Green-Blue Infrastructure Manual

Design Consultant Summary

Stonnington City Council

City of STONNINGTON

E2DESIGNLAB

1. INTRODUCTION

1.1 How to use this guide

This is summary of the Green-Blue Infrastructure Manual and is intended to be used as a guide for design consultants. Refer to the original Manual for additional information.

Chapter 1: Introduction
Context and drivers for Green-Blue assets.

Chapter 2: What is Green-Blue Infrastructure
Brief description of terminology.

Chapter 3: Design principles and steps
A series of guiding design principles and a step-by-step plan on how to implement them.

Chapter 4: Design responses
Visual summary of Green-Blue streetscape responses.

Chapter 5: Identify site constraints
An overview of key site considerations that can influence the success of Green-Blue assets.

Chapter 6: Identify design response
Suggested design responses for eight common site types in the City of Stonnington.

Appendix: Technical drawings and specifications:
Cross-sectional drawings and technical specifications that can be adapted for use within a project.

1.2 Vision and Context

The City of Stonnington (Council) aspires to be an inclusive, healthy, creative, sustainable and smart community. However, it is faces a range of challenges, including:

- Urbanisation: Development pressures are creating more impermeable surfaces like roofs, roads and paths. This increases stormwater flows and stormwater pollutants (i.e. oil, grease, litter, nutrients, sediment etc) sent to downstream aquatic environments (i.e. Yarra River and Port Phillip Bay). This leads to poor water quality, waterway health and potential nuisance flooding.
- Climate change: Metropolitan Melbourne is facing greater heat-related health risks with increased frequency, duration and intensity of heatwaves. These risks are amplified by the urban heat island effect in heavily built-up areas like Stonnington. Future droughts also risk the health and longevity of Stonnington's street trees, gardens and parks from persistent shortfalls in soil moisture.
- Population growth: Stonnington's population is growing. This places a greater demand on existing public space and a need for public assets to be increasingly multi-functional.
- Community: Citizens expect accessible, vibrant, high-quality streetscapes and green open space. These attributes contribute to the city's sense of identity, amenity, and the provision of liveability and economic vitality.

1.3 Council Commitment

Council is committed to creating a sustainable and resilient City, with enhanced natural and urban environments that are enjoyed by the community. This will be achieved by the following objectives set by Council's *2017-2021 Plan*, *Sustainable Environment Strategy 2018-2023,* and *Urban Forest Strategy 2017-2022:*

- Improve stormwater quality entering waterways via Water Sensitive Urban Design (WSUD) treatments.
- Protect, maintain, and enhance biodiversity and liveability values through the development of its urban forest.
- Enhance design outcomes of public spaces, places and building via the integration of green infrastructure.

1.4 Purpose of this Guide

The purpose of this guide is to simultaneously support Council's stormwater quality, urban forestry, and public space objectives via the successful integration of Green-Blue infrastructure into Council's streetscape projects. It is aimed to be a practical and educational resource for professionals in streetscape planning, design, construction and maintenance.

Significant benefits can also be achieved through park scale Green-Blue infrastructure. This manual focuses on streetscapes and does not address these.

2. WHAT IS GREEN-BLUE INFRASTRUCTURE

Green Infrastructure

Green infrastructure commonly refers to 'green' urban elements such as trees, parks, gardens, nature strips, road medians and verges, as well as newer technologies such as green roofs, walls, and facades. For the purpose of this guide 'Green Infrastructure' focuses on street trees and the development of tree canopy to establish an urban forest.

It is widely recognised urban forests will play a vital role in maintaining the health and liveability of Australian cities. The City of Stonnington (Council) has a clear vision to address this need as set out in its *Urban Forest Strategy 2017-2022.*

Blue Infrastructure

Blue infrastructure refers to urban elements that manage drinking water, wastewater and stormwater. For the purpose of this guide 'Blue Infrastructure' focuses on Water Sensitive Urban Design (WSUD) measures used to manage stormwater. WSUD encompasses a range of innovative practices and assets that aim to restore the natural water cycle in urban environments and limit the environmental impacts of urbanisation.

Typical assets include rain gardens, bioretention cells, wetlands, and tree pits that capture and treat stormwater. A key function of these assets is to increase the quality and reduce the quantity of stormwater runoff flowing into aquatic environments via biological treatment, soil infiltration and evapotranspiration.

Green-Blue Infrastructure

For the purpose of this guide 'Green-Blue' infrastructure focuses on assets that jointly deliver on establishing a healthy urban forest and address Council's stormwater management needs through WSUD approaches.

When planned and designed well, Green-Blue infrastructure can passively deliver soil moisture to trees and vegetation and simultaneously treat and absorb urban stormwater runoff into the natural environment.

Suitable Green-Blue infrastructure assets for streetscapes include tree raingardens and self-watering tree pits. There are a range of potential approaches and design configurations to suit different contexts and drivers.

3. DESIGN PRINCIPLES AND STEPS

It is important to consider a broad range of factors and objectives in the design of streetscapes. These include various modes of transport, safety, stormwater, services and aesthetics.

The selection of appropriate streetscape Green-Blue measures is based on a set of principles that follow a logical series of questions about the opportunities and constraints at each site. The following principles guide Green-Blue measure selection and placement:

- Collaborate with other government agencies and the community to enhance beneficial outcomes of Green-Blue streetscape projects
- Deliver stormwater pollution and flow reduction
- Creation of comfortable micro-climates through canopy cover and increased soil moisture
- Improvement of urban biodiversity
- Enhance streetscape amenity values through replacement of hard surfaces with green landscape features promoting passive irrigation with stormwater
- Effectively integrate economic, environmental and social objectives into road and drainage business operations
- Undertake continuous review, innovation and improvement for road and drainage operations/programs delivered by Council

The following steps form the recommended structure to plan and implement Green-Blue infrastructure:

1. **Project planning meeting**

   An initial planning meeting with key project stakeholders is important for a successful Green-Blue infrastructure project.

2. **Identify site-appropriate Green-Blue responses**

   Most sites have several options for Green-Blue infrastructure. The first step is to identify site type and what responses are best suited.

3. **Determine preferred design configuration**

   To determine the optimal response from those available, the site's unique characteristics must be analysed.

4. **Concept design**

   Once a response has been decided, a concept design should be developed that addresses critical design elements.

5. **Functional design**

   Functional design involves detailed stormwater quality modelling (i.e. MUSIC), service proving, and initial budgeting.

6. **Detailed design**

   Detailed engineering drawings, specifications, and tender documents must be prepared to transition the project to construction.

4.

DESIGN RESPONSES

Tree Raingardens

Raingardens

Open tree pits

Grated tree pits

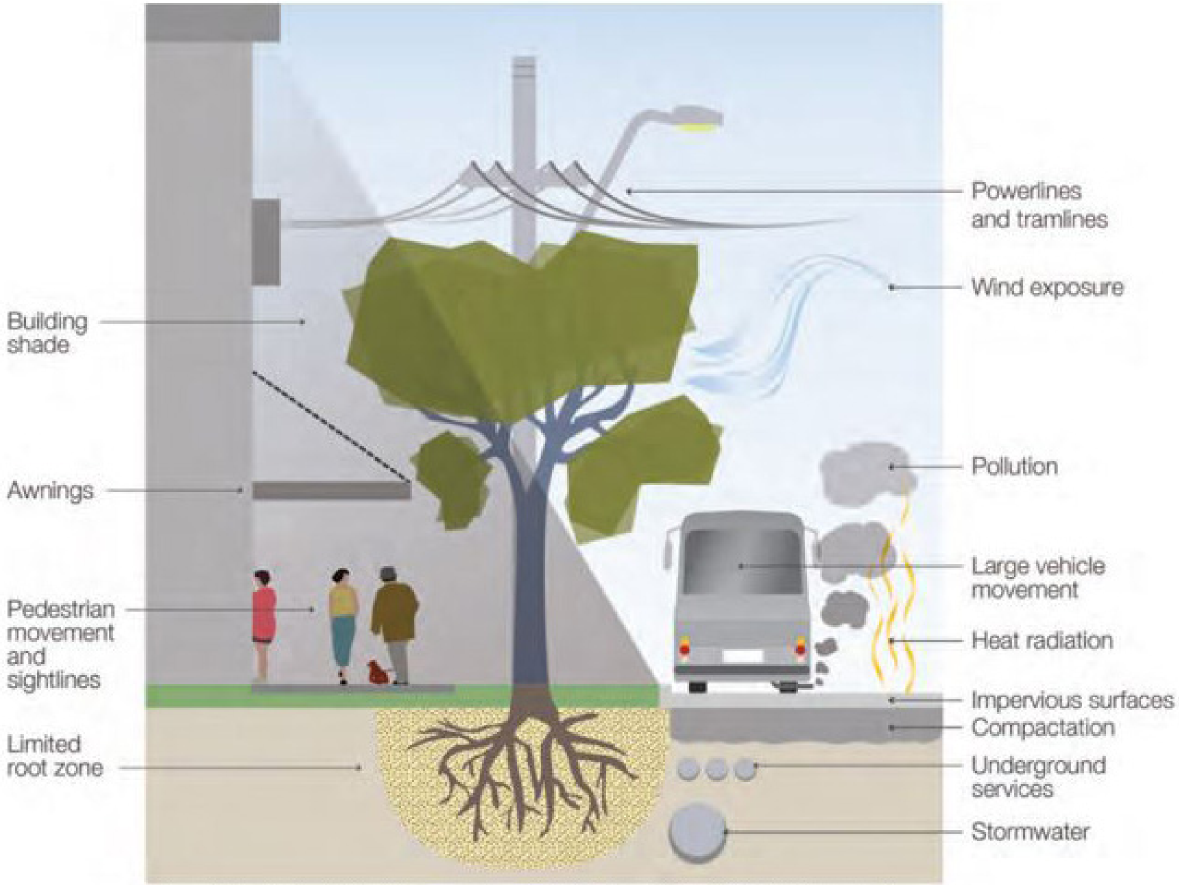
Permeable pavement & structural soil

Soil cell systems
(E.g. Citygreen Stratavault)

5. IDENTIFY SITE CONSTRAINTS

There are a range of site characteristics that influence the implementation of Green-Blue assets in streetscapes. A good understanding of a site's characteristics is key for appropriate asset location, placement, and its long-term success at the site. The table below lists some important considerations and some potential resulting issues.

Consideration	Potential issues
1. Sunlight and shade	• Stunted tree growth with less than 6 hours of filtered sunlight per day. Most tree species require full sun.
2. Overhead conditions	• Tree canopy conflicts with buildings, awnings, powerlines, tram lines etc.
3. Underground conditions	• Stunted tree growth from restricted soil volumes and waterlogging • Tree root conflicts with underground services
4. Maintenance access	• Safety issues in maintaining asset performance (i.e. tree canopy, asset drainage, debris collection)
5. Ground slope	• Poor stormwater treatment performance with an uneven infiltration zone • Potential soil erosion from fast entering flows
6. Catchment area	• Stunted tree growth from excessive drying out periods or frequent inundation events
7. Local debris	• Poor stormwater treatment performance from sediment and leaf litter clogging • Increased maintenance requirements from unsightly litter accumulation
8. Safety requirements	• Poor interface with other site activities and users (i.e. pedestrians, traffic) can create a potential hazard. • Asset damage from conflicting site activities (i.e. heavy foot traffic, parking)



There is no perfect site. The many constraints Green-Blue infrastructure must contend with in inner Melbourne.

6.

IDENTIFY DESIGN RESPONSE

The context and available space of a site are the most critical factors when deciding on a Green-Blue response and it's successful implementation. The traffic light table below can be used to identify appropriate responses for eight common site types across Stonnington. However, this table should only be seen as a high-level guide. Through innovative approaches and council aspirations, many Green-Blue responses can be successfully customised to suit the context of the site.

It should be noted that where passive irrigation is not feasible, increasing the soil volume available to trees will still improve canopy cover outcomes. The decision to enhance soil volume via structural soils or a soil cell system must be confirmed prior to detailed design as it difficult to make changes later on. Refer to the original Manual for a background to stormwater management and further information on the selection of project type and specific design configurations.

Contextual Green-Blue infrastructure responses

Common Site types		***Raingardens***		***Tree pits***		***Soil volume systems***	
		Tree raingarden	**Raingarden**	**Open tree pit**	**Grated tree pit**	**Permeable pavement & structural soil**	**Soil cell system (e.g. Strata-flow)**
Residential street with	kerb bump-outs	Proceed	Proceed	Consider	Avoid	Avoid	Avoid
	wide nature strips	Proceed	Proceed	Proceed	Avoid	Consider	Consider
	narrow nature strips	Avoid	Avoid	Consider	Consider	Proceed	Proceed
	no nature strips	Avoid	Avoid	Avoid	Proceed	Proceed	Proceed
Commercial shopping strip		Avoid	Avoid	Consider	Proceed	Proceed	Proceed
Laneway		Avoid	Avoid	Avoid	Avoid	Proceed	Proceed
Carpark		Proceed	Proceed	Proceed	Consider	Proceed	Proceed
Park and open space		Proceed	Proceed	Consider	Avoid	Consider	Consider

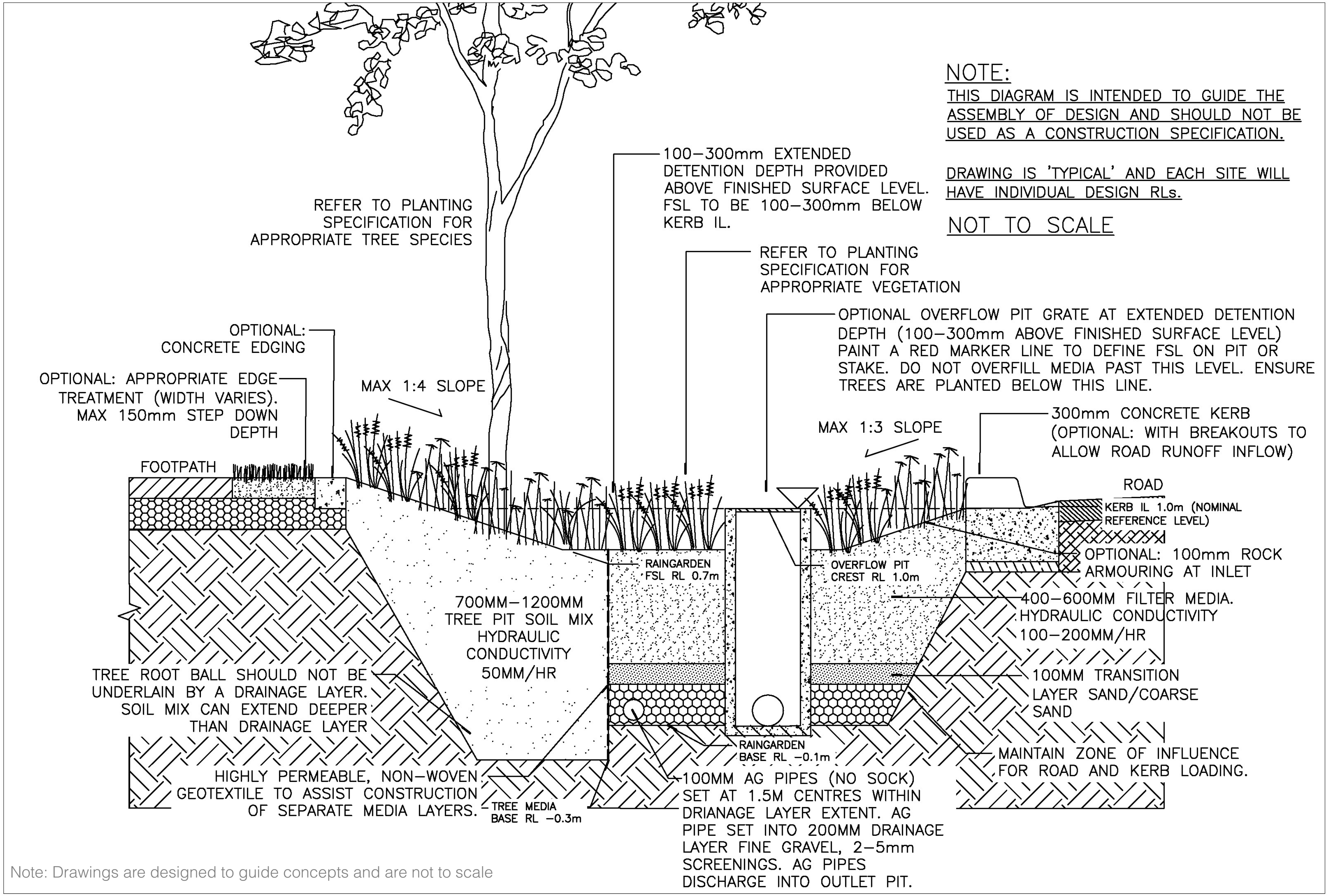
Legend: Proceed (green) Consider (yellow) Avoid (red)

APPENDIX A
Technical Design Drawings

Provides cross-sectional drawings of the following Green-Blue assets to guide future design. Drawings are not to scale and should not be used as a construction specification.

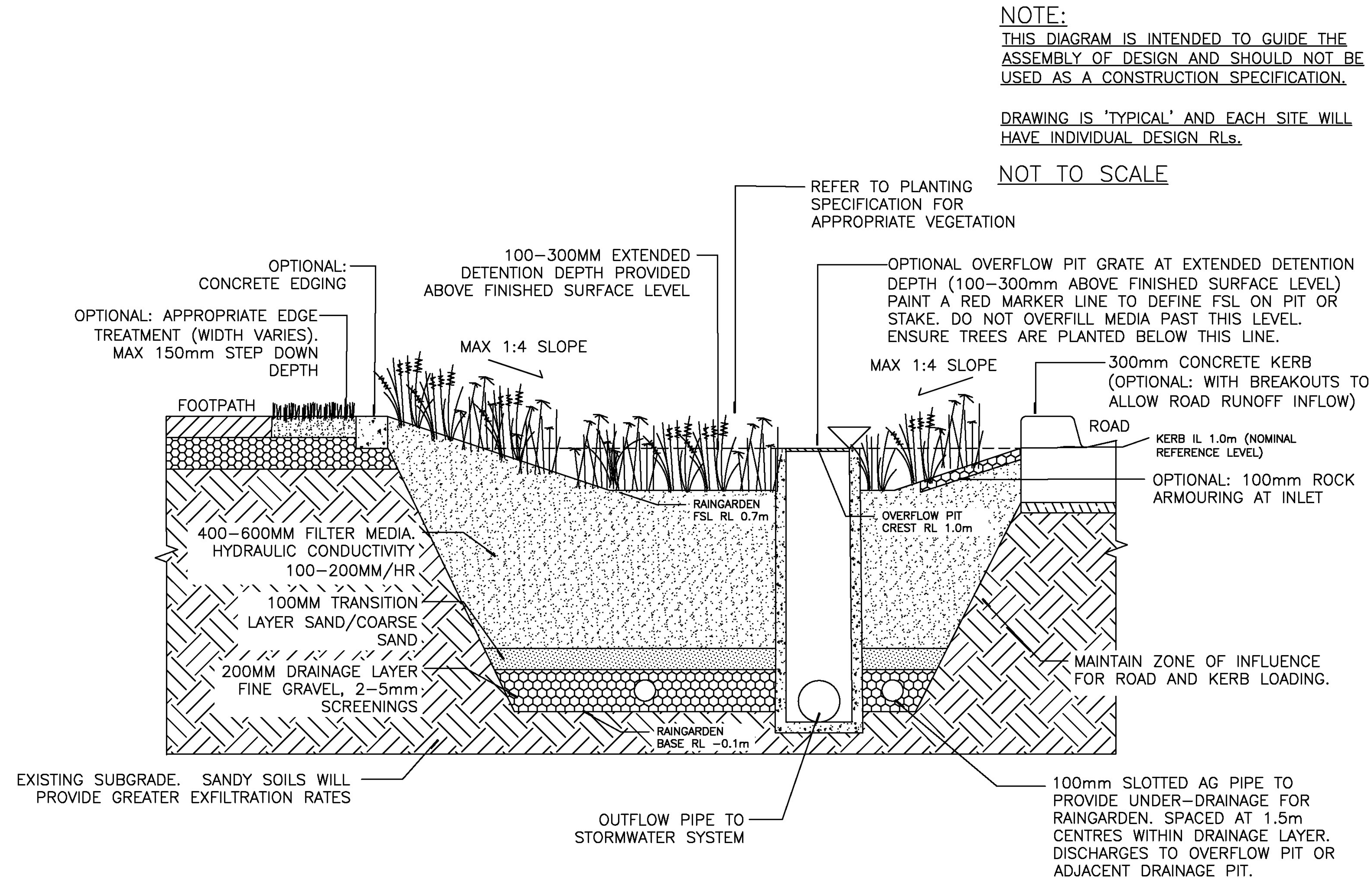
- Tree raingarden
- Raingarden
- Open tree-pit
- Grated tree-pit
- Soil Permeable
- Tree Planting

Tree Raingarden



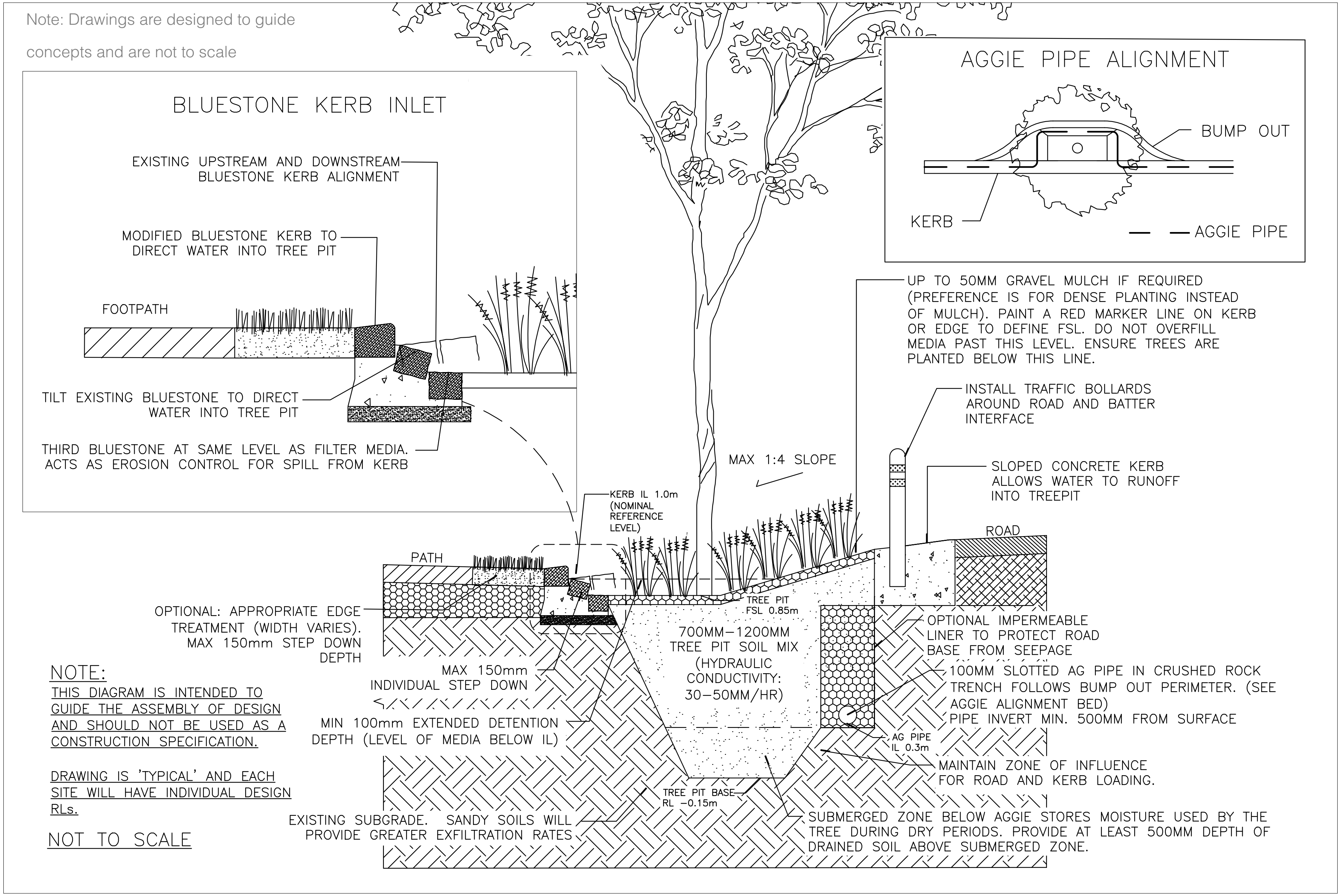
Note: Drawings are designed to guide concepts and are not to scale

Raingarden



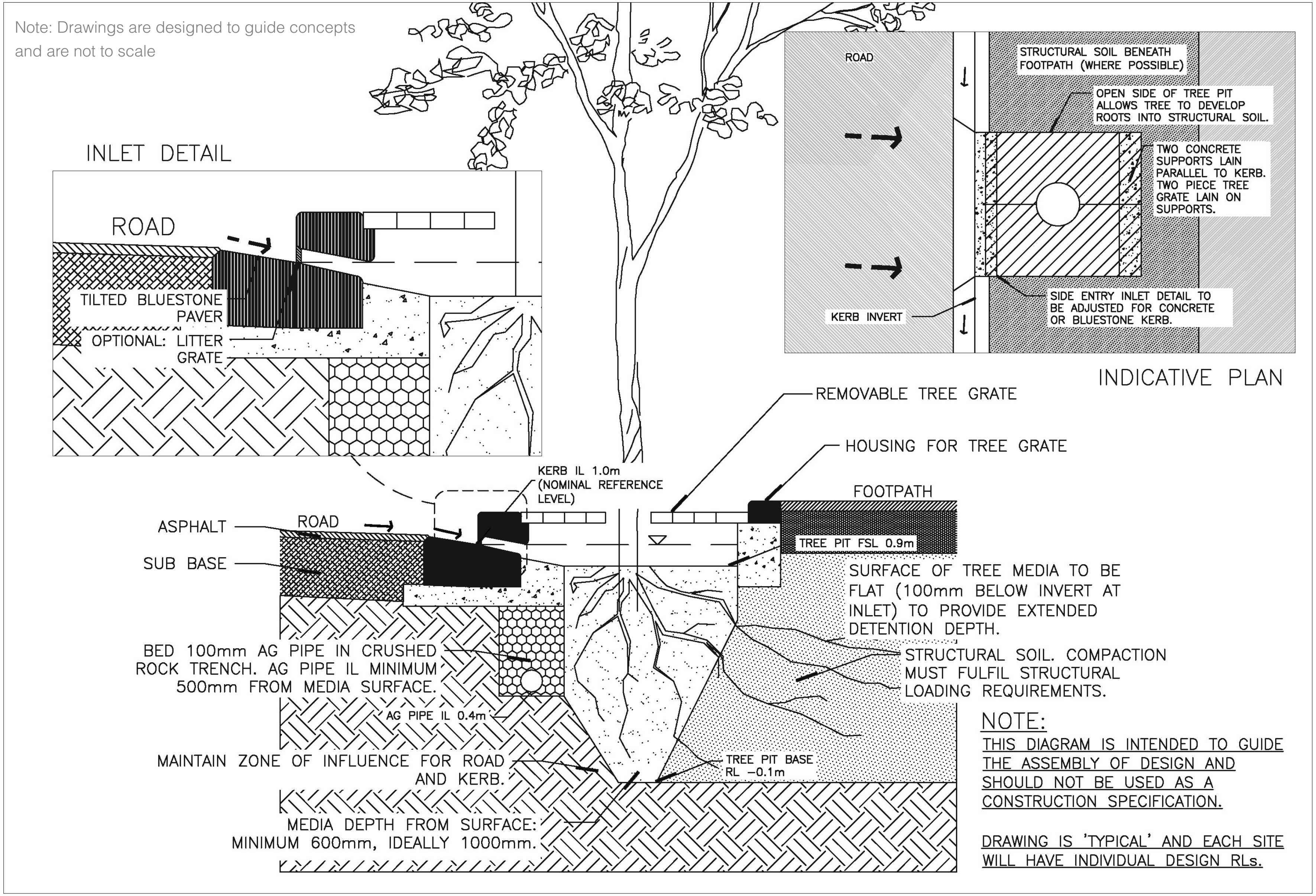
Note: Drawings are designed to guide concepts and are not to scale

Open Tree-Pit

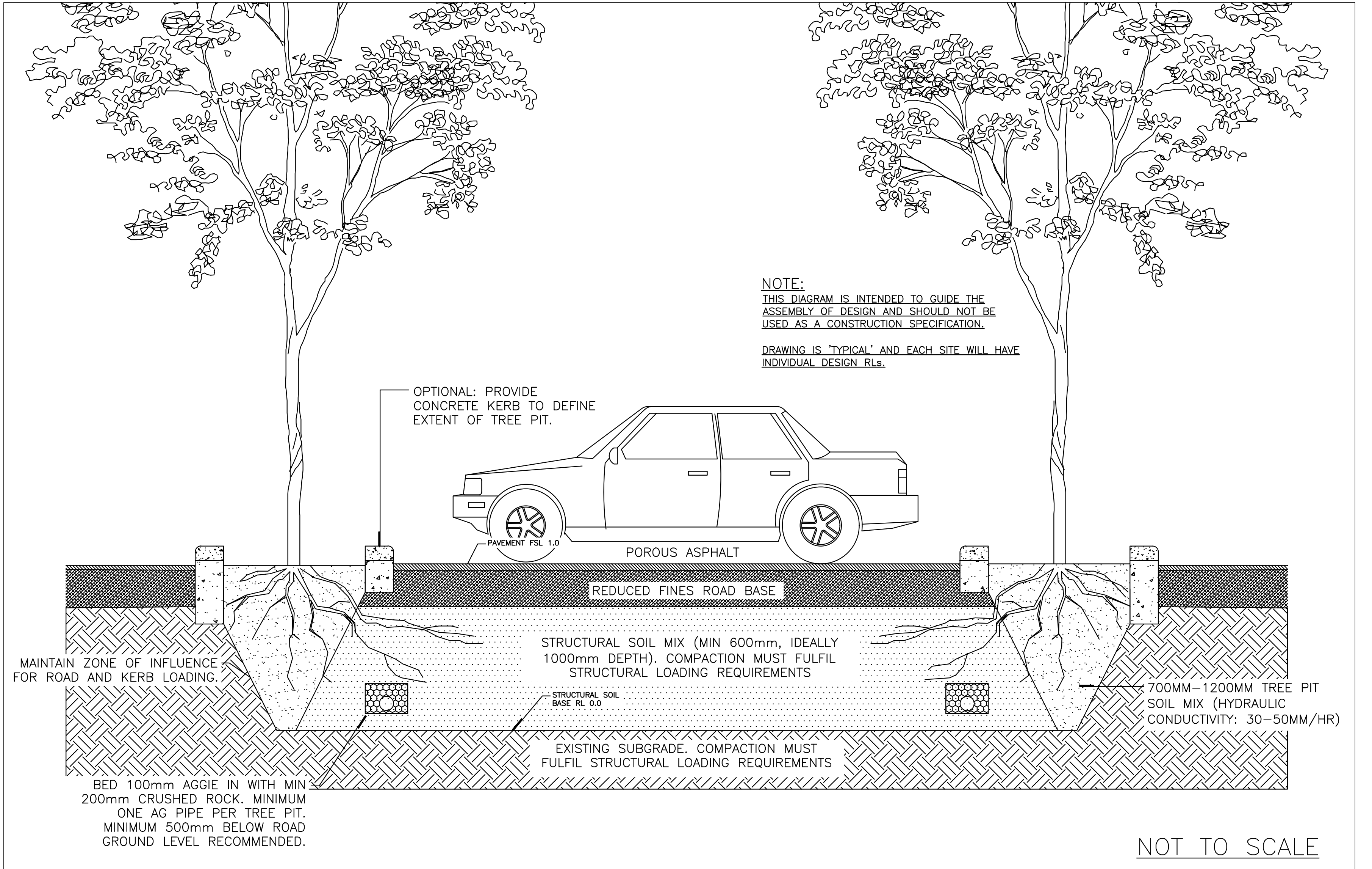


Grated Tree-Pit

Note: Drawings are designed to guide concepts and are not to scale

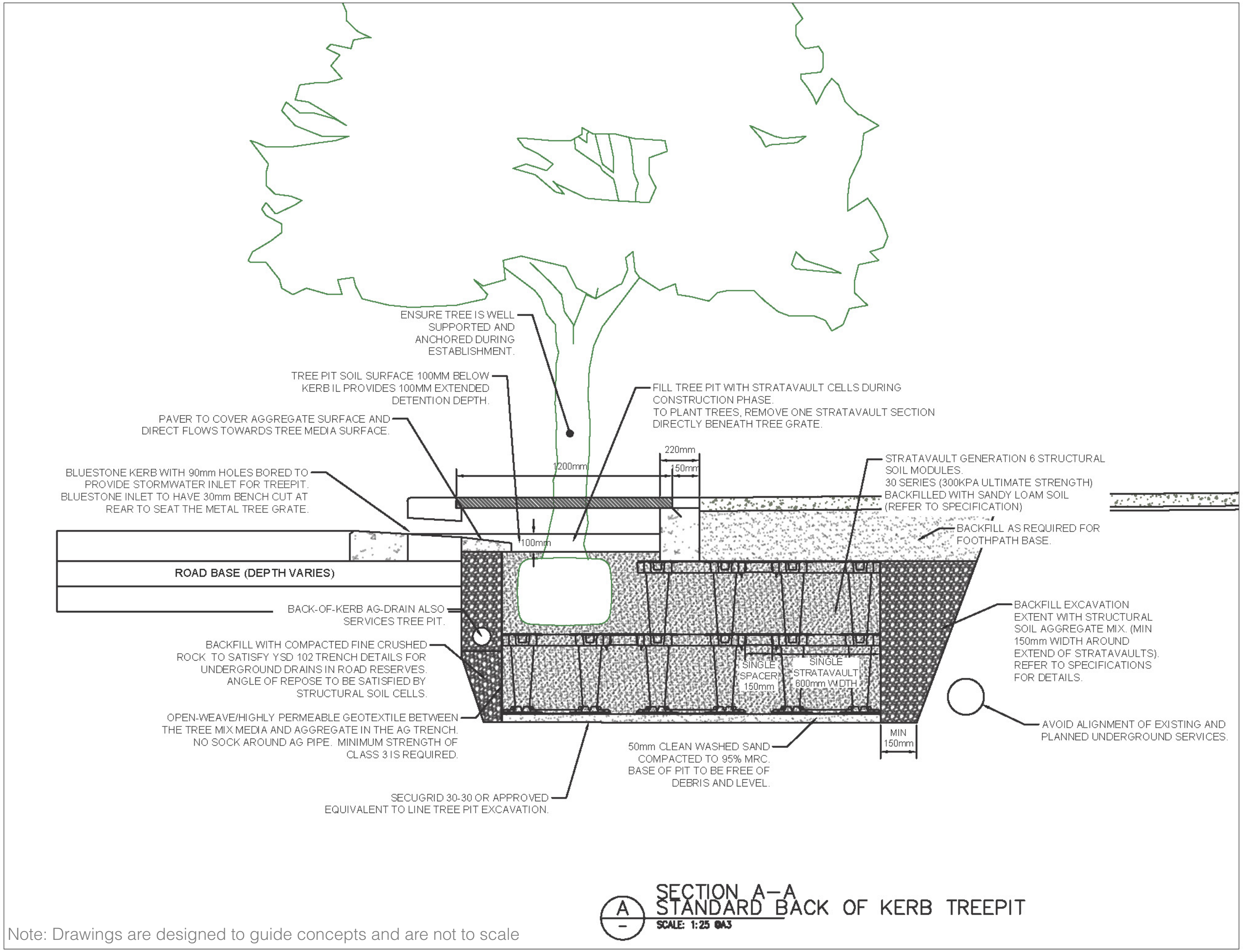


Permeable Pavement with Structural Soil



Note: Drawings are designed to guide concepts and are not to scale

Citygreen Strataflow System



Note: Drawings are designed to guide concepts and are not to scale

Tree Planting

TREE NOTES:
1. All trees must be healthy specimens free of pests, diseases & pathogens, scarring, damaged leaders, abrasions of the bark, disfigured knots or fresh cuts of limbs that have not been callused.

2. Advanced trees to show a vigorous central leader, open branching framework and well formed 'v' crotches. All limbs and trunks to be well formed, sturdy and well rooted. All dead wood & branches are to be removed.

3. Trees should be self supporting. Bamboo stakes are not to be used. Hardwood stakes and ties are to be used primarily for tree protection from strong winds and pedestrian traffic and accordingly ties are to be loosely fastened to allow for some movement.

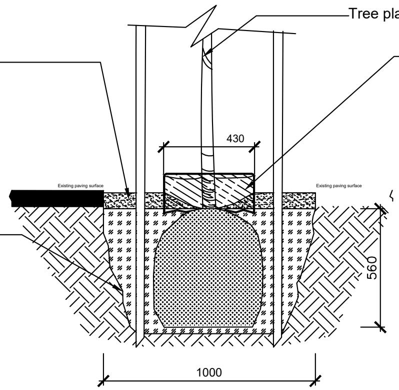
4. Height, pot sizes and calliper sizes shall be as indicated on the drawings and shall be regarded as minimum dimensions, not maximum. Trees shall be planted as detailed on the drawings.

5. The contractor is to ensure that the trees are true to species and size specified on the drawings and in the schedule. The Superintendent is to be able (if requested) to inspect all trees prior to planting by the contractor, and may reject any tree and request alternatives be sourced.

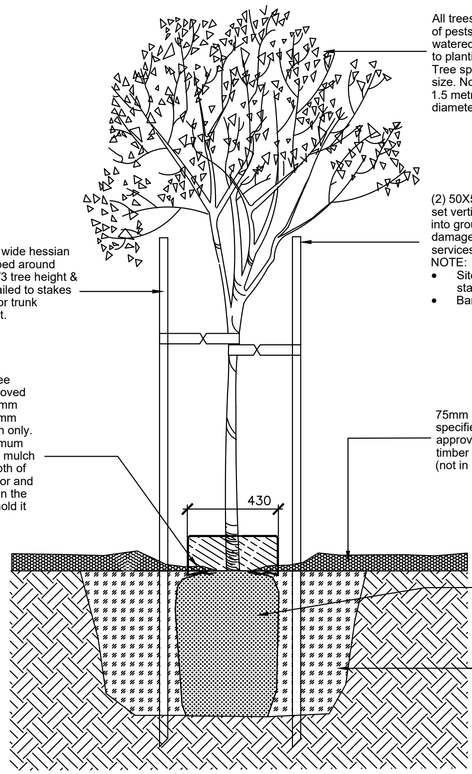
6. Trees to be well watered a maximum of 24 hours prior to planting. Tree Reservoirs to be filled to the lip upon establishment and thereafter. Hydrocell flakes must be fully waterlogged prior to placement in tree hole, and never used dry.

7. Trees are to be placed a minimum offset of 1 metre from adjacent structures, bollards, bins, path edges, concrete pads and similar, or as determined by Site Superintendant.

8. The Site Superintendent may inspect the tree holes prior to trees being planted - at his/her discretion



01 **ADVANCED TREE PLANTING IN GRANITIC SAND**
SECTION



02 **ADVANCED TREE PLANTING IN TURF/MULCH**
SECTION

ALL DIMENSIONS IN MM   DO NOT SCALE   IF IN DOUBT ASK

Amendments

Issue	Rev	Revision Description	Amend.	Date
A	1	DRAFT	PT	15.11.16

DO NOT SCALE - USE WRITTEN DIMENSIONS ONLY

General notes / Cross references

Stonnington City Centre, 311 Glenferrie Road, Malvern Victoria 3144

Project: LANDSCAPE STANDARD DRAWINGS

Title: SOFTSCAPE - TREE PLANTING

Scale	North	Date Drawn	Drawn	Checked	Drawing Number	ISSUE
1:20 @ A3		JULY 2016	PT	SM	LDB01	A

APPENDIX B
Standard Specifications

Provides standard specifications for the following design elements:

- Raingarden Filter Media
- Tree Pit Soil Mix
- Raingarden Vegetation
- Tree Species
- Permeable Pavement
- Structural Soil

B.

Raingarden Filter Media

The raingarden filter material shall preferably be based on a 'washed sand' of siliceous or calcareous origin, one that has been mined and processed. Topsoils are not usually suitable. 'Burdettes Turf 200' or 'Daisy's garden supplies bio-drain' or similar may be suitable as a base with amendment or addition of sandy loam soil to increase soil moisture retention, reduce hydraulic conductivity and meet the particle size distribution requirements.

Filter media shall be sourced by the Contractor from an approved supplier. Approval shall be obtained from the Principal prior to purchase.

Filter media properties

Saturated hydraulic conductivity

In the range of 100 - 200 mm/hr. If the hydraulic conductivity exceeds 200 mm/hr it should be amended to increase the soil moisture retention capacity and reduce hydraulic conductivity to within the range by mixing with fine sand or loamy sand with low nutrient content.

Particle size distribution (PSD) - composition (w/w) requirements

The material shall preferably meet the following particle size distribution shown below, however this should be treated as a guide and meeting the hydraulic conductivity, nutrient and soil moisture requirements are of greater importance.

Particle Size distribution

Description	Proportion	Grading
Clay & Silt	<3%	<0.05 mm
Very Fine Sand	5-30%	0.05-0.15 mm
Fine Sand	10-30%	0.15-0.25 mm
Medium to Coarse Sand	40-60%	0.25-1.0 mm
Coarse Sand	7-10%	1.0-2.0 mm
Fine Gravel	<3%	2.0-3.4 mm

The total clay and silt mix should be less than 3% (w/w) to reduce the likelihood of structural collapse. The filter media should be well-graded i.e., it should have all particle size ranges present from the 0.075 mm to the 4.75 mm sieve (as defined by AS1289.3.6.1 - 1995). There should be no gap in the particle size grading, and the composition should not be dominated by a narrow particle size range.

Soil nutrition

The filter media shall comply with the following specifications as defined by AS4419 – 2003 (Soils for Landscaping and Garden Use);

- Organic Matter Content – less than 5% (w/w). An organic content higher than 5% is likely to result in leaching of nutrients
- pH 6.2 – 6.8 before delivery to site, add dolomite as required
- Electrical Conductivity (EC) <1.2 dS/m
- Orthophosphate content <50 mg/kg
- Total nitrogen content < 800 mg/kg

Potential filter media shall be assessed by a horticulturalist to ensure it is capable of supporting a healthy vegetation community. This assessment should take into consideration delivery of nutrients by stormwater. Any component or soil with high levels of salt (as determined by EC measurements), high levels of clay or silt particles (exceeding the particle size limits set above), or any other extremes which may retard plant growth should be rejected.

Soil moisture storage capacity

The soil should have a volumetric water content of >=15% and preferably >=20% at the optimum root zone depth.

Testing requirements

Tests are to be undertaken on all filter media prior to delivery and again from the onsite stockpile to confirm soil suitability and conformance with the above described requirements. Testing shall be conducted by a NATA approved laboratory, and a copy of the test results sent to the project superintendent for approval, prior to the filter soil installation.

The submission shall include the following test results to determine whether a soil is suitable:

- Saturated hydraulic conductivity (HC) in accordance with AS 4419, ASTM F1815-06
- Particle size distribution in accordance with ASTM 1289.3.6.1 – 2009
- Soil moisture release curve
- pH, salts and nutrients

The F1815-06 test uses a compaction method that best represents field conditions. The Contractor shall allow for the testing of three (3) delivered samples taken from the stockpile prior to placement. The Contractor shall allow for a minimum of 3 working days for the testing and reporting of filter media. All costs associated with testing should be included in the Contractors price for supply. Recommendations for suitable testing labs can be made by the Principal if required.

The Contractor must provide testing of the filter media and submit testing results to the superintendent. Any unsatisfactory media will need to be removed from site and replaced with specified and approved media.

Amelioration of top 150 mm of filter media

The top 150 mm of the filter medium should be ameliorated with appropriate organic matter, fertiliser and trace elements with the constituents and quantities as recommended by the soil assessor or detailed in the following table.

Amelioration to top 150mm of Filter Media

Constituent	Quantity (kg/100m^2 Filter Area)
Granulated Poultry Manure Fines	50
Superphosphate	2
Magnesium Sulphate	3
Potassium Sulphate	2
Trace Element Mix	1
Fertilizer NPK (16.4.14)	4
Lime	20

Raingarden Filter Media (cont.)

Transition and submerged zone layers

In a standard raingarden system a transition layer is included. In a submerged zone system the transition layer also functions as a submerged zone layer. To prevent the filter media from washing into the drainage layer, a transition layer is required between the filter media and fine gravel drainage layer. The transition layer should be a clean, well graded coarse sand material containing <2% fines. The transition layer must meet 'bridging' criteria as follows based on engineering principles that rely on the largest 15% of the overlying layer particles 'bridging' with the smallest 15% of the underlying layer particles. This results in smaller voids, which prevent the migration of filter media particles into the sand. The particle size distribution of the transition layer shall be assessed to ensure it meets the following criteria:

D15 (transition layer) is less than or equal to 5 x D85 (filter media) where:

- D15 (transition layer) is the 15th percentile particle size in the transition layer material, and D85 (filter media) is the 85th percentile particle size in the filter media.

D15 (drainage layer) is less than or equal to 5 x D85 (transition layer) where:

- D15 (drainage layer) is the 15th percentile particle size in the drainage layer material, and D85 (transition layer) is the 85th percentile particle size in the transition layer.

A suitable product is washed A3 filter sand (Vicroads) with 90% particles retained above 0.25 mm. The transition layer shall be tested to determine its particle size distribution to ensure it meets the required grading and 'bridging' criteria. The superintendent may also require testing of hydraulic conductivity. Where the transition layer is also required to function as a submerged zone, it should be constructed using transition layer material as described above with addition of carbon sources and mixed as follows (per 100 L):

- 98 Litres of Transition Layer Material.
- 500 g biodegradable sugar cane mulch.
- 1.5 kg recycled, untreated hardwood chips or plantation hardwood chips.

The purpose of the submerged zone is to temporarily hold water for plants for a longer period of time and allow anaerobic (no air) processes to break down nutrients to occur below the aerobic root zone.

Drainage layer

The purpose of the drainage layer is to convey infiltrated flows horizontally across the base of the system into the slotted underdrainage pipes. The slotted underdrainage pipes that convey the treated stormwater are to be 100 mm in diameter and surrounded by the gravel drainage layer.

The drainage layer shall have a uniform thickness of 200 mm. Suitable materials include coarse sand (coarser than transition layer) or washed fine gravel in the range 2 mm - 7 mm. Scoria and unwashed gravels with a significant quantity of fine particles are not acceptable.

The transition layer shall be tested to determine its particle size distribution to ensure it meets the required grading and 'bridging' criteria. The superintendent may also require testing of hydraulic conductivity.

Installation of filter media

The filter media shall be lightly compacted during installation to prevent migration of fine particles. A single pass for each lift with a drum lawn roller should be performed. Under no circumstance should heavy compaction or multiple-passes be made. Filter media should be installed and compacted in two lifts to achieve the finished compacted depth.

Hold points

The contractor shall seek approval from the superintendent before proceeding to the next stage at the following inspection hold points and allow 24 hours' notice for a council representative to attend site inspections:

- Provision of samples and specified test results for all materials (filter media, submerged zone (transition layer media) and drainage media).
- At completion of drainage connections associated with raingarden and before backfill with soil material including gravel, sand, soil or filter media. Under-drainage must not be installed with filter socks.
- Placement of any soil material within raingarden including drainage layer, transition/submerged zone layer and filter media.
- Practical completion of raingarden including plants and rock work.

Tree Pit Soil Mix

The soil mix for Green-Blue tree pits has been designed to balance the need for permeability and moisture holding capacity. The hydraulic conductivity is less than that of raingarden filter media and designed to promote optimal tree growth conditions.

Tree pit soil shall be sourced by the Contractor from an approved supplier. Approval shall be obtained from the Principal prior to purchase.

Saturated hydraulic conductivity

In the range of 30 - 50 mm/hr. If the hydraulic conductivity exceeds 100 mm/hr it should be amended to increase the soil moisture retention capacity and reduce hydraulic conductivity to within the range by mixing with fine sand or loamy sand with low nutrient content.

Particle size distribution (PSD) - composition (w/w) requirements

The material shall preferably meet the following particle size distribution shown below, however this should be treated as a guide and meeting the hydraulic conductivity, nutrient and soil moisture requirements are of greater importance.

Table 4. Particle Size Distribution

Description	Proportion	Grading
Clay & Silt	<10%	<0.05 mm
Very Fine Sand	10-30%	0.05-0.15 mm
Fine Sand	10-30%	0.15-0.25 mm
Medium to Coarse Sand	20-40%	0.25-1.0 mm
Coarse Sand	4-10%	1.0-2.0 mm
Fine Gravel	<3%	2.0-3.4 mm

Soil nutrition

The tree pit soil mix shall comply with the following specifications as defined by AS4419 – 2003 (Soils for Landscaping and Garden Use);

- Organic Matter Content – 4-8% (w/w). An organic content higher than 5% is likely to result in leaching of nutrients.
- pH 5.5 – 7.5 before delivery to site, add dolomite as required.
- Electrical Conductivity (EC) <1.2 dS/m.
- Orthophosphate content <50 mg/kg.
- Total nitrogen content < 800 mg/kg.

Potential tree pit soil mix shall be assessed by an arborist to ensure it is capable of supporting a healthy vegetation community. This assessment should take into consideration delivery of nutrients by stormwater. Any component or soil with high levels of salt (as determined by EC measurements), high levels of clay or silt particles (exceeding the particle size limits set above), or any other extremes which may retard tree growth should be rejected.

Soil moisture storage capacity

The soil should have a volumetric water content of >=20% and preferably >=25% at the optimum root zone depth.

Tree Pit Soil Mix (cont.)

Testing requirements

Tests are to be undertaken on tree pit soil mix prior to delivery and again from the onsite stockpile to confirm soil suitability and conformance with the above described requirements. Testing shall be conducted by a NATA approved laboratory, and a copy of the test results sent to the project superintendent for approval, prior to the soil installation.

The submission shall include the following test results to determine whether a soil is suitable:

- Saturated hydraulic conductivity (HC) in accordance with AS 4419, ASTM F1815-06.
- Particle size distribution in accordance with ASTM 1289.3.6.1 – 2009.
- Soil moisture release curve.
- pH, salts and nutrients

The F1815-06 test uses a compaction method that best represents field conditions. The Contractor shall allow for the testing of three (3) delivered samples taken from the stockpile prior to placement. The Contractor shall allow for a minimum of 3 working days for the testing and reporting of filter media. All costs associated with testing should be included in the Contractors price for supply. Recommendations for suitable testing labs can be made by the Principal if required.

The Contractor must provide testing of the filter media and submit testing results to the superintendent. Any unsatisfactory media will need to be removed from site and replaced with specified and approved media.

Raingarden Vegetation

Raingardens shall generally be planted with an average finished density of approximately 8 plants/m2. Individual species for each mix will be distributed within the area so that the final layout is a well-mixed assortment of different plant types. The plants shall cover the entire base of the raingarden. The subsoils (filtration media or in-situ soil) shall be well saturated the previous day prior to the planting of vegetation. Plants are to be supplied as 50 mm tubes. All waste is to be disposed of by the Contractor.

An inspection shall be made by the Superintendent or their representative following completion of planting to ensure that vegetation has been planted in such a manner as to ensure successful establishment and as per the intended design. Any plants deemed to be unsatisfactorily planted shall either be replanted or replaced at the Contractors expense.

At least 50% of raingarden plant species must be selected for effective stormwater treatment. The following tables provides a list of recommended species for stormwater treatment with suggested percentage cover and planting density. The Standard Mix a typical species selection for raingarden and the Dry Mix is a species selection suited for dry environments. Further details and growing conditions for both species selections are provided in the following pages.

Raingarden - Vegetation-Standard Mix

Species	Proportional Cover (%)	Planting Density (plants/m^2)
Carex appressa	30	6
Ficinia nodosa	20	8
Juncus amabilis	10	10
Juncus flavidus	10	10
Poa labillardieri	10	4
Goodenia ovata	10	2
Melaleuca ericifolia	10	1

Raingarden - Vegetation-Dry Mix

Species	Proportional Cover (%)	Planting Density (plants/m^2)
Lomandra longifolia	30	4
Ficinia nodosa	20	8
Dianella caerula	10	8
Juncus flavidus	10	10
Poa labillardieri	10	4
Dietes bicolor	10	2
Goodenia ovata	10	2

B.

Raingarden Vegetation

Vegetation-Standard Mix – Species description

Species	Details	Growing Conditions	Image
Carex appressa	**Common Name:** Tall Sedge **Size at maturity (HXW):** 0.5 -1.2m x 0.5 -1m	Wet soils beside or along margins of soil areas. Will tolerate some drying out. Frost tolerant. Full sun, semi shade.	
Ficinia nodosa	**Common Name:** Knobby Club Rush **Size at maturity (HXW) :** 0.5 -1 x 0.5 -1m	Grows in a range of conditons and soil types, in full sun to part-shade. Fast growing.	
Juncus amabilis	**Common Name:** Hollow Rush **Size at maturity (HXW) :** 0.2 -1.2 x 0.2 -0.5m	Seasonally moist to inundated soils, tolerating drying out in summer. Full sun, semi shade.	
Juncus flavidus	**Common Name:** Rush **Size at maturity (HXW):** 0.4 -1.2 x 0.2 -1m	Moist to wet soils, tolerating drier conditions in summer. Full sun, semi shade	
Poa labillardieri	**Common Name:** Common Tussock-grass **Size at maturity (HXW):** 0.8m x 0.8m	Grows in clay loam, heavy clay, loam, sandy loam and sandy clay loam of medium to high fertility. Establishes quickly with a shallow root system. Very low maintenance and no irrigation.	
Goodenia ovata	**Common Name:** Hop Goodenia **Size at maturity (HXW):** 1- 2.5m x 1- 3m	Full sun to full shade. Loamy, Sandy loam, Clay loam soils. Minimal watering but preferences damp to moist soils. Will tolerate periods of waterlogging. Fast growing	
Melaleuca ericifolia	**Common Name:** Swamp Paperbark **Size at maturity (HXW):** 4- 9m x 2- 6m	Moist to wet swampy conditions, forming thickets. Frost tolerant. Full sun to semi shade.	

B.

Raingarden Vegetation

Vegetation-Dry Mix – Species description

Species	Details	Growing Conditions	Image
Lomandra longifolia	**Common Name:** Mat Rush **Size at maturity (HXW):** 1- 1.5m x 1- 1.3m	Grows in a wide range of soils from light (sandy) to heavy (clay) soil, in semi-shaded areas or non-shaded areas. Highly drought-tolerant. Moist soil during growth stage.	
Ficinia nodosa	**Common Name:** Knobby Club Rush **Size at maturity (HXW) :** 0.5 - 1m x 0.5 - 1m	Grows in a range of conditons and soil types, in full sun to part-shade. Fast growing.	
Dianella caerula	**Common Name:** Paroo Lily **Size at maturity (HXW):** 0.2- 0.5m x 0.3- 1m	Well drained moist soils. Frost tolerant. Full sun to dappled shade.	
Juncus flavidus	**Common Name:** Juncas **Size at maturity (HXW):** 0.4 -1.2 x 0.2 -1m	Tolerant of most soil conditons, including wet areas and swampy soil. Tolerant of frost.	

Species	Details	Growing Conditions	Image
Poa labillardieri	**Common Name:** Common Tussock-grass **Size at maturity (HXW):** 0.8m x 0.8m	Grows in clay loam, heavy clay, loam, sandy loam and sandy clay loam of medium to high fertility. Establishes quickly with a shallow root system. Very low maintenance and no irrigation.	
Dietes bicolor	**Common Name:** Peacock flower, wild iris **Size at maturity (HXW):** 0.6 x 0.6 m	Prefers a light to medium well-drained soil in an open sunny position, drought and frost resistant. Hardy.	
Goodenia ovata	**Common Name:** Hop Goodenia **Size at maturity (HXW):** 1- 2.5m x 1- 3m	Full sun to full shade. Loamy, Sandy loam, Clay loam soils. Minimal watering but preferences damp to moist soils. Will tolerate periods of waterlogging. Fast growing	

Reference:

Yarra Ranges Local Plant Directory

http://fe.yarraranges.vic.gov.au/Residents/Trees_Vegetation/Yarra_Ranges_Plant_Directory/Yarra_Ranges_Local_Plant_Directory

Australian National Botanic Gardens

https://www.anbg.gov.au/gnp/index.html

B.

Tree Species for Green-Blue Infrastructure

The choice of tree species in Green-Blue infrastructure is influenced by a range of factors that include:

- available overhead space,
- leaf fall,
- infrastructure risk,
- native/exotics, and
- aesthetic considerations.

Available overhead space for tree canopy must be considered to avoid issues with streetscape infrastructure (powerlines, street awnings etc.). Full mature canopy and future infrastructure works must be considered when assessing appropriate tree species for a site. Tree species with small canopies are recommended for sites with overhead constraints.

Both native and exotic trees can be implemented in Green-Blue infrastructure. Native species tend to be non-deciduous and therefore lend themselves to more successful implementation within raingardens, open tree pits and permeable pavement systems. Native species are also generally better suited to Australian conditions and can be hardier through dry periods.

Deciduous trees can have a large impact on the performance of raingardens, permeable pavements and other infiltration systems. Autumn leaf litter can block inlets and the high concentration of organic material that can hamper the performance of raingardens. Permeable pavements are susceptible to blockage as leaves decompose. Where possible, avoid planting deciduous species in or around raingardens, open tree pits or permeable pavements. When deciduous species must be near these systems, ensure that maintenance schedules are increased throughout autumn to intercept leaf fall.

Certain species have aggressive root systems that actively seek out underground water, and can cause problems for nearby underground infrastructure. Care must be taken when planning Green-Blue infrastructure near underground services.

An approved tree species list by the City of Stonnington is provided on the following page.

B.

Tree Species for Green-Blue Infrastructure (cont.)

Trees species suited for Green-Blue assets:

Non-Deciduous Trees

- Angophora costata
- Brachychiton ‘Griffith Pink’
- Brachychiton ‘Jerilderee Red’
- Corymbia citriodora ‘Scentuous”
- Corymbia Maculata
- Elaeocarpus reticulatus
- Eucalyptus ‘Eukie Dwarf’
- Eucalyptus leucoxylon subsp. megalocarpa
- Eucalyptus sideroxylon

Deciduous Trees

- Acer buergerianum
- Acer campestre ‘Elsrijk’
- Fraxinus Cimmaron
- Fraxinus exc elsior ‘Aurea’
- Fraxinus ‘Urbanite’
- Gleditsia ‘Elegantissima’
- Gleditsia triacanthos ‘Shademaster’
- Jacaranda mimosifolia
- Koelreuteria paniculata
- Lagerstroemia ‘Biloxi’
- Lagerstroemia ‘Lipan’
- Lagerstroemia ‘Natchez’
- Lagerstroemia ‘Tuscarora’
- Lagertsroemia ‘Sioux’
- Liquidambar styraciflua
- Melia azedarach ‘Elite’
- Pistachia chinensis
- Platanus orientalis ‘Autumn Glory’
- Pyrus ‘Arisrocrat’
- Pyrus Capital
- Pyrus ‘Chanticleer’
- Pyrus ‘Southworth Dancer’

Permeable Pavement

Permeable Surface

The surface layer must be a porous material that allows the infiltration of water into the subsurface layers. This can comprise of open graded asphalt (with air voids between 20-25%), permeable pavers or interlocking paver arrangements with voids between pavers.

Base course

Permeable pavements that allow water to infiltrate require a modified base course that allows water to pass into the surrounding soil. To allow water to move through the base course, fine particles of the material are removed to increase void space. While it is desirable to maximise the void ratio of a base material to maximise for stormwater purposes, uniform materials with very high void ratios (40%) are unsuitable for carrying trucks and other significant traffic.

It is recommended to use a standard road base (e.g. 20 mm crushed rocks) to underlie permeable pavements, with fine particles of a certain size scalped out. Scalping fine particles increases permeability, while reducing the structural capacity of the material. This is a necessary compromise that can be controlled by the size of particles scalped out of the material.

This gives designers the ability to preference the permeability or structural capacity requirements of the pavement, depending on the situation. For example, the removal of material smaller than 0.600mm from a sample of 20mm crushed rock resulted in a forty-fold increase in permeability and a reduction of the Resilient Modulus (indicator of structural capacity) between 20% and 45%. Removing material smaller than 1.18mm provided a 100 times increase in permeability, but also a 30% to 55% reduction in resilient modulus[1].

Given concerns regarding the compaction and structural integrity of structural soils it is recommended to adopt the conservative case to remove fine particles smaller than 0.600mm. For design purposes it is recommended to assume a resilient moduli of saturated, scalped base materials to be about half those normally used in pavement design[1]. Scalped base courses generally exhibit void ratios of around 15%, meaning their capacity for retaining water is much less than materials with uniform particle size.

Aggregate Layer

The permeable pavement is directly underlain by a washed aggregate layer. The aggregate layer is to be a minimum of 75mm thick, compacted to 95% modified compaction.

Structural Soil Layer

Structural soils are a weight-bearing substrate made largely of crushed stone (basalt) and a small amount of filler soil mix (loam to clay loam with nutrient additives) at a ratio of 5:1 of volume (assuming void space of 40%). A minimum depth of 600mm is required. Structural soil layers should be compacted to 95% modified compaction. Under compaction, structural soils form a uniform, rigid, stone “lattice” with dispersed spaces (pores or voids) that allows for the controlled passage of oxygen, water and tree roots deep beneath concreted pavements and roads. These voids also provide room for an uncompacted soil mix rich in nutrients and trace elements for plant growth and water retention.

The crushed stone is the primary component of the soil system and must be uniformly sized and highly angular to create an open “lattice” structure when compacted. The properties of the soil filler material should have a high stability and longevity, high cation exchange capacity, high water holding ability, low potential for downward migration, and high pH buffer capacity. To avoid the separation of filler soil and aggregate during transport, the structural soil mix should be kept moist during mixing and transportation to avoid separation of materials. Structural soil should be installed in 150mm lifts, with compaction of each lift, to ensure consistent compaction of the entire layer.

Subgrade

Subgrade underlying structural soils should be compacted as per standard road construction.

1 *Shackel, B., Beecham, S. & David Pezzaniti, B. M., 2008. Design of Permeable Pavements for Australian Conditions. Adelaide, 23rd ARRB Conference.*

Structural Soil Component Composition[2]

Structural Soils (Typically 600 -1,000 mm deep)

Structural soil mix is to be a thoroughly combined mix of aggregate and filler soil mix in a ratio of 5:1 (by weight) to the structural requirements of the project civil engineer as follows:

Aggregate

SHALL BE 40MM CRUSHED BASALT. GRAVEL SHALL BE CLEAN AND FREE FROM CLAY AND OTHER MATTER. SUBMIT SAMPLE FOR APPROVAL. THE AGGREGATE SHALL BE OF THE FOLLOWING PARTICLE SIZE DISTRIBUTION:

A.S. SIEVE	PERCENT PASSING
53.0	100
37.5	90-100
26:5	0-75
19.0	<15
13.2	<2
9.5	<2
6.7	<2
4.75	<2
2.36	0

TRANSPORTING: SOIL MIXES MUST BE DELIVERED TO SITE PRE-BLENDED. THE SOIL MIX MUST BE TRANSPORTED IN A MOIST CONDITION TO PREVENT SEGREGATION OF COMPONENTS.

Filler Soil Mix

FILLER SOIL SHALL BE A THOROUGHLY COMBINED MIX OF A CLAY LOAM OR SIMILAR SOIL (BURDETT'S MOUNTAIN SOIL BLEND MAY BE SUITABLE) AND 5% BY VOLUME OF COMPOSTED GREEN WASTE, SCREENED TO LESS THAN 12MM, WITH THE FOLLOWING PROPERTIES.

SUBMIT SAMPLE FOR APPROVAL.

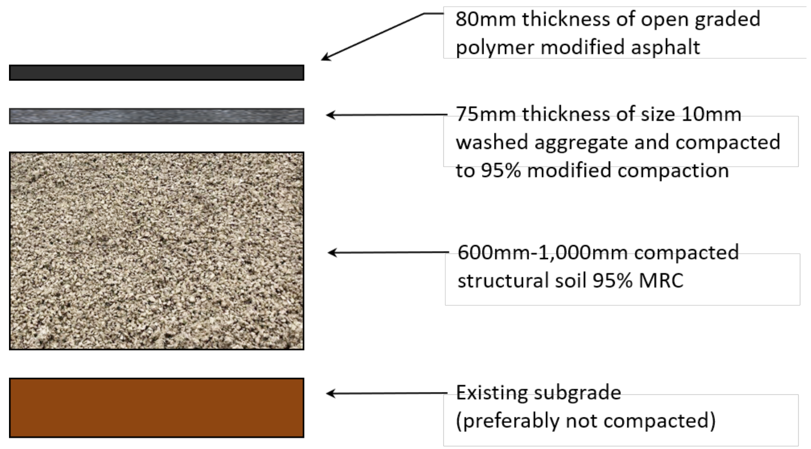
ORGANIC MATTER	<1% BY WEIGHT
PH IN WATER	5.5 - 6.5
ELECTRICAL CONDUCTIVITY	<1.2 DS/M
AMMONIUM	20-200MG/KG
PHOSPHOROUS	10-50MG/KG

Nutrient Additives

TO THE ABOVE FILLER SOIL COMPONENTS, THE FOLLOWING ADDITIONS ARE REQUIRED (TO BE CONFIRMED DURING TESTING OF SAMPLES FOR APPROVAL).

MAGRILIME OR A 50/50 LIME/DOLOMITE MIX	TO BRING PH TO 5.5 - 6.5
TRACE ELEMENT MIX	100G/ CUBIC METRE
POTASSIUM NITRATE	300G/ CUBIC METRE
NITRAM (AMMONIUM NITRATE)	300G/ CUBIC METRE
SUPERPHOSPHATE	300G/ CUBIC METRE
IRON SULPHATE	500G/ CUBIC METRE
CONTROLLED RELEASE FERTILISER (8-9 MONTH OSMOCOTE)	1.5KG/ CUBIC METRE
GYPSUM	300G/ CUBIC METRE
MAGNESIUM SULPHATE (EPSOM SALTS)	150G/ CUBIC METRE

THESE ADDITIVES MUST BE MIXED WITH THE FILLER SOIL AND TESTED FOR COMPLIANCE WITH THE SPECIFICATION. FILLER SOIL MIX SHALL BE INSTALLED AS DETAILED.



[2] City of Melbourne (2017). *Structural soil composition guide.*
URL: http://www.melbourne.vic.gov.au/sitecollectiondocuments/porous-asphalt-pavement-structural-soil.pdf