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

ALL DIMENSIONS SHOWN ARE MINIMUMS, UNLESS OTHERWISE SPECIFIED

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Halifax Street
SA 5000

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Fax 08 8406 4007
www.jpe.com.au
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Project: Street Trees in Challenging Spaces
City of West Torrens

Title: TREE PLANTING DETAILS
SPACE CONSTRAINTS
NATURE STRIP

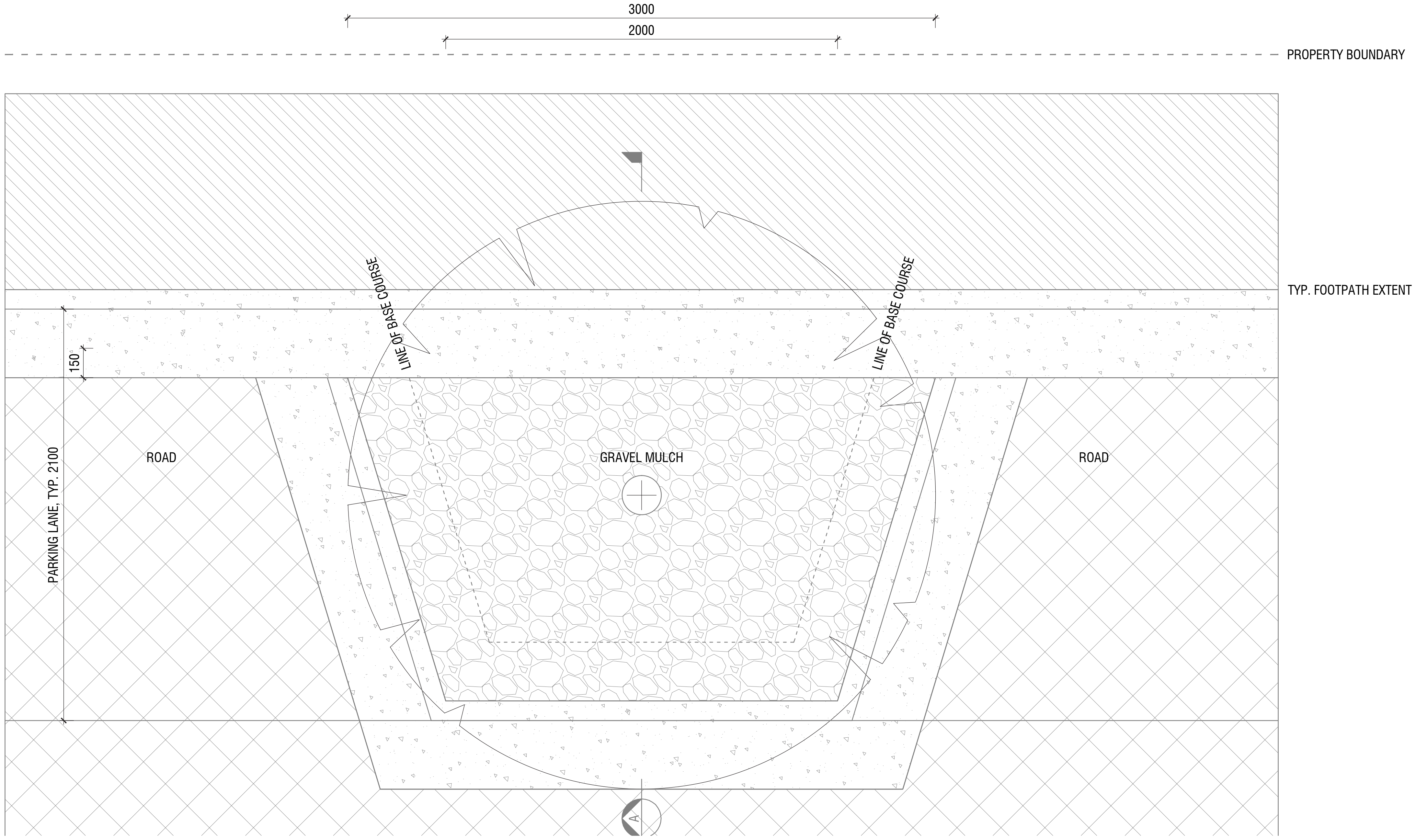
Scale: 1:25 @ A3

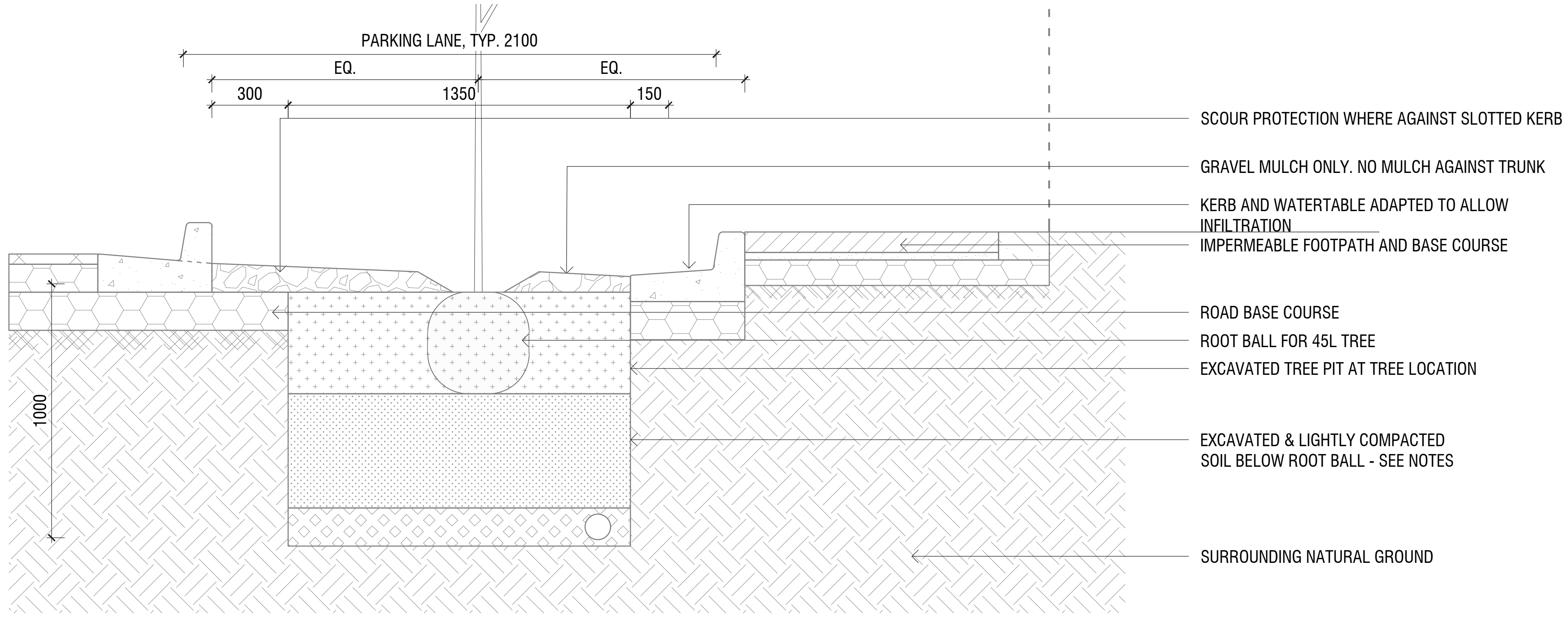
Date: Aug 20

Project No: 01520

Drawing No: SN3

Status: PRELIMINARY





1 SP1: PROTUBERANCE

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 2.7M3
INFILTRATION: 4.1M2

Amendments:

Rev.	Date	Amendments	Initial

NOTES:

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FOOTPATH WIDTH:

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MIN. WIDTH FOR LENGTH OF <2m: 900mm
MIN. WIDTH FOR LENGTH OF >2m: 1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

ALL DIMENSIONS SHOWN ARE MINIMUMS, UNLESS OTHERWISE SPECIFIED

JPE
JPE Design Studio

JPE Design Studio ABN 97 007 776 249
Level 4, 19 Gilles Street Adelaide 5000
PO Box 6401 Halifax Street SA 5000
Tel 08 8406 4000
Fax 08 8406 4007
www.jpe.com.au
design@jpe.com.au

Project: Street Trees in Challenging Spaces City of West Torrens

Title: TREE PLANTING DETAILS SPACE CONSTRAINTS PARKING LANE

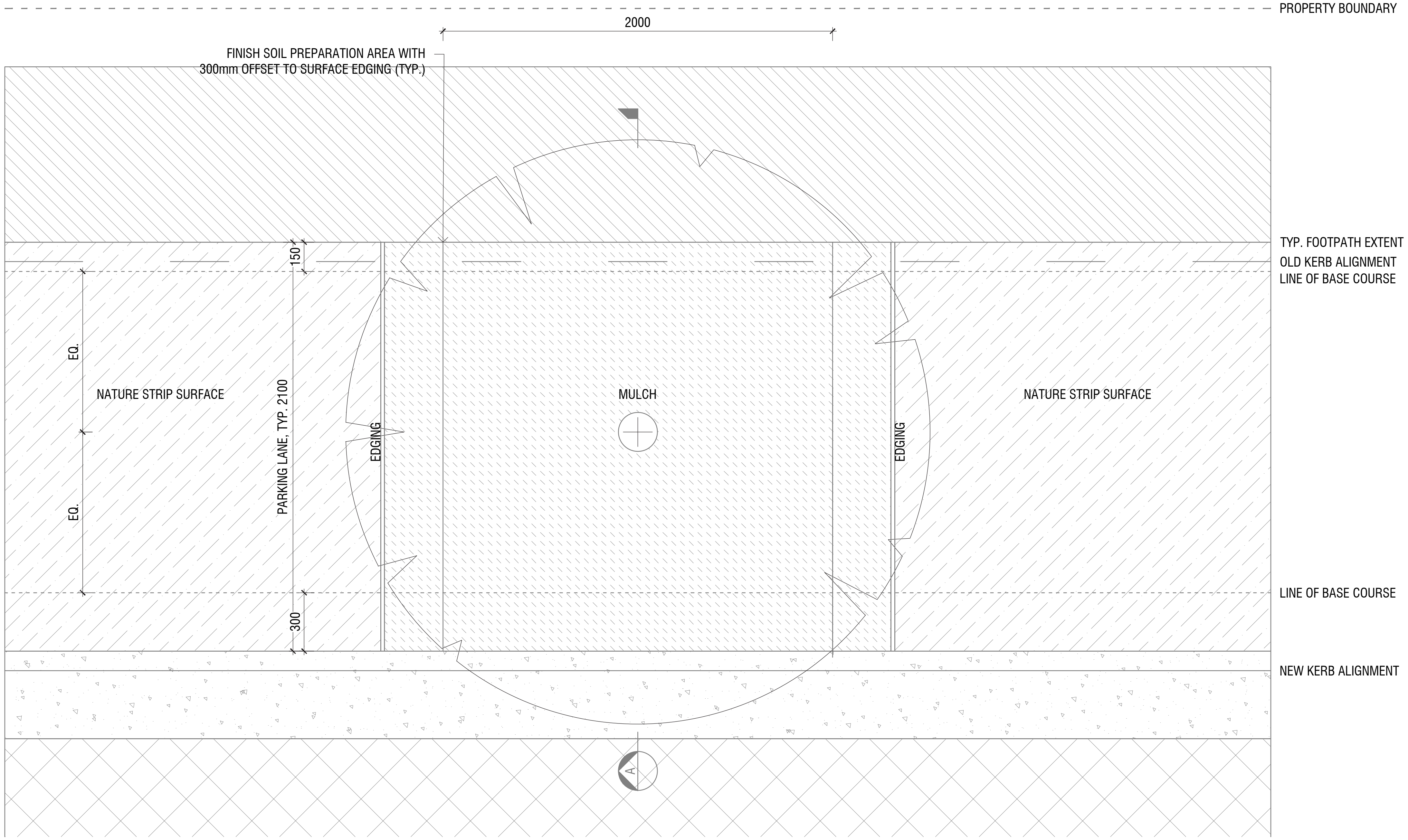
Scale: 1:25 @ A3

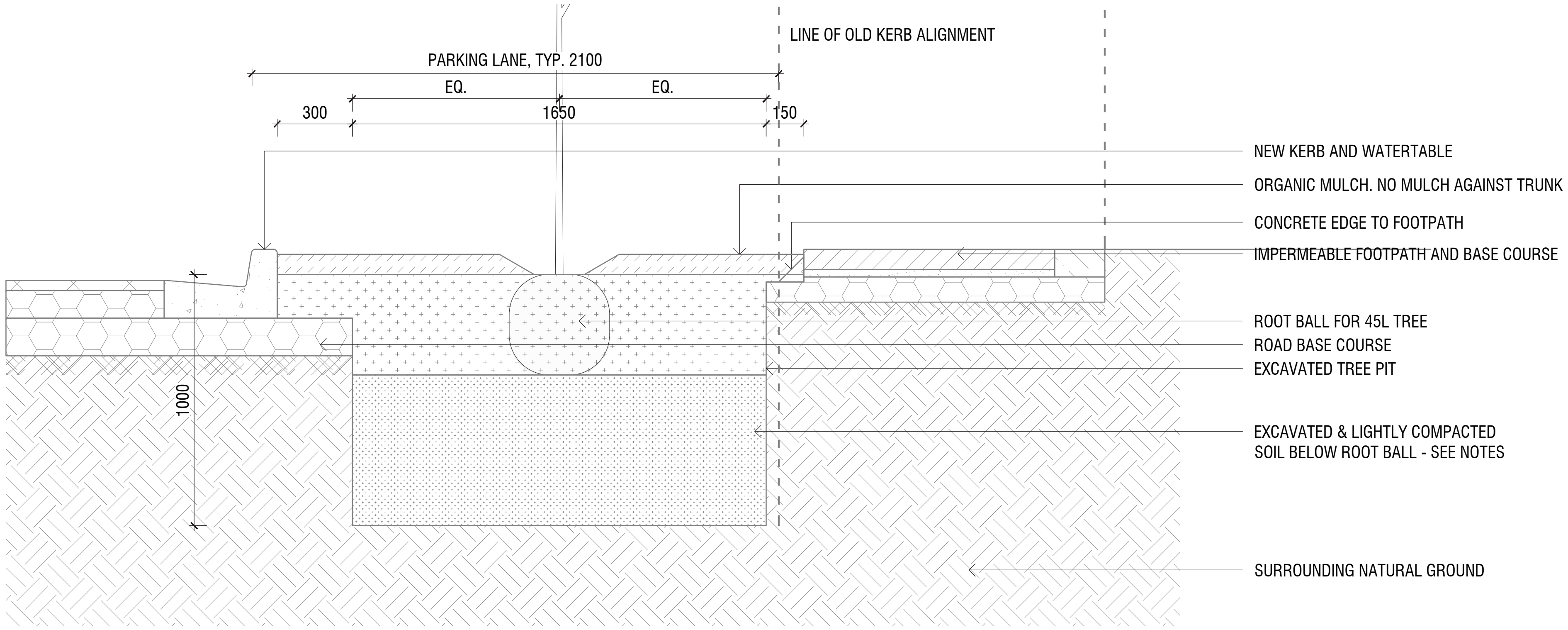
Date: Aug 20

Project No: 01520

Drawing No: SP1

Status: PRELIMINARY





1 SP2: PLANTING BED

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 3.4M3
INFILTRATION: 4.2M2

Amendments:

Rev.	Date	Amendments	Initial

NOTES:

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FOOTPATH WIDTH:

PREFERRED WIDTH:	1350mm
MIN. WIDTH FOR LENGTH OF <2m:	900mm
MIN. WIDTH FOR LENGTH OF >2m:	1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

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ABN 97 007 776 249
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www.jpe.com.au
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Project: Street Trees in Challenging Spaces
City of West Torrens

Title: TREE PLANTING DETAILS
SPACE CONSTRAINTS
PARKING LANE

Scale: 1:25 @ A3

Date: Aug 20

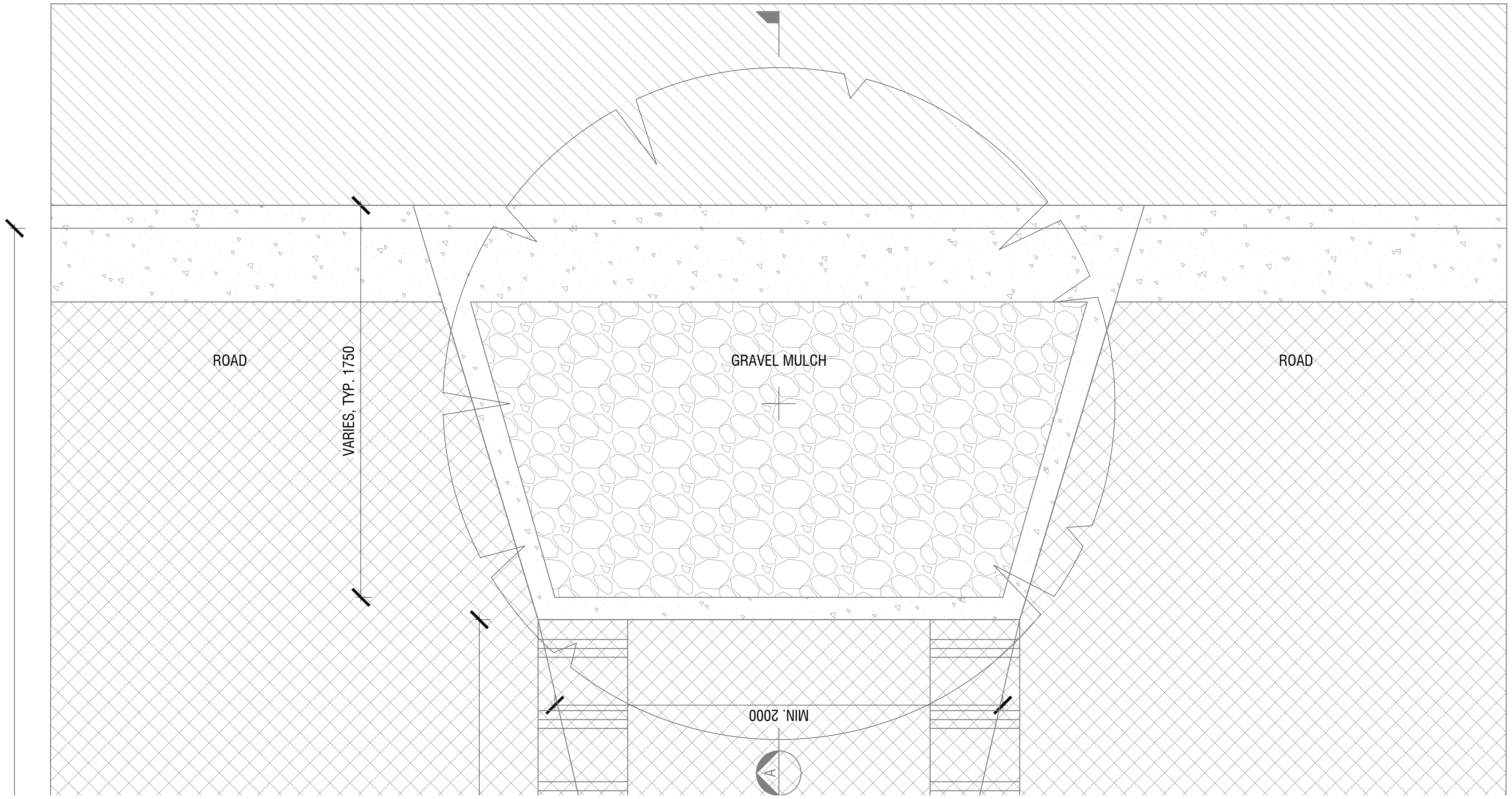
Project No: 01520

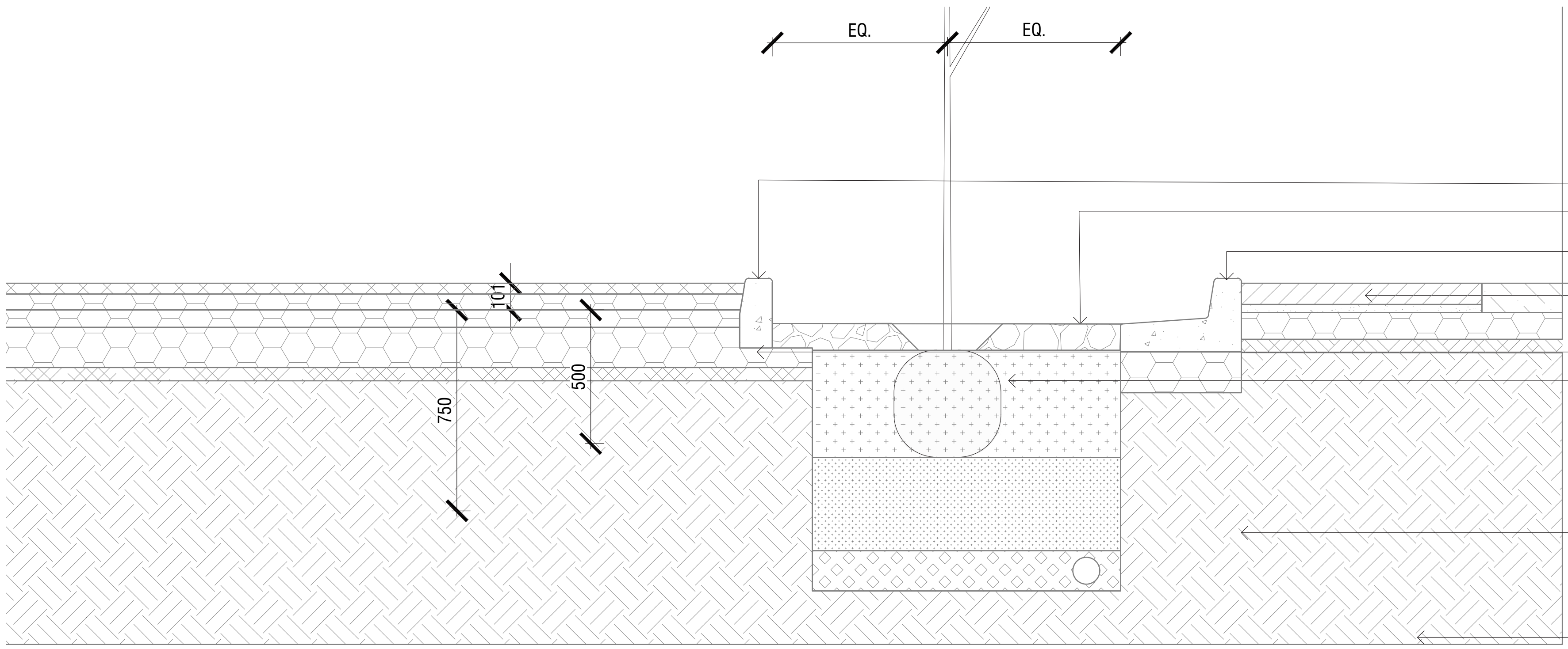
Drawing No: SP2

Status: PRELIMINARY

Amendments:

Rev.	Date	Amendments	Initial





1 SR1: SLOW POINT

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: /M3
INFILTRATION: /M2

NOTES:

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FOOTPATH WIDTH:

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MINIMUM TREE OFFSET TO KERB: 400mm

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ABN 97 007 776 249

Level 4,
19 Gilles Street
Adelaide 5000
PO Box 6401
Halifax Street
SA 5000

Tel 08 8406 4000
Fax 08 8406 4007
www.jpe.com.au
design@jpe.com.au

Project: Street Trees in Challenging Spaces
City of West Torrens

Title: TREE PLANTING DETAILS
SPACE CONSTRAINTS
ROADWAY

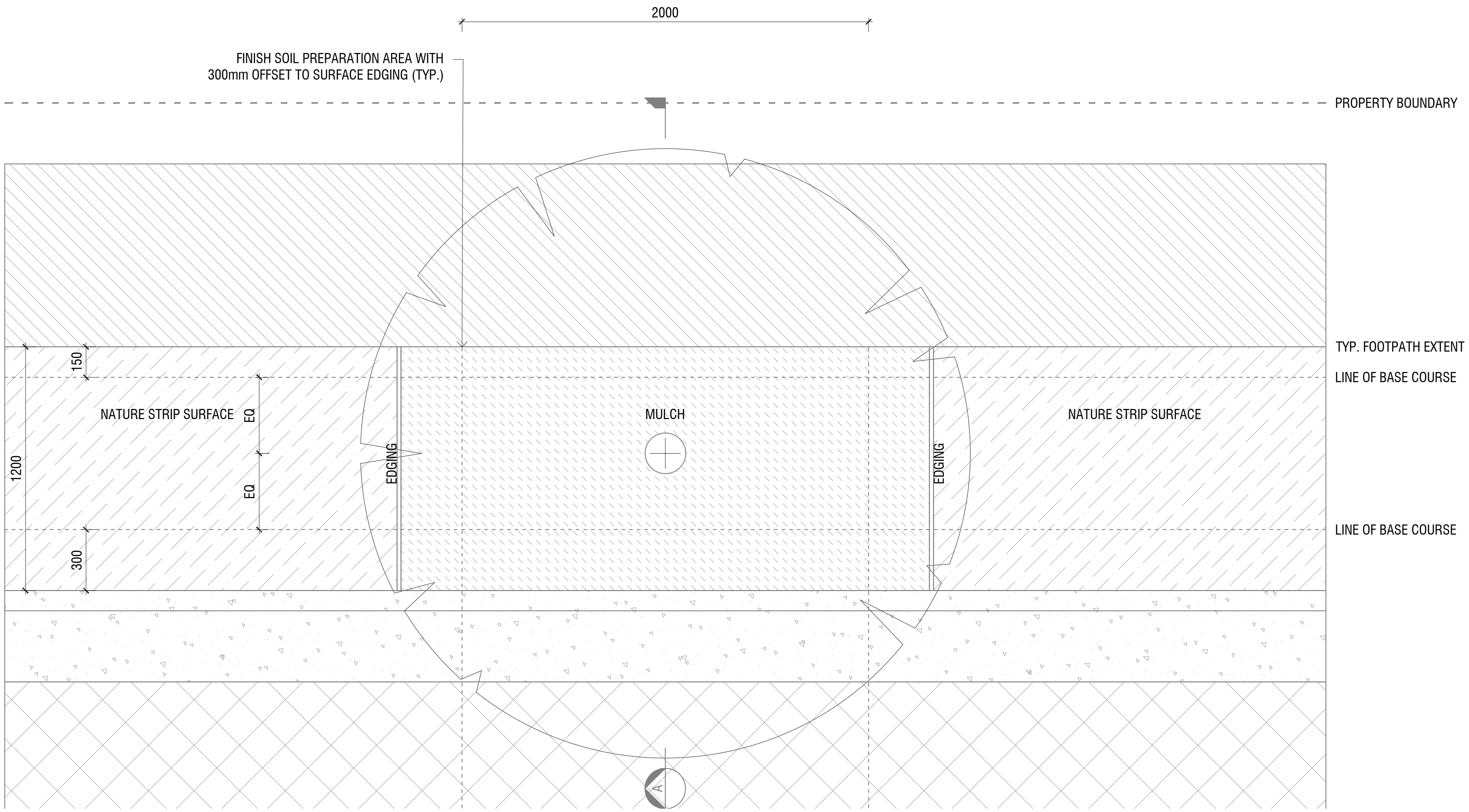
Scale: 1:25 @ A3

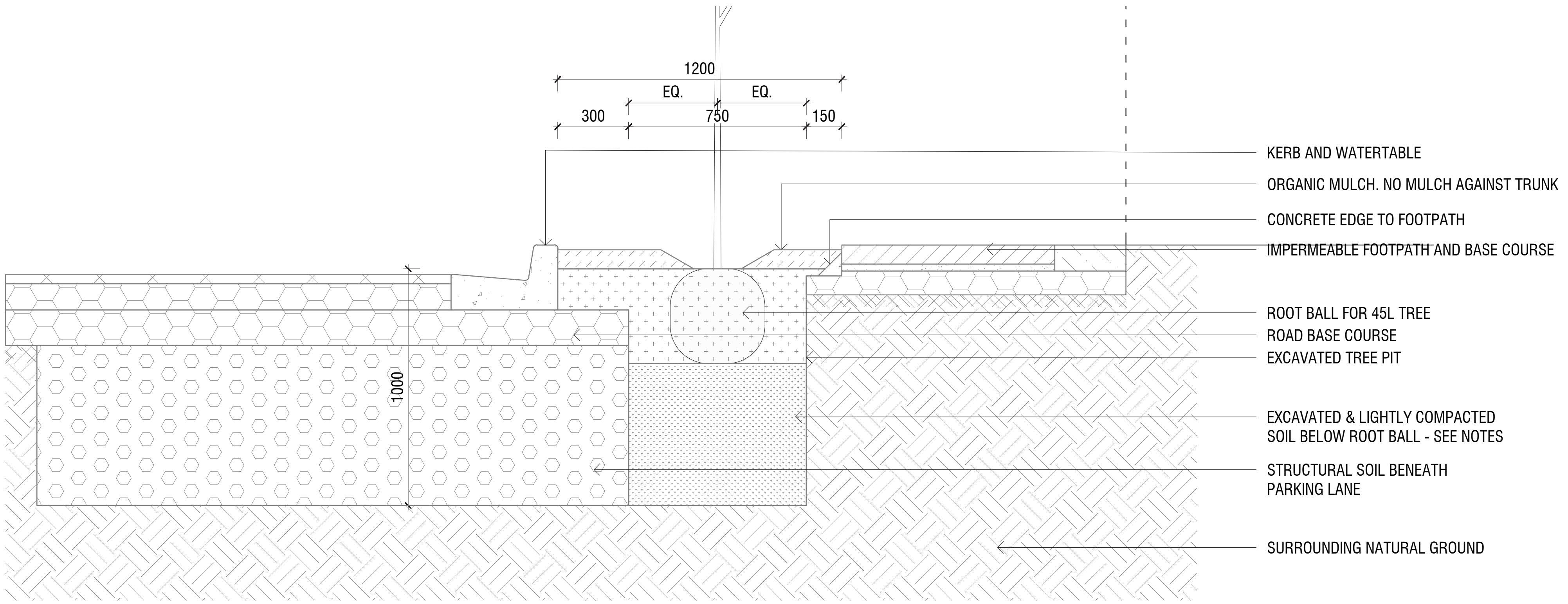
Date: Aug 20

Project No: 01520

Drawing No: SR1

Status: PRELIMINARY





1 | SR2: STRUCTURAL SOIL

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 5M3
INFILTRATION: 2.4M2

Amendments:

Rev.	Date	Amendments	Initial

NOTES:

TREE PIT EXCAVATION DEPTH
SITE SOIL CONDITIONS WILL DETERMINE DEPTH OF TREE PIT EXCAVATION.

WHERE EXISTING SITE SOIL IS OF A SUITABLE STRUCTURE, TREE PIT IS TO BE EXCAVATED ONLY TO DEPTH OF ROOT BALL.

WHERE EXISTING SITE SOIL IS OF AN UNSUITABLE STRUCTURE, TREE PIT IS TO BE EXCAVATED TO A DEPTH OF 1m AND LIGHTLY COMPACTED BELOW ROOT BALL.

SOILS
RETAINING SITE SOIL IS PREFERABLE WHERE EXISTING SOILS ARE SUITABLE WITHIN TREE PIT. WHERE SOILS ARE UNSUITABLE FOR TREE PLANTING, IMPORTED SOIL IS TO BE INSTALLED WITHIN TREE PIT. TO BE CONFIRMED WITH COUNCIL ARBORIST.

FOOTPATH WIDTH:
PREFERRED WIDTH: 1350mm
MIN. WIDTH FOR LENGTH OF <2m: 900mm
MIN. WIDTH FOR LENGTH OF >2m: 1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

ALL DIMENSIONS SHOWN ARE MINIMUMS, UNLESS OTHERWISE SPECIFIED

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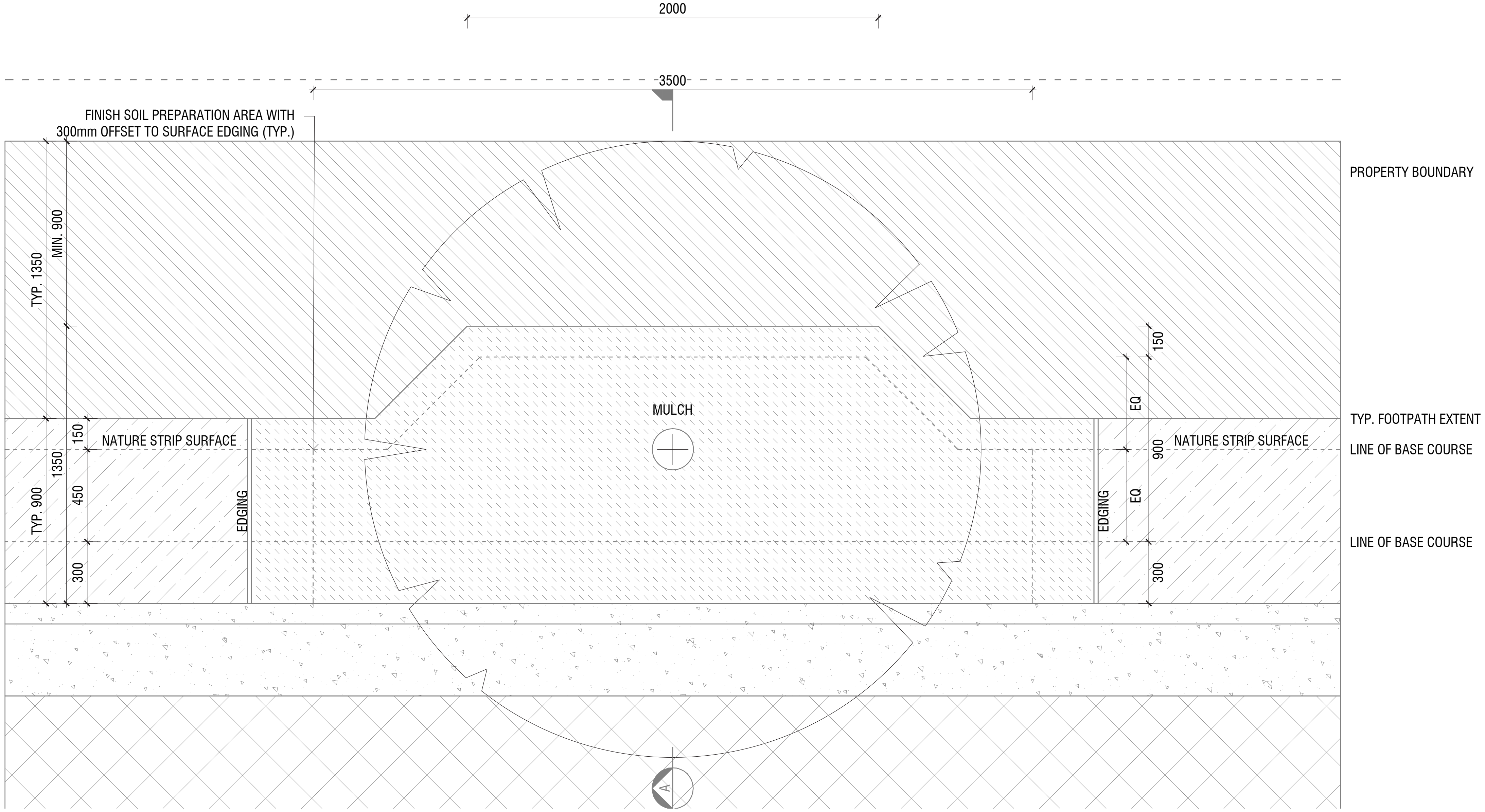

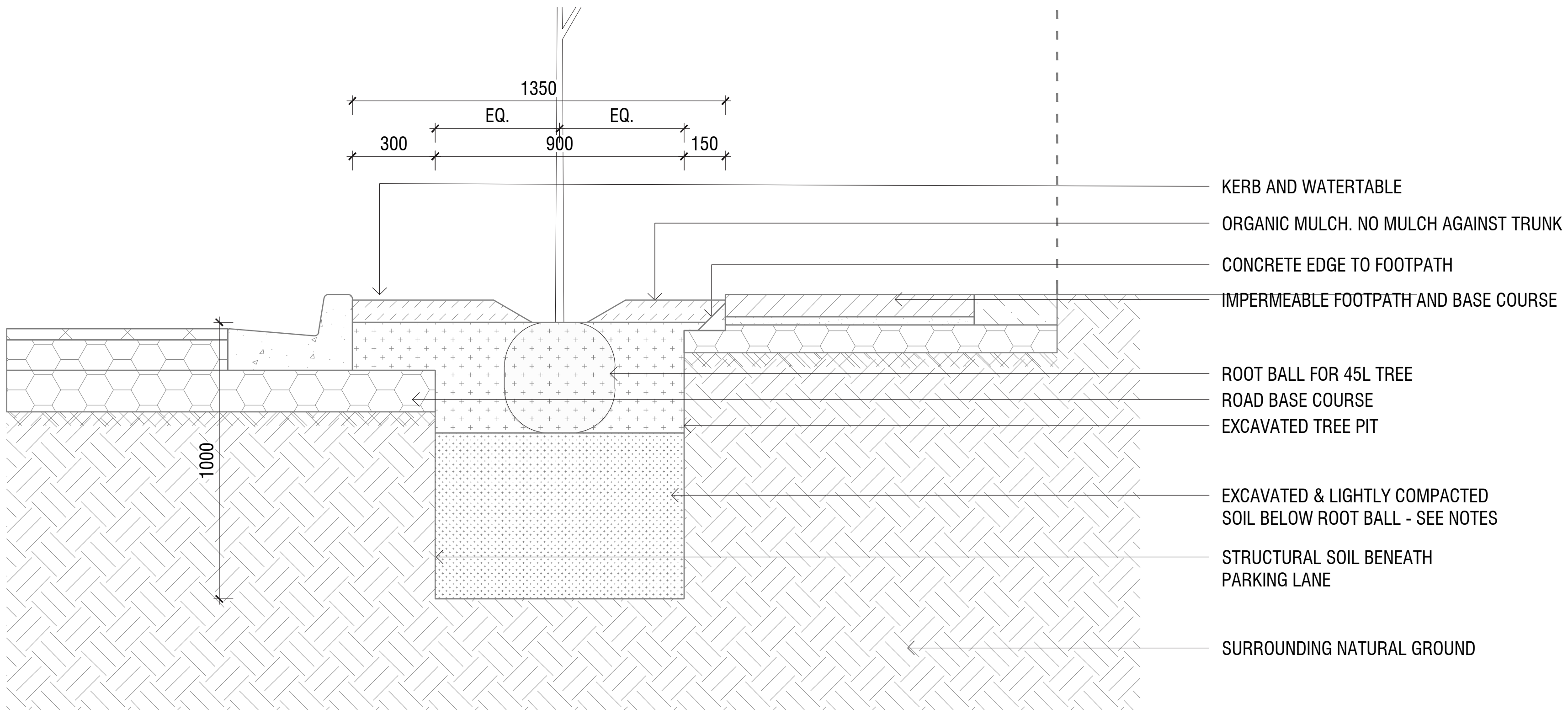

1 SF1: INDENTED TREE PIT

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 2.8M3
INFILTRATION: 4.2M2

NOTES:

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FOOTPATH WIDTH:

PREFERRED WIDTH:	1350mm
MIN. WIDTH FOR LENGTH OF <2m:	900mm
MIN. WIDTH FOR LENGTH OF >2m:	1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

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Date:	Aug 20
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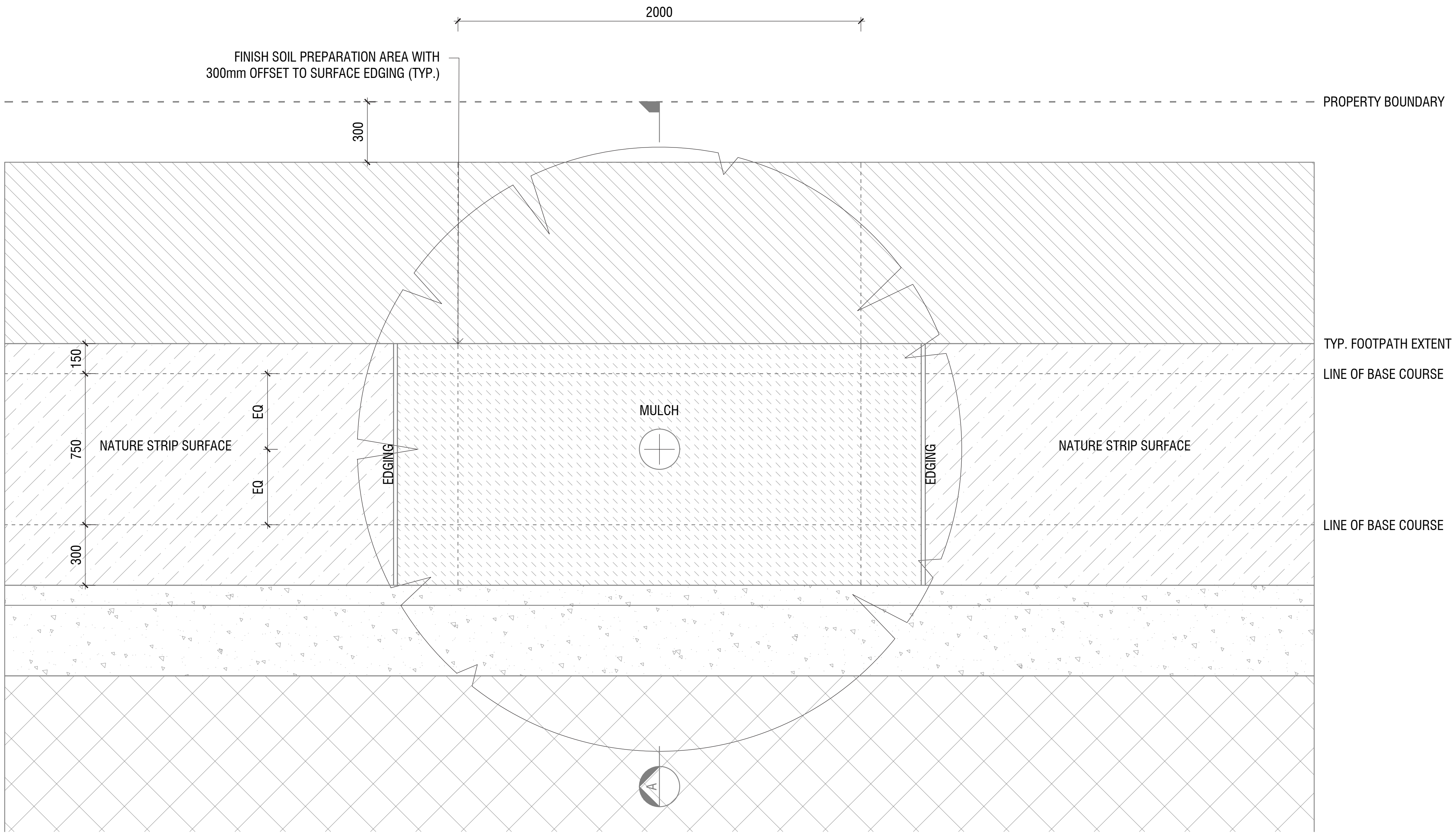

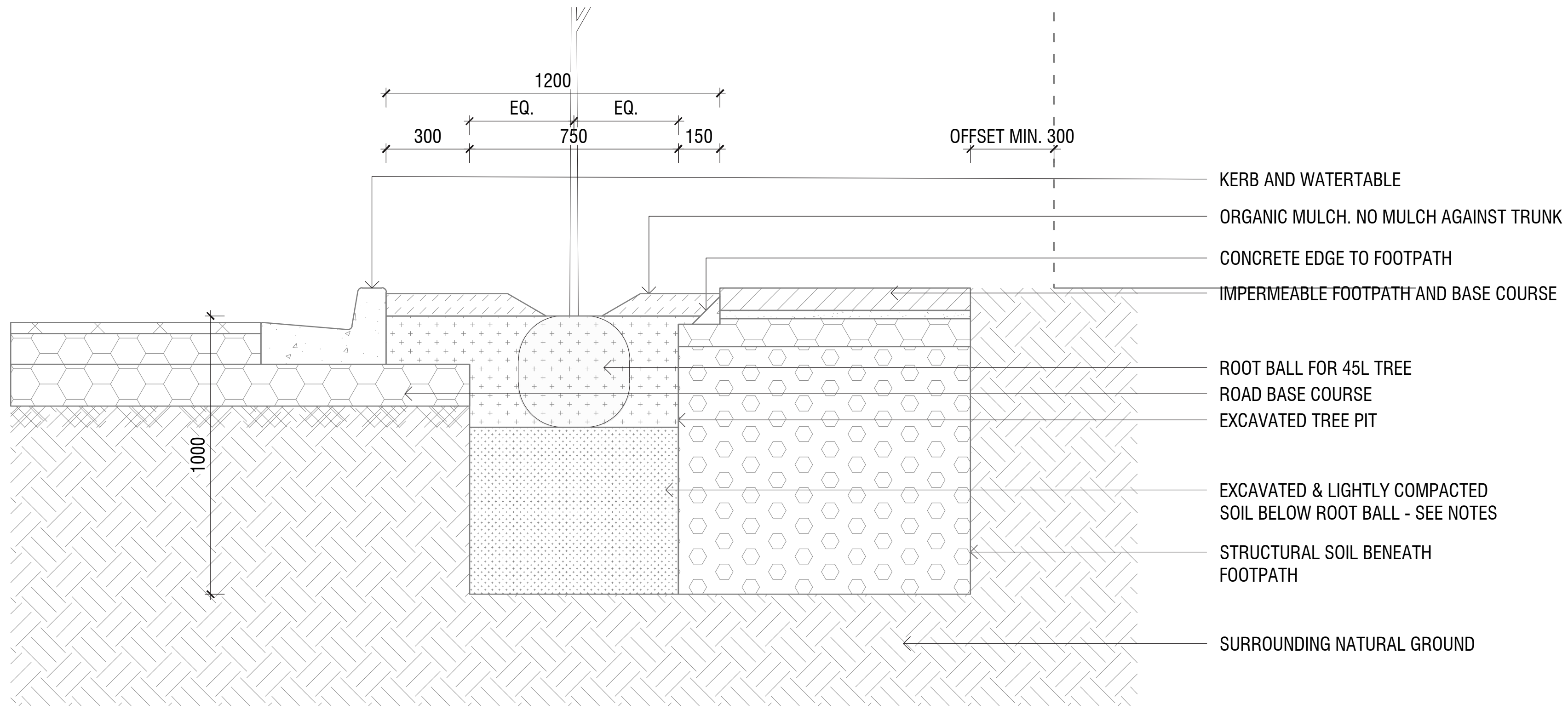

1 SF2: STRUCTURAL SOIL

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 4M3
INFILTRATION: 2.4M2

Amendments:

Rev.	Date	Amendments	Initial

NOTES:

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FOOTPATH WIDTH:

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MIN. WIDTH FOR LENGTH OF >2m:	1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

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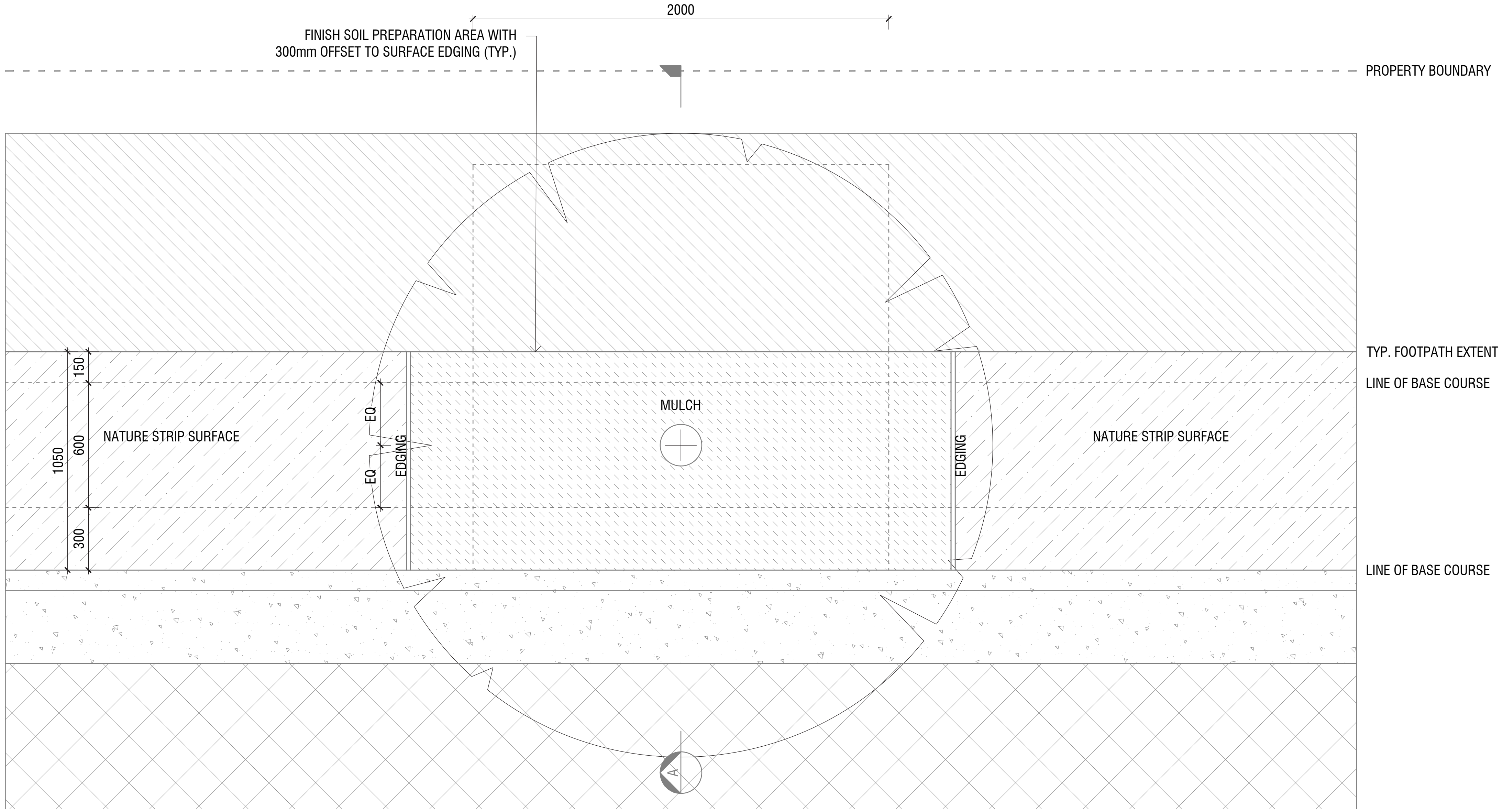
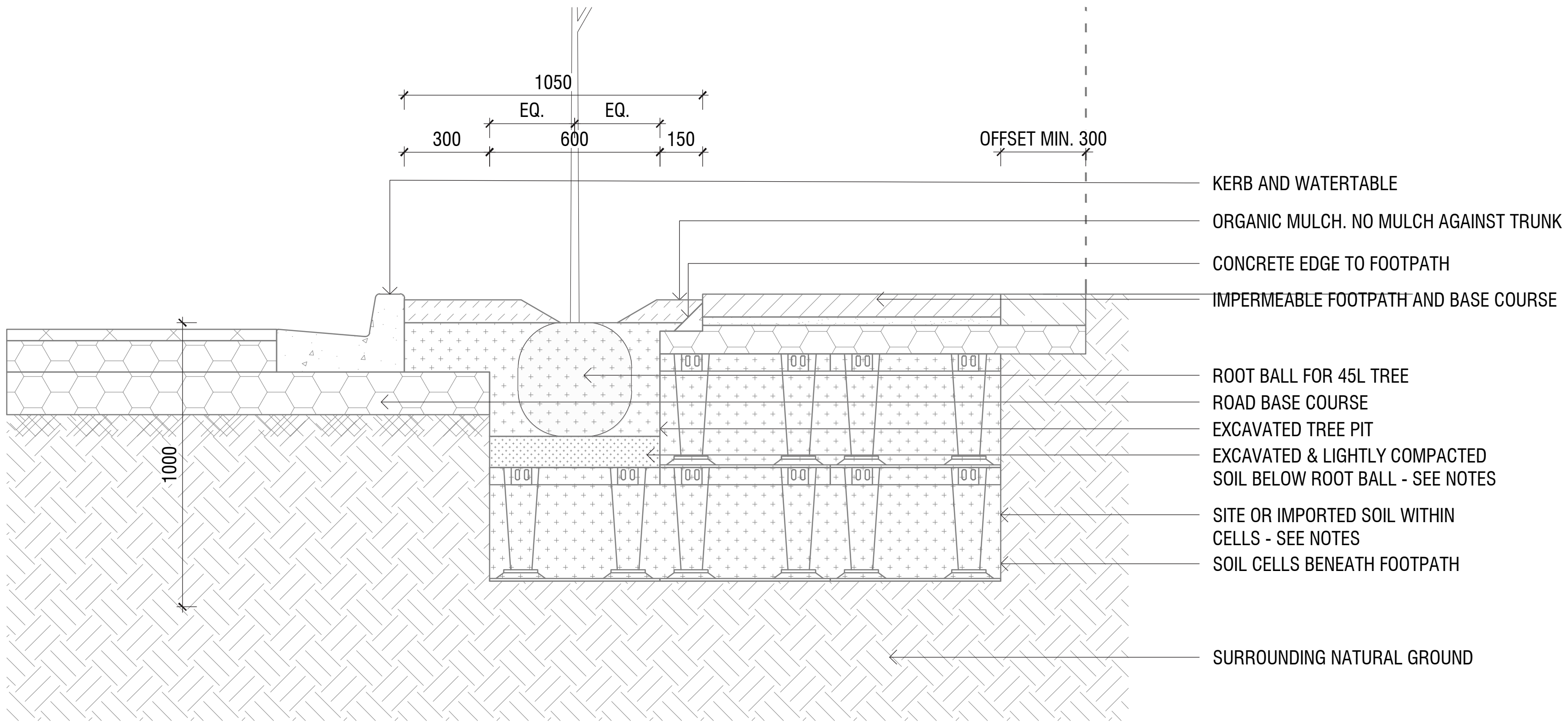
Date:	Aug 20
Project No:	01520
Drawing No:	SF2
Status:	PRELIMINARY





1 SF3: SOIL CELLS

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 3.1M3
INFILTRATION: 2.1M2

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FOOTPATH WIDTH:

PREFERRED WIDTH:	1350mm
MIN. WIDTH FOR LENGTH OF <2m:	900mm
MIN. WIDTH FOR LENGTH OF >2m:	1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

ALL DIMENSIONS SHOWN ARE MINIMUMS, UNLESS OTHERWISE SPECIFIED

Amendments:

Rev.	Date	Amendments	Initial

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Project: Street Trees in Challenging Spaces City of West Torrens

Title: TREE PLANTING DETAILS SPACE CONSTRAINTS FOOTPATH

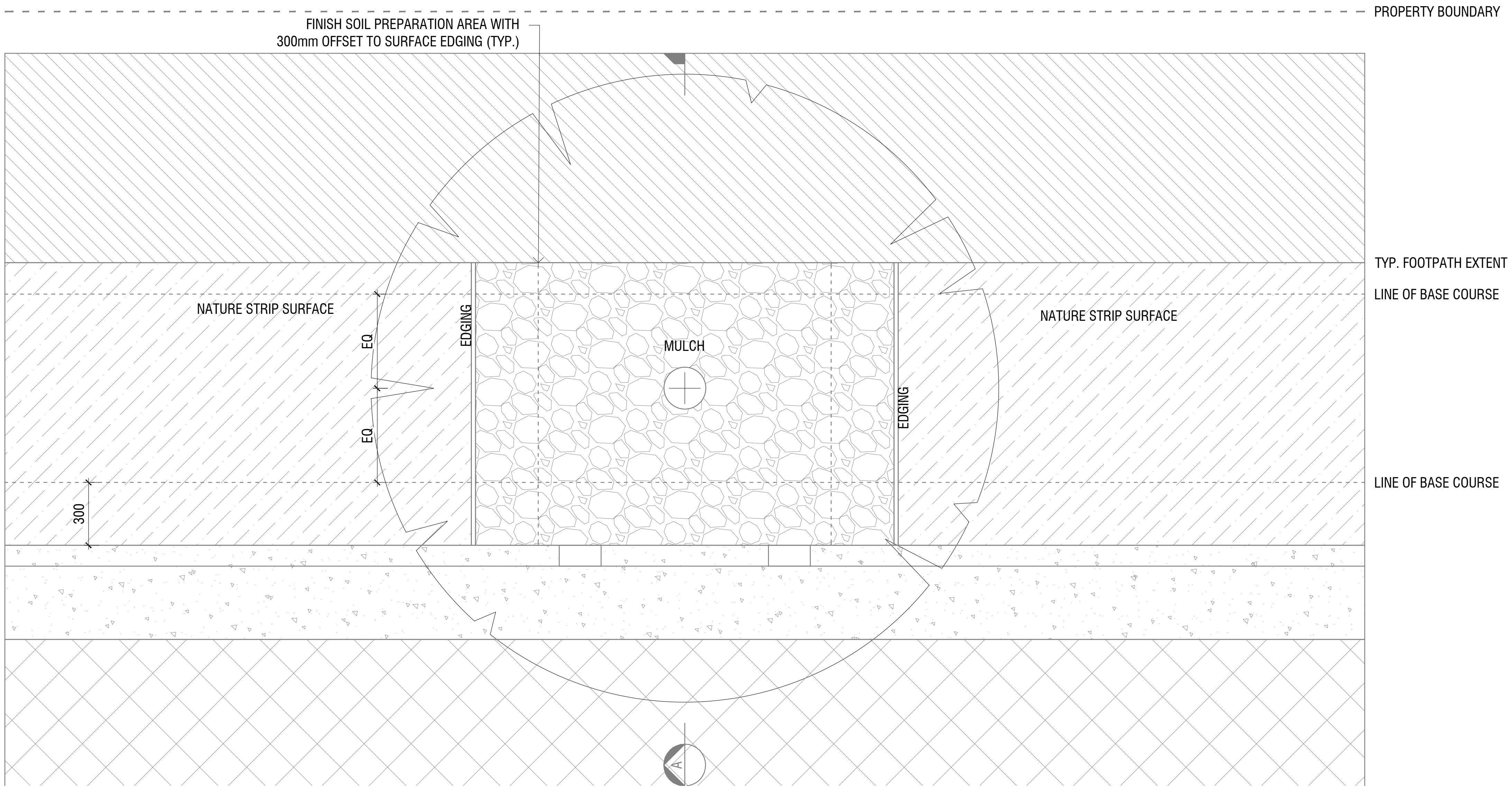
Scale: 1:25 @ A3

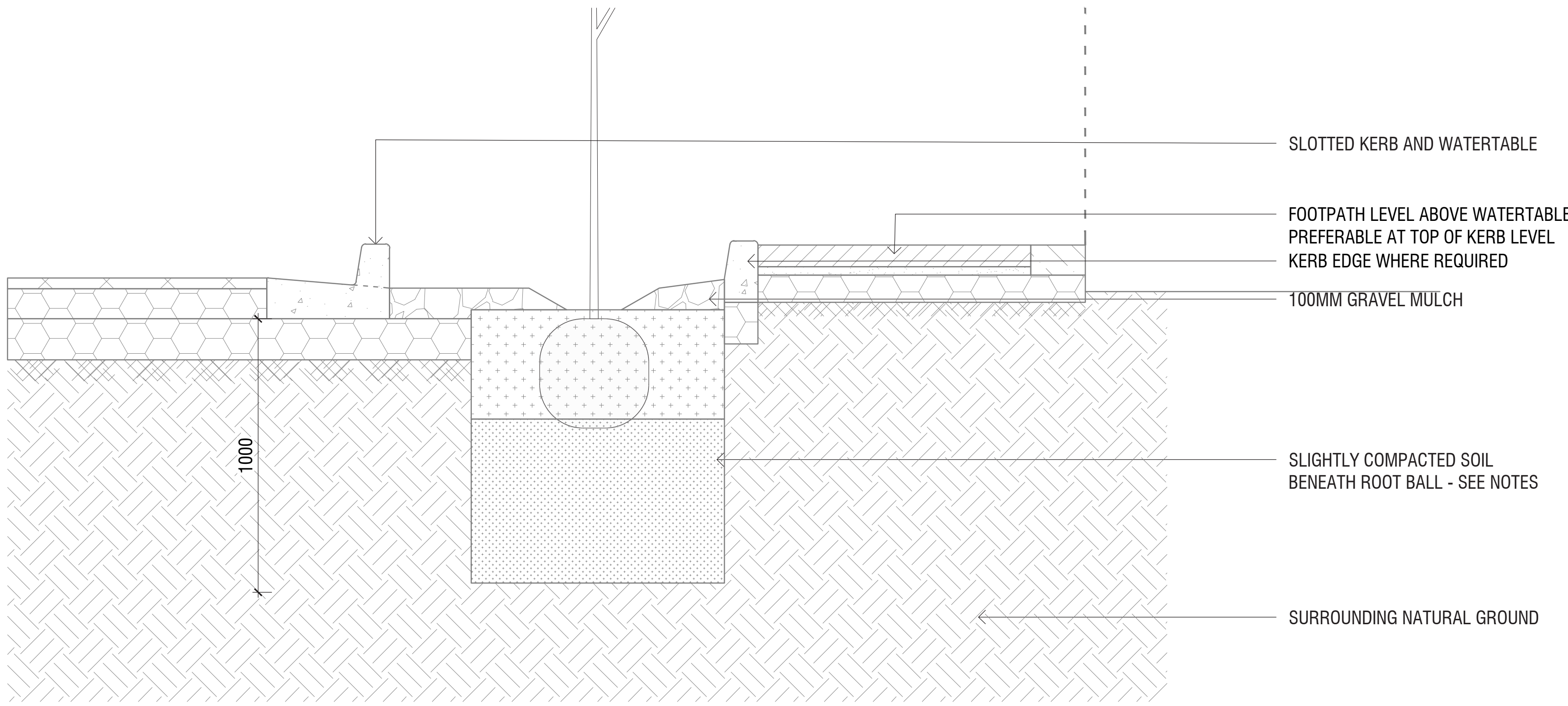
Date: Aug 20

Project No: 01520

Drawing No: SF3

Status: PRELIMINARY





1 WK1: SLOTTED KERB

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 1.8M3
INFILTRATION: 2.7M2+

Amendments:

Rev.	Date	Amendments	Initial

NOTES:

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FOOTPATH WIDTH:

PREFERRED WIDTH:	1350mm
MIN. WIDTH FOR LENGTH OF <2m:	900mm
MIN. WIDTH FOR LENGTH OF >2m:	1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

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Project: Street Trees in Challenging Spaces
City of West Torrens

Title: TREE PLANTING DETAILS
ACCESS TO WATER
KERB & WATERTABLE

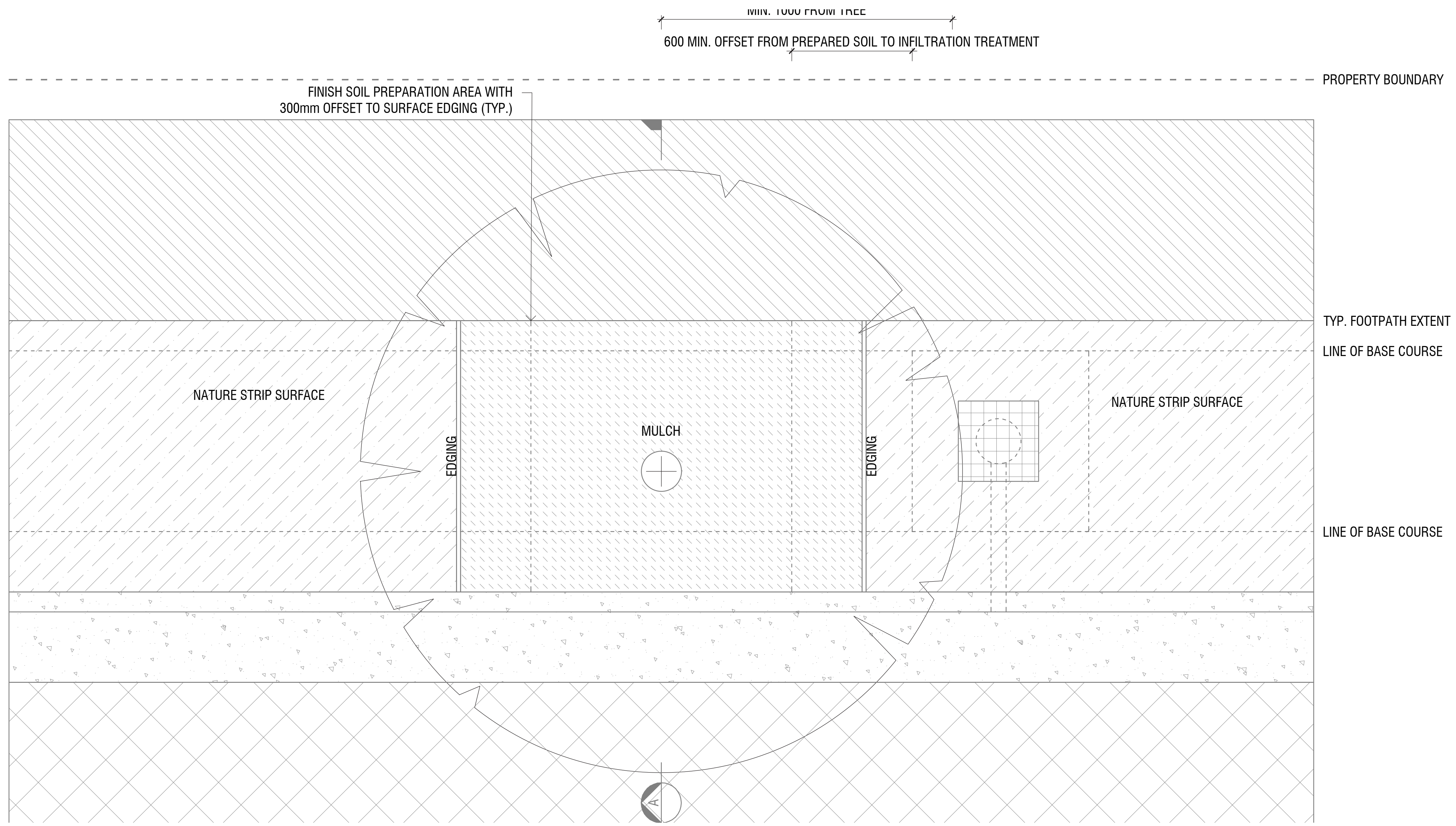
Scale: 1:20 @ A3

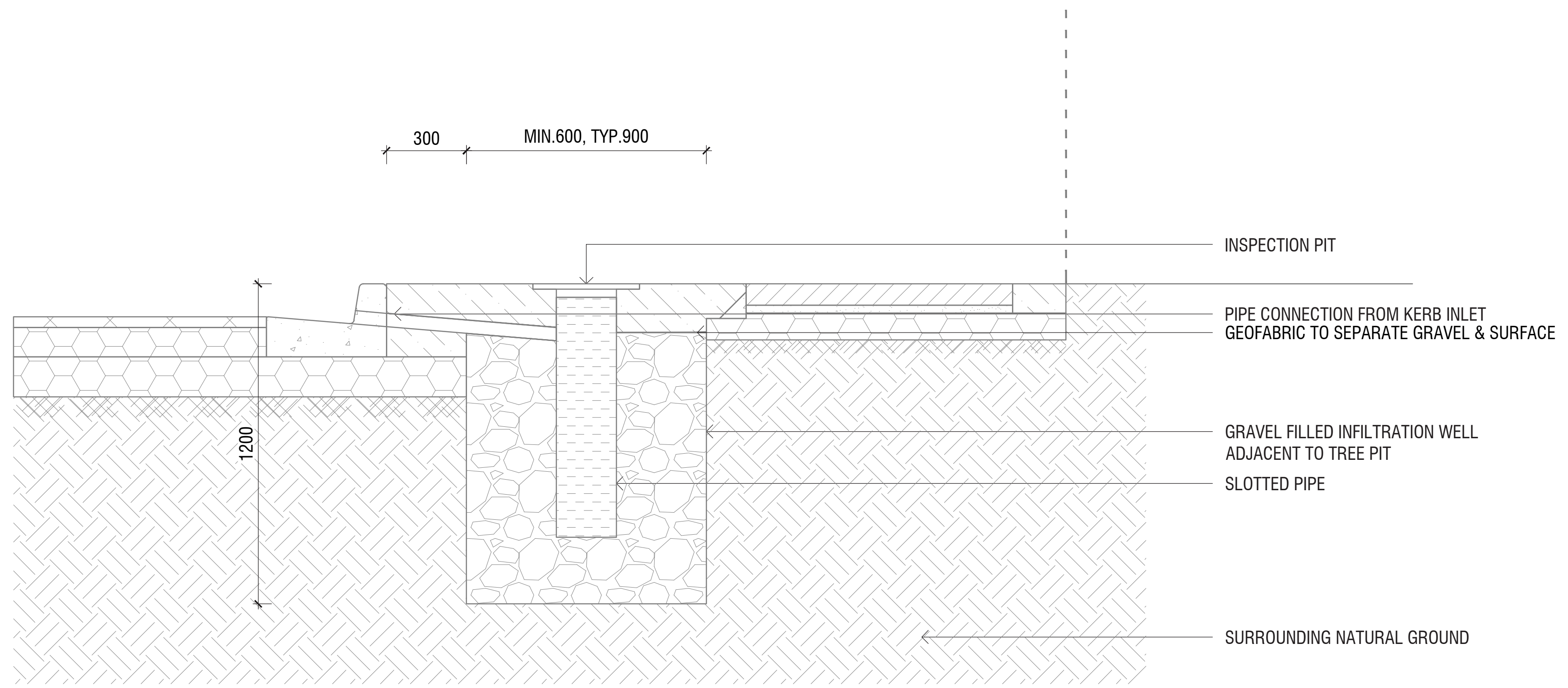
Date: Aug 20

Project No: 01520

Drawing No: WK1

Status: PRELIMINARY





1 WK2: LEAKY WELL

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 2.5M3
INFILTRATION: 4.5M2

Amendments:

Rev.	Date	Amendments	Initial

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FOOTPATH WIDTH:

PREFERRED WIDTH:	1350mm
MIN. WIDTH FOR LENGTH OF <2m:	900mm
MIN. WIDTH FOR LENGTH OF >2m:	1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

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Project: Street Trees in Challenging Spaces
City of West Torrens

Title: TREE PLANTING DETAILS
ACCESS TO WATER
KERB & WATERTABLE

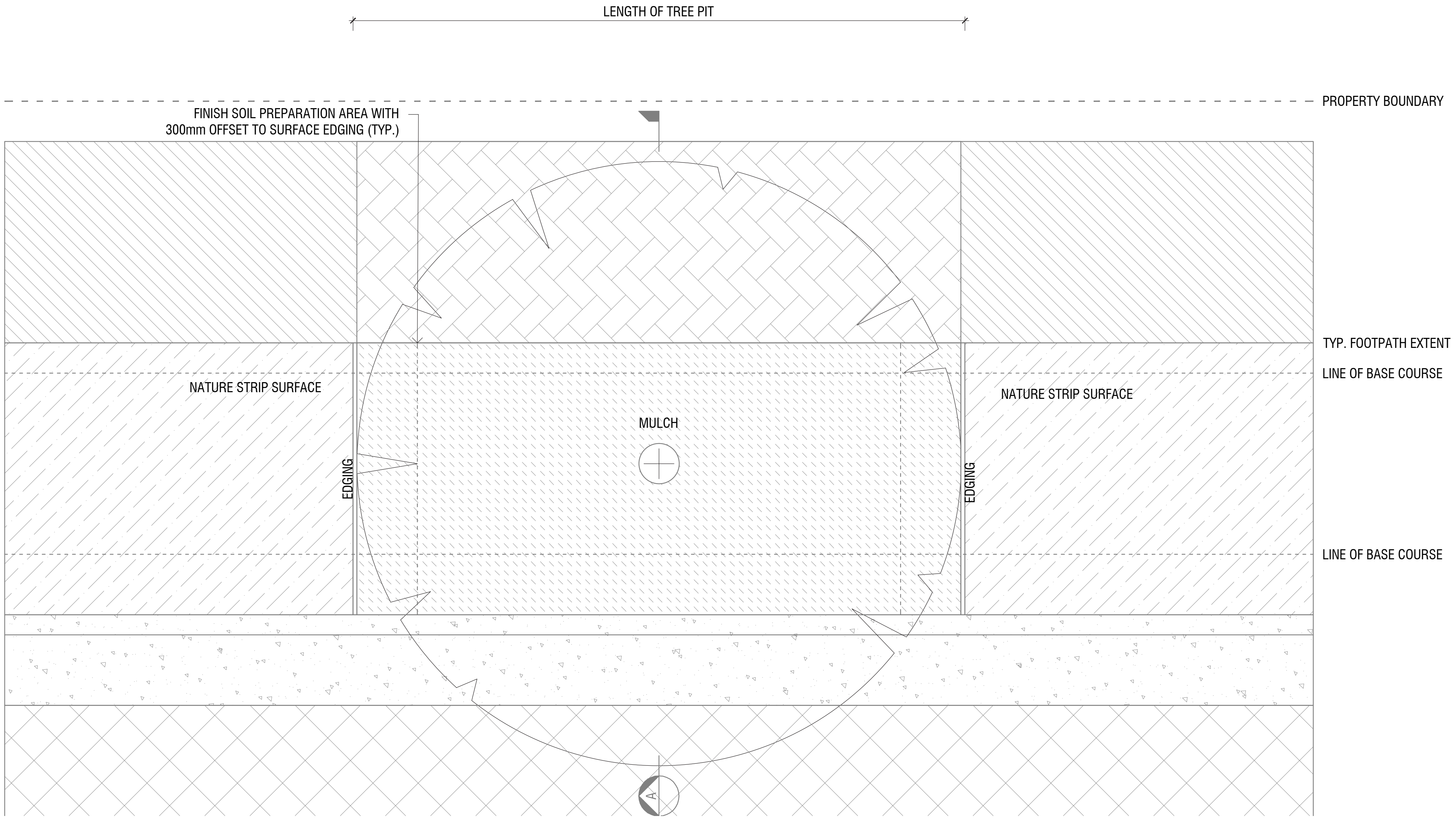
Scale: 1:25 @ A3

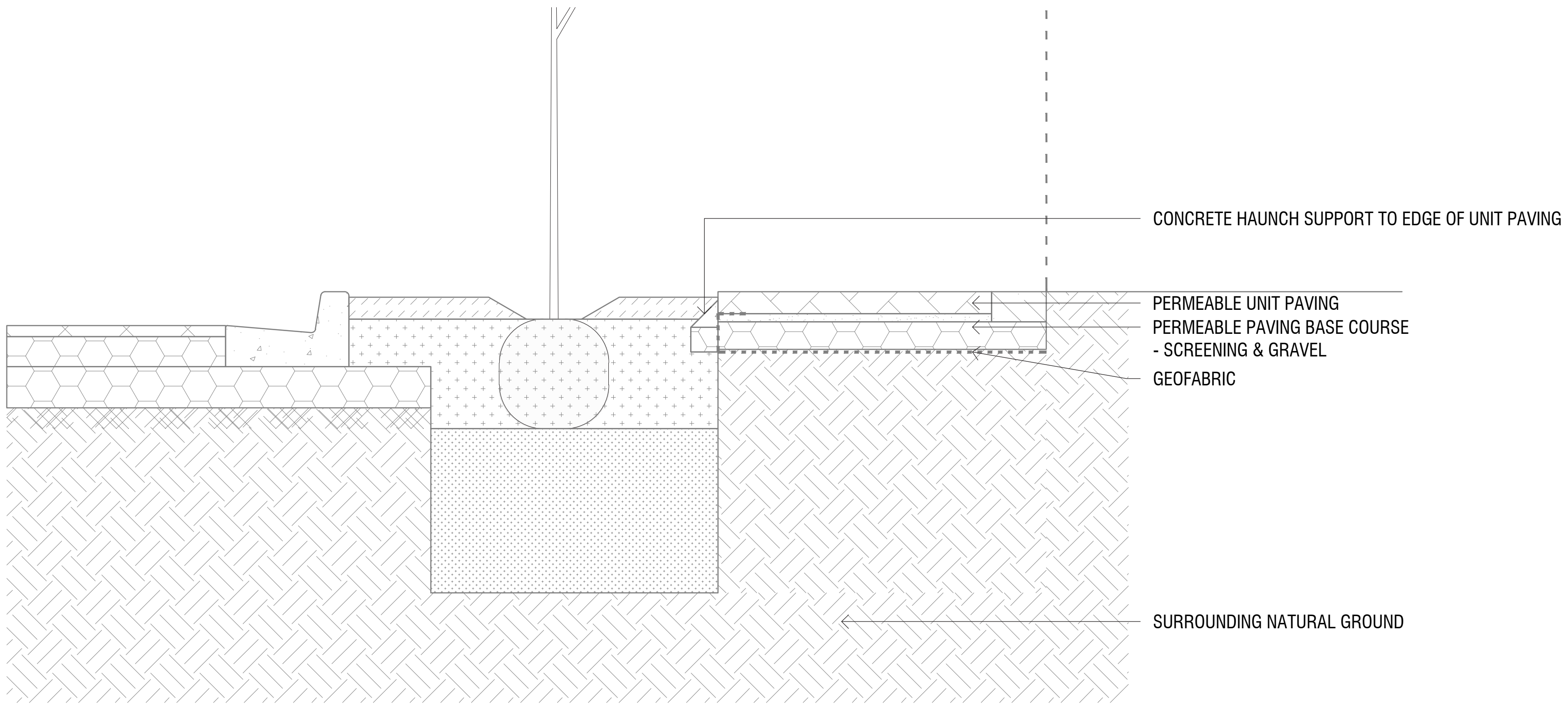
Date: Aug 20

Project No: 01520

Drawing No: WK2

Status: PRELIMINARY





1 WS1: PERMEABLE PAVING

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 6.5M3
INFILTRATION: 7M2

Amendments:

Rev.	Date	Amendments	Initial

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FOOTPATH WIDTH:

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MINIMUM TREE OFFSET TO KERB: 400mm

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Project: Street Trees in Challenging Spaces
City of West Torrens

Title: TREE PLANTING DETAILS
ACCESS TO WATER
SURFACE TREATMENT

Scale: 1:25 @ A3

Date: Aug 20

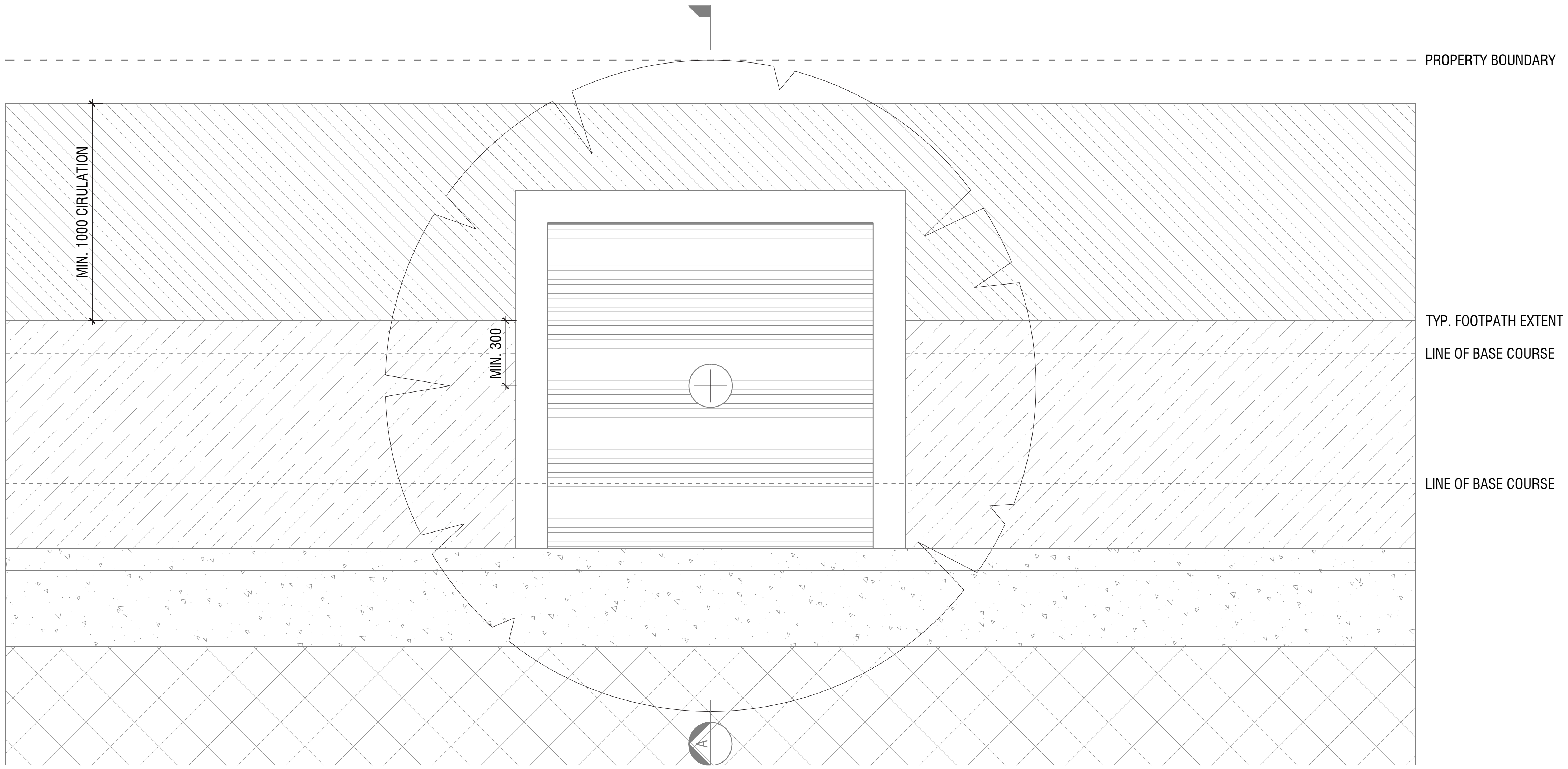
Project No: 01520

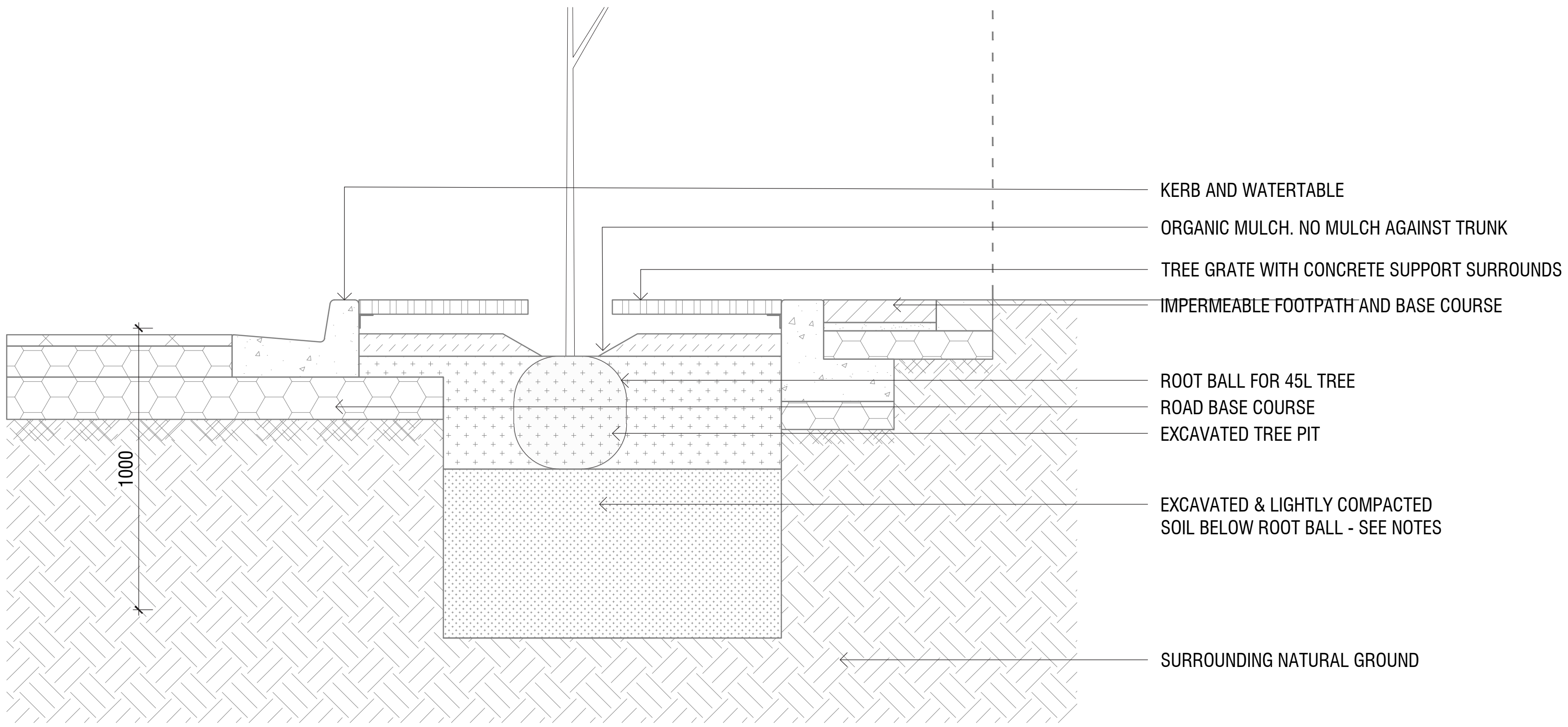
Drawing No: WS1

Status: PRELIMINARY

Amendments:

Rev.	Date	Amendments	Initial





1 | WS2: TREE GRATE

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 1.8M3
INFILTRATION: 2.2M2

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FOOTPATH WIDTH:

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MIN. WIDTH FOR LENGTH OF >2m:	1000mm

MINIMUM TREE OFFSET TO KERB: 400mm

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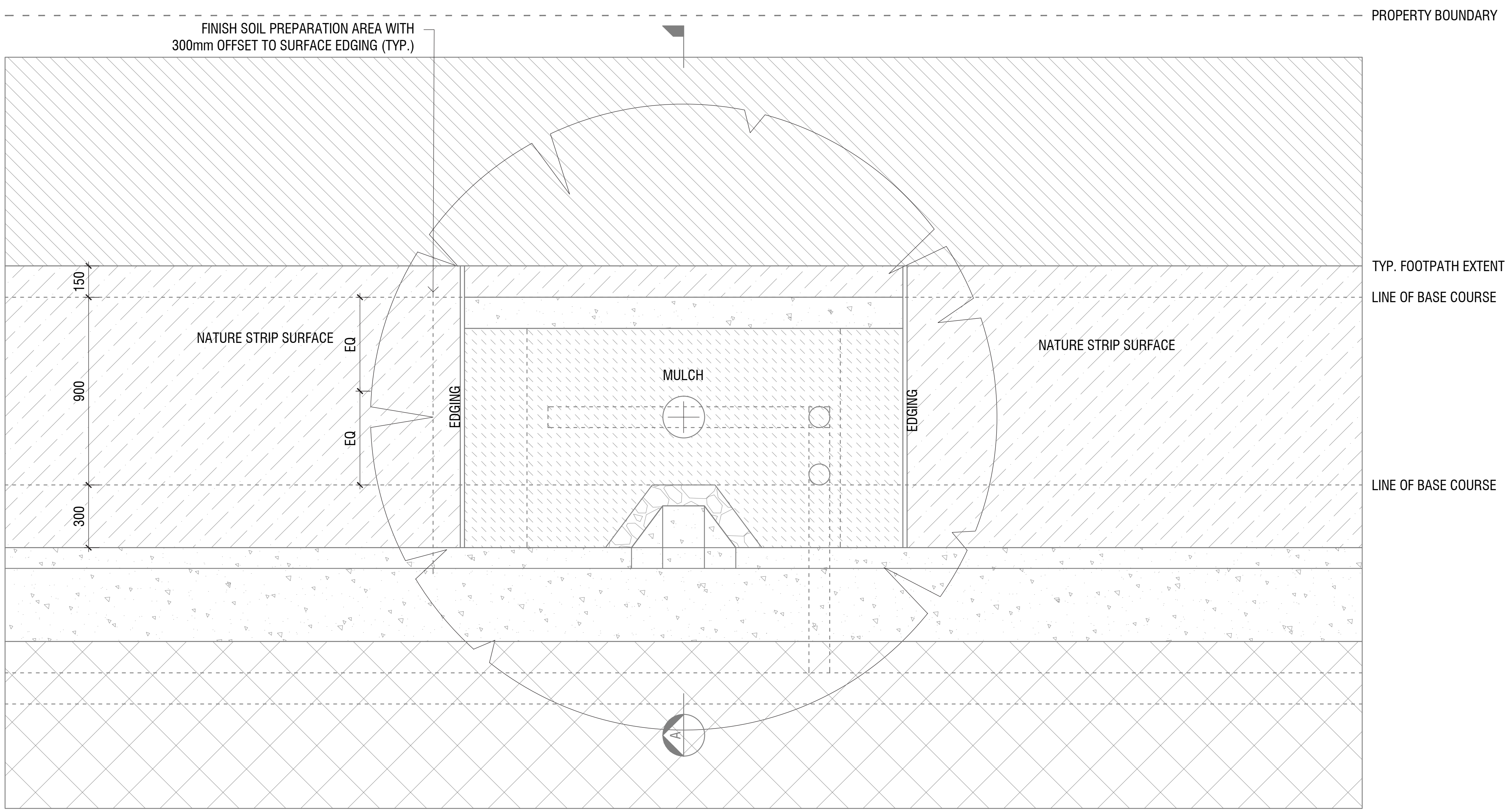
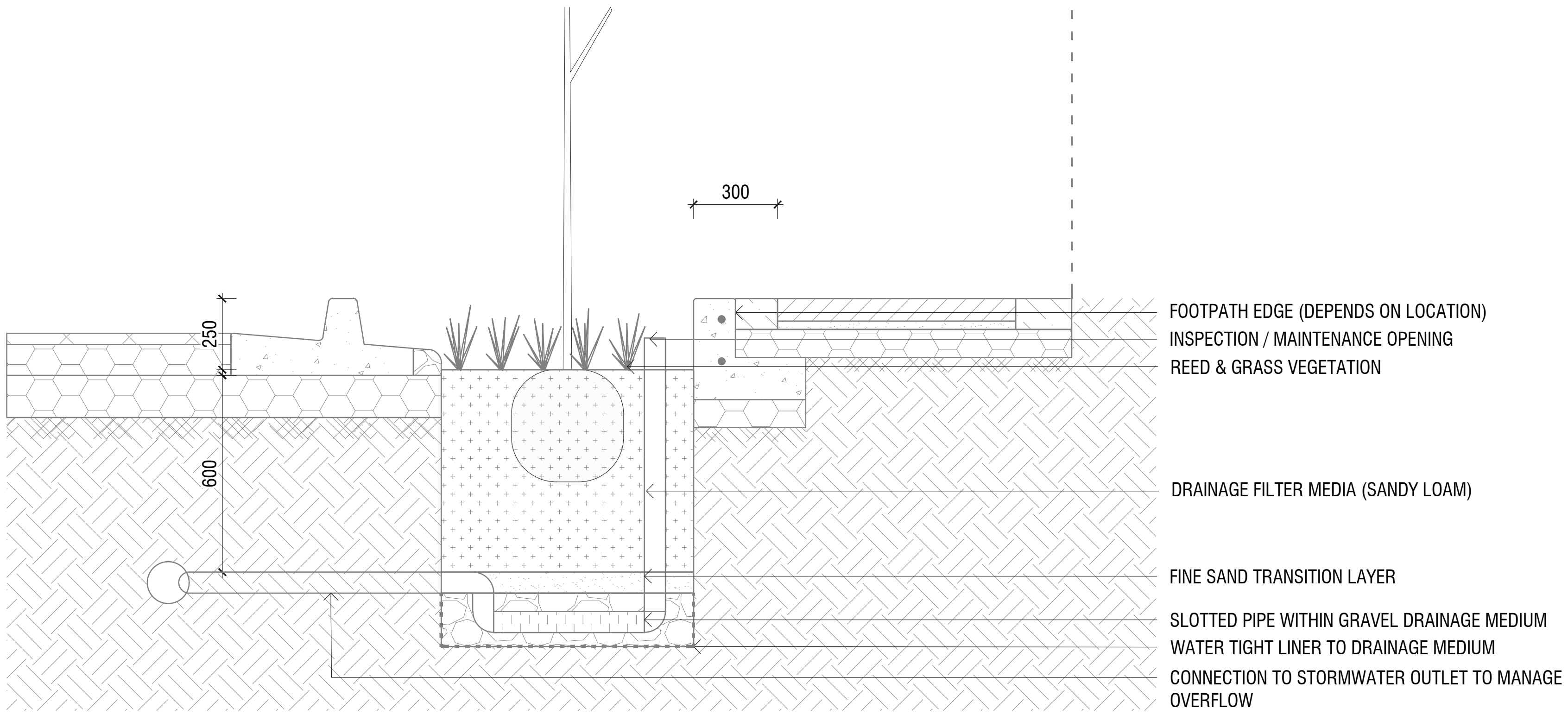
Project:	Street Trees in Challenging Spaces City of West Torrens
Title:	TREE PLANTING DETAILS ACCESS TO WATER SURFACE TREATMENT
Scale:	1:25 @ A3
Date:	Aug 20
Project No:	01520
Drawing No:	WS2
Status:	PRELIMINARY





1 WP1: RAINGARDEN

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 0M3
INFILTRATION: 0M2+

Amendments:

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MINIMUM TREE OFFSET TO KERB: 400mm

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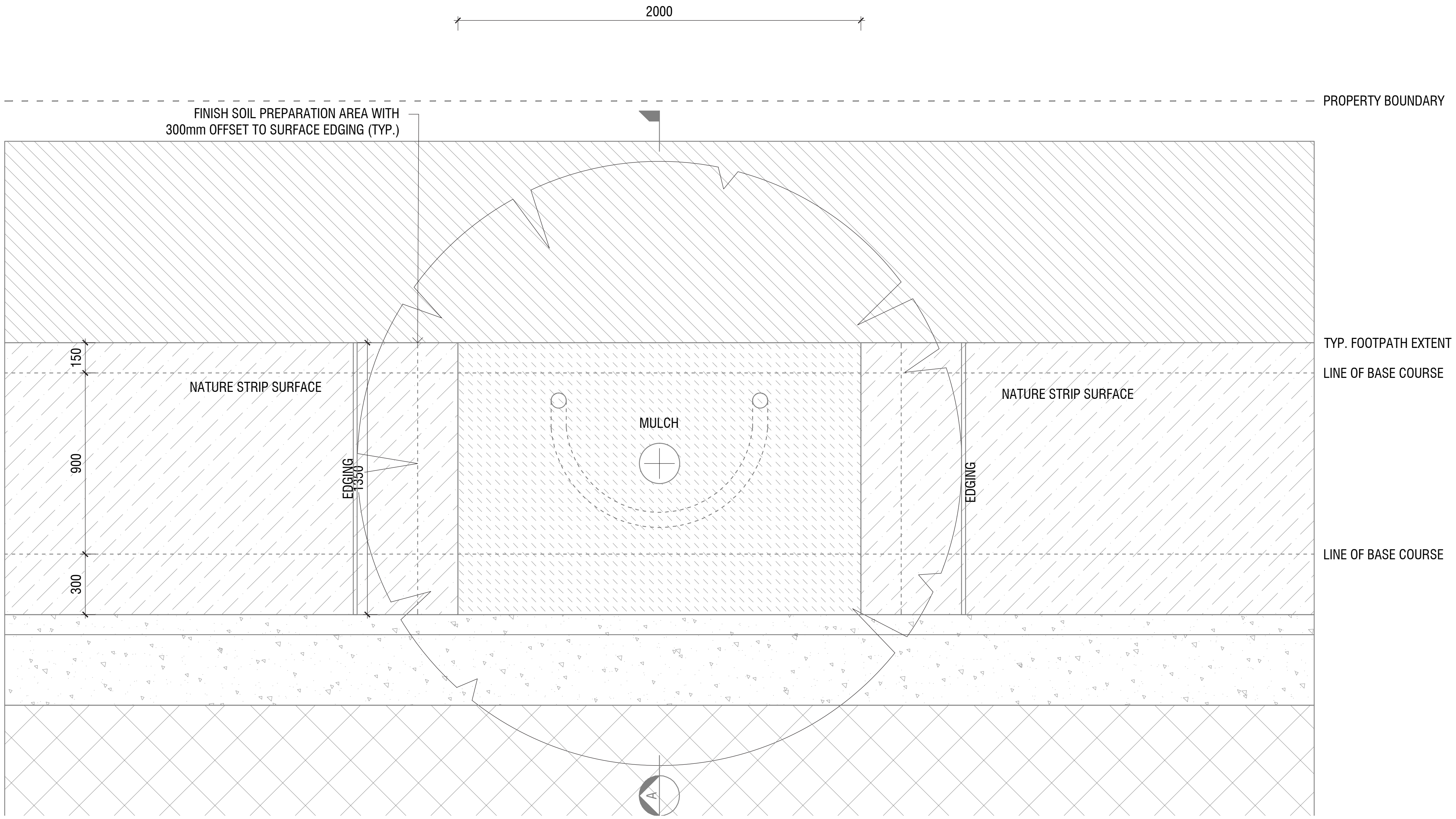
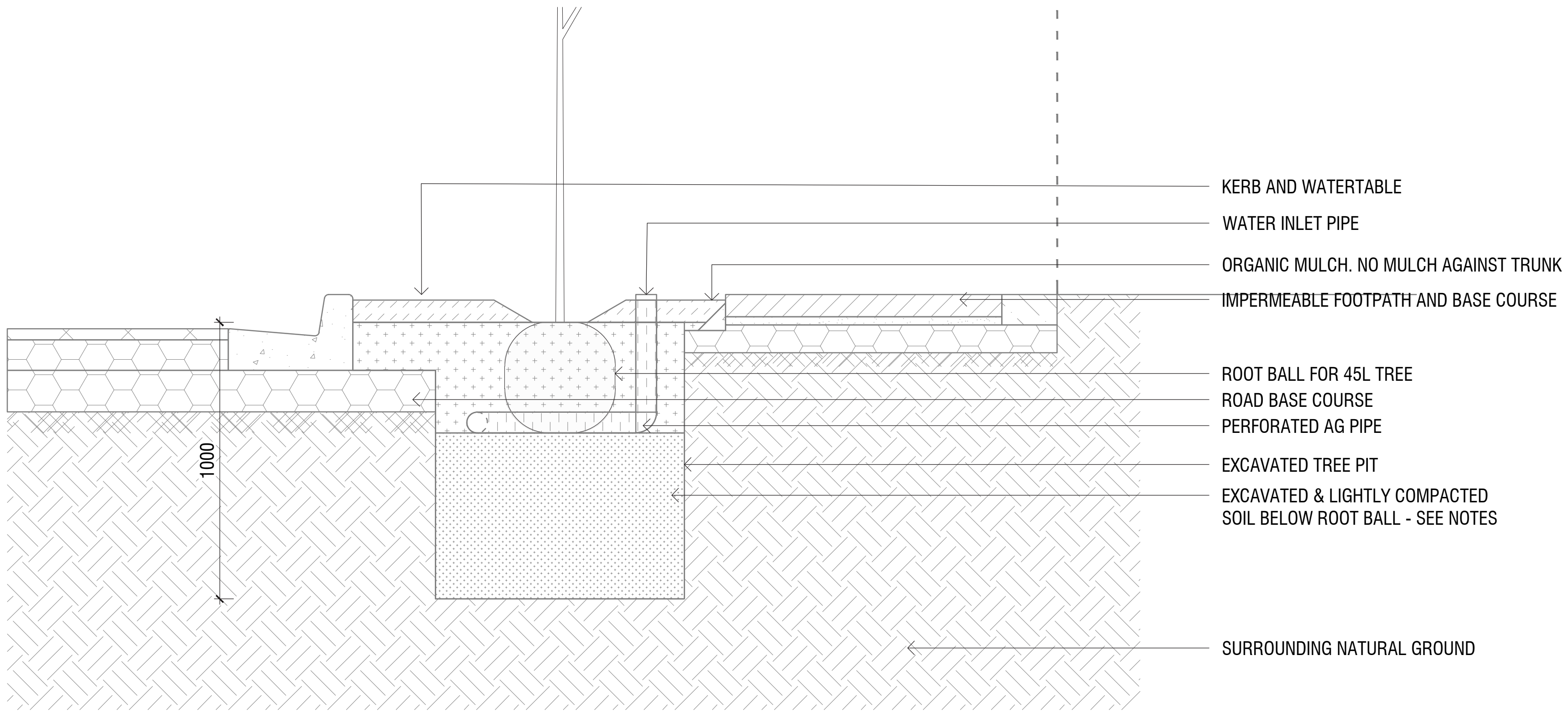
Title:	TREE PLANTING DETAILS ACCESS TO WATER PASSIVE IRRIGATION
Scale:	1:25 @ A3
Date:	Aug 20
Project No:	01520
Drawing No:	WP1
Status:	PRELIMINARY





1 | WP2: AG PIPE CONNECTION

scale: 1:25 @ A3

AVAILABLE SOIL VOLUME: 1.9M3
INFILTRATION: 2.7M2+

Amendments:

Rev.	Date	Amendments	Initial

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Project: Street Trees in Challenging Spaces
City of West Torrens

Title: TREE PLANTING DETAILS
ACCESS TO WATER
PASSIVE IRRIGATION

Scale: 1:25 @ A3

Date: Aug 20

Project No: 01520

Drawing No: WP2

Status: PRELIMINARY

Appendices

City of West Torrens Trees in Challenging Spaces
Tree species selections

Species		Size			Soil Volume	Recommended - Authorities					Tree Type	Recommended Tree Species - Adelaide Metropolitan Councils								Notes	Councils
Scientific	Common	Height m	Width m	Trunk mm	m3	DPTI	OTR	SAPN	Sewer <2m	<3.5m		CWT	Burnside	Charles Sturt	Marion	Salisbury	Prospect	Playford	Holdfast Bay		
Acacia cultriformis	Knife-leaf Wattle	4	4				2	.	.												0
Acacia oswaldii	Umbrella Wattle	5	5				2	.		p											0
Acacia pendula	Weeping Myall	10	8														.			Not suitable beneath powerlines	1
Acacia pycnantha	Golden Wattle	6	6				2	.	p												0
Acacia victoriae spp. victoriae	Elegant Wattle	5	5				2	.	p												0
Acer buergerianum	Trident Maple	8	4	420	33.6		2					.				.	.			Slow growing	3
Acer campestre	Field Maple							.								.	.				2
Acer fremanii	Freeman Maple													.						Slow growing, large optimum size, can be constrained in Adelaide	1
Acer monspessulanum	Montpelier Maple	8	8					.		.											0
Acer negundo 'Sensation'	Box Elder Maple Sensation	8	6	350	28							.					.			Roots can be vigurous	2
Agonis flexuosa	Willow Myrtle	15	15							.			.		.				.	Large trunk, small roots,	3
Albizzia julibrissan	Silk Tree	5	4														.				1
Allocasuarina verticillata	Drooping She-oak, Southern Lofty	8	6					.							.						1
Angophora costata	Smooth-Barked Apple Myrtle	20	10	680	136	.				.	LARGE	.	.	.	.				.		5
Angophora hispida	Dwarf Apple	7	3				2	.	p						.					Stock availability low, but makes a great small tree	1
Araucaria sp.	Southern Conifers																				0
Araucaria heterophylla	Norfolk Island Pine	30	15																.		1
Arbutus x andrachnoides	Hybrid Strawberry Tree	8	8					.		.											0
Banksia integrifolia	Coast Banksia	20	10					.	p					.					.	Possibility as a coastal species	2
Banksia marginata	Silver Banksia	10	5					.												Possibility as a coastal species	0
Bauhinia variegata	Orchid Tree	6	3				2	.	.				.						.		2
Brachychiton acerifolius	Illawarra Flame Tree	40	15							.			.			.				Trunk size can be an issue	2
Brachychiton acerifolia x populneus	Bella Donna							.		.						.					1
Brachychiton discolor x populneus	Griffith Pink	8	7					.	.	.										Trunk size can be an issue	0
Brachychiton populneus	Kurrajong	20	6							.			.						.	Trunk size can be an issue	2
Brachychiton populneus x acerifolius 'Jerilderie Red'	Glorious Brachychiton	10	8																.	Trunk size can be an issue	1
Brachychiton rupestris	Bottle Tree	8	4										.							Trunk size can be an issue	1
Buckinghamii celssisimia	Ivory Curl Flower												.								1
Callistemon citrinus	Bottlebrush	5	5				2	.	.											Root system can be large, trunk flare, surface roots	0
Callistemon citrinus 'Splendens'	Bottlebrush	4	4				2	.												Root system can be large, trunk flare, surface roots	0
Callistemon citrinus x viminalis 'Harkness'	Harkness	6	4	200	12	.	2	.	.				.	.			.		.	Root system can be large, trunk flare, surface roots	4
Callistemon 'King's Park Special'	Bottlebrush	5	4				2	.	p				.							Root system can be large, trunk flare, surface roots	1
Callistemon viminalis	Bottlebrush	6	4	300	18	.	2	.	.				.							Root system can be large, trunk flare, surface roots	1
Callitris gracilis	Southern Cypress Pine	20	8					.	.				.				.				2
Callitris verrucosa	Mallee Pine	5	3				2	.		p											0
Calodendron capense	Cape Chestnut	10	6																.		1
Celtis australis	Southern Hackberry	11	10	500	55	.				.			.	.	.		.		.		5
Celtis laevigata	Mississippi Sugar Berry	15	4														.				1
Celtis occidentalis	Hackberry	11	10	400	44					.		.	.		.		.			Root system aggressive, invasive fruiting	4
Cercis canadensis 'Forest Pansy'	Eastern Redbud	10	4					.			SMALL					.				Good species	1
Cercis siliquastrum	Judas Tree	6	4	200	12	.											.				1
Citrus glauca	Lime Bush	7	6					.													0
Citrus limon 'Eureka'	Lemon	6	6					.													0
Citrus limon 'Lisbon'	Lemon	6	6					.													0
Citrus x sinensis 'Washington Navel'	Washington Navel Orange	5	3					.													0
Corymbia citriodora	dwarf varieties							.													0
Corymbia eximia 'Nana'	Dwarf Yellow Bloodwood	8	7					.													0
Corymbia ficifolia	Red Flowering Gum	10	5							.	MEDIUM		.	.		.			.		4
Corymbia ficifolia Dwarf	Dwarf Red Flowering Gum						2												.		1
Corymbia maculata	Spotted Gum	20	10	500	100	.							.	.	.				.		4
Crataegus oxycantha	Hawthorn																.				1
Cupaniopsis anacardioides	Tuckeroo	8	5	300	24	.		.			MEDIUM		.	.	.			.	.		5
Eucalyptus albopurpurea	Port Lincoln Gum	18	8					.													0
Eucalyptus calycogona	Square-fruited Mallee	6	6					.	.												0
Eucalyptus camaldulensis	River Red Gum	40	15										.								1
Eucalyptus cosmophylla	SA Cup Gum	10	10				2		.				.								1
Eucalyptus erythronema var. erythronema	Red Flowering Mallee	9	4				2	.	.												0
Eucalyptus leucoxylon 'Goolwa Gem'														.							1
Eucalyptus kruseana	Book-leaf Mallee	4	6				1	.	.												0
Eucalyptus lansdowneana	Crimson Mallee Box	6	6				2	.													0
Eucalyptus leucoxylon	Blue Gum	20	10	500	100	.					LARGE		.	.							2
Eucalyptus leucoxylon 'Euky Dwarf'	Euky Dwarf	8	5	240	19.2	.	2	.				.		.						Not as dwarf as they appear	2
Eucalyptus leucoxylon 'Megalocarpa'	Large Fruited Yellow Gum	12	10											.	.						2
Eucalyptus leucoxylon 'Rosea'	Red Flowering Yellow Gum	20	18																.		1
Eucalyptus melliodora	Yellow Box	35	30										.								1
Eucalyptus microcarpa	Grey Box Gum	20	20										.								1

Eucalyptus nicholii	Narrow Leaf Peppermint	18	10																	.		1
Eucalyptus orbifolia	Round-leaved Mallee	6	8				2	.	.													0
Eucalyptus platypus	Round-leaved Moort	8	8					.		.												0
Eucalyptus porosa	Mallee Box Gum	14	12							p			.		.							2
Eucalyptus torquata	Coral Gum	8	4	200	16	.				.				.	.	.						3
Eucalyptus viridis	Green Mallee	6	5				2	.		.												0
Eucalyptus websteriana	Webster's Mallee	6	6				2	.	.													0
Ficus microcarpa var. hillii	Hill's Weeping Fig	15	10																	.		1
Flindersia australis	Crows Ash	20	15											.								1
Flindersia maculosa	Leopardwood												.									1
Fraxinus angustifolia 'Raywoodii'	Claret Ash	12	9	500	60	.	2						.		.					.		3
Fraxinus griffithii	Evergreen Ash	7	4	200	14	.		.					.				.					2
Fraxinus ornus	Manna Ash	10	7	200	20	.	2			.				.			.					2
Fraxinus ornus 'Meczek'	Flowering Ash							.														0
Fraxinus pannsylvanica 'Urbanite'	Urbanite Ash	11	8	300	33	.								.								1
Fraxinus pannsylvanica 'Cimmaron'	Cimmaron Ash	15	8										.									1
Fraxinus rotundifolia	Ash																.					1
Geijera parviflora	Wilga	9	10				2	.	.				.	.	.	.				.		5
Ginkgo biloba	Maidenhair	11	6	420	46.2	.				p	MEDIUM	.	.	.							Good tree, growth can be constrained by roots	3
Gleditsia tricanthos	Honey Locust																			.		1
Gleditsia triacanthos 'Continental'	Honey Locust							.		.							.					1
Gleditsia triacanthos 'Ruby Lace'	Honey Locust																.					1
Gleditsia triacanthos 'Shademaster'	Weeping Gleditsia	20	8										.									1
Gleditsia triacanthos 'Sunburst'	Honey Locust																.					1
Hakea laurina	Pin-cushion Hakea	5	4					.	.					.							Worth a mention, can be pruned up to single stem	1
Harpullia pendula	Tulipwood	15	3										.									1
Hibiscus tiliaceus 'Rubra'	Red Cotton Tree	8	8				1	.	.													0
Hymenosporum flavum	Native Frangipani	15	6	300	45	.				.											Where height available	0
Jacaranda mimosifolia	Jacaranda	10	8	330	33	.				.	MED/LARGE	.	.	.	.	.	.		.	Larger situation	7
Koelreuteria bipinnata	Chinese Flame Tree	10	5	400	40	.		.					.	.	.	.	.					5
Koelreuteria paniculata	Golden Rain Tree	8	8	220	17.6	.	2	.		.	SMALL	.	.	.	.	.	.	.	.		8
Laburnum speciosum	Laburnum						2			.			.									1
Lagerstroemia indica x fauriei 'Tuscarora'	Crepe Myrtle	6	5	220	13.2	.	2	.	.		SMALL	.	.	.	.		.			Tuscarora the preferred street species	5
Lagerstroemia x indica 'Biloxi'	Crepe Myrtle	6	5				2		.				.	.	.		.		.		5
Lagerstroemia x indica 'Lipan'	Crepe Myrtle	4	3				2		.				.	.	.		.				4
Lagerstroemia x indica 'Sioux'	Crepe Myrtle						2		.				.	.	.		.				4
Lagerstroemia x indica 'Natchez'	Crepe Myrtle	8	5				2		.				.	.	.		.		.	Form wider than Tuscarora	5
Lophostemon confertus	Queensland Box	15	8											.	.	.	.	.			5
Malus ionensis	Crab Apple								.				.									1
Malus ionensis plena	Bechel's Crab	4	3				2										.					1
Melaleuca decussata	Crossed-leaved Honey Myrtle	5	4				1	.	p													0
Melaleuca halmaturorum	KI Paperbark	6	6				2	.		.												0
Melia azedarach 'Elite'	White Cedar	8	9	350	28	.				.			.	.			.					3
Metrosideros excelsa	New Zealand Christmas Tree	15	5																.			1
Myoporum platycarpum	Sugarwood	6	4					.		p												0
Pistacia chinensis	Chinese Pistachio	8	8	240	19.2	.		.		p	MED/LARGE	.	.	.	.	.	.	.	.	Medium to large tree, suitable to wide spaces	8
Pittosporum angustifolium	Native Apricot	10	5					.	.													0
Platanus x acerifolia	London Plane Tree	14	10	400	56	.					LARGE				.			.	.			3
Platanus insularis	Cyprian Pine	25	8										.									1
Platanus orientalis	Oriental Plane Tree	15	10	500	75	.																0
Platanus orientalis 'Liberty'	Plane Tree																.					1
Podocarpus lawrencei	Mountain Plum Pine	6	3				1	.														0
Prunus x blireana	Flowering Plum	5	3	200	10	.	2		.					.								1
Prunus cerasifera 'Nigra'	Purple-leaved Cherry Plum	6	5				2	.	.								.					1
Prunus cerasifera 'Oakville Crimson Spire'	Flowering Plum	6	2					.	.					.								1
Prunus fruticosa 'Globosa'	Designer Cherry							.	.													0
Pyrus betulaefolia 'Southworth Dancer'	Southworth Dancer	8	5					.		p												0
Pyrus calleryana	Callery Pear	15	6				2												.			1
Pyrus calleryana 'Bradford'	Bradford' Callery Pear	10	8	500	50			.		p		.				.						2
Pyrus calleryana 'Capital'	Capital' Callery Pear	11	4	420	46.2	.		.		p	MEDIUM	.	.	.			.			Good street tree	4
Pyrus calleryana 'Chanticleer'	Chanticleer' Callery Pear	11	6	350	38.5	.				p			.	.	.		.			Prefer Chanticleer over Bradford	4
Pyrus calleryana x betulaefolia 'Edgedell'	Ornamental Pear							.		p												0
Pyrus nivalis	Snow Pear									p			.									1
Pyrus ussuriensis	Manchurian Pear	12	10	400	48	.				p			.	.			.		.			4
Quercus ilex	Holm Oak	24	12											.								1
Quercus palustris	Pin Oak	15	8	500	75	.					LARGE		.		.							2
Quercus palustris ' Green Pillar'	Green Pillar Pin Oak	14	3	350	49	.																0
Quercus robur	English Oak	20	6										.									1
Quercus rubra	Red Oak	10	9	300	30	.																0
Quercus suber	Cork Oak	20	15											.								1
Robinia	Mop Top Robinia						2												.			1
Santalum acuminatum	Quandong	5	4				2	.														0
Sapium sebiferum	Chinese Tallow	8	6	240	19.2	.				p		.	.	.		.	.		.	Seeds can be hard and create a slipping hazard	6

Sophora japonica	Japanese Pagoda Tree	6	5			.		.							.		.			2
Tilia rubra	Red Cottonwood														.					1
Toona australis	Red Cedar												.							1
Triadica sebiferum	Chinese Tallowtree														.					1
Tristaniopsis laurina	Kanooka Gum	10	5				2	.		p	MEDIUM					.		.	Include where it will receiving rainfall	2
Ulmus cornubiensis	Cornish Elm												.							1
Ulmus glabra 'Lutescens'	Golden Elm	12	12										.							1
Ulmus parvifolia	Chinese Elm	10	11							p			.	.	.		.	.		5
Ulmus procera	English Elm	16	11										.							1
Zelkova serrata	Japanese Zelkova	10	10	450	45							.	.		.					3
Zelkova serrata 'Green Vase'	Japanese Elm	14	10	300	42	.								.		.			Suitable species	2
Zelkova serrata 'Mushashino'	Japanese Elm	14	10	300	42	.													Suitable species	

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JPE Design Studio
www.jpe.com.au

Level 4, 19 Gilles Street
Adelaide SA 5000
(08) 8406 4000
design@jpe.com.au