TREES AND WATER SENSITIVE URBAN DESIGN

BY GREENBLUE URBAN

GreenBlue URBAN

Establishing the future urban landscape

Contents

Above: *A completed project in Bletchley using RootSpace 600, ArborFlow and Precast ArboResin tree grille.*

LID & SUDS

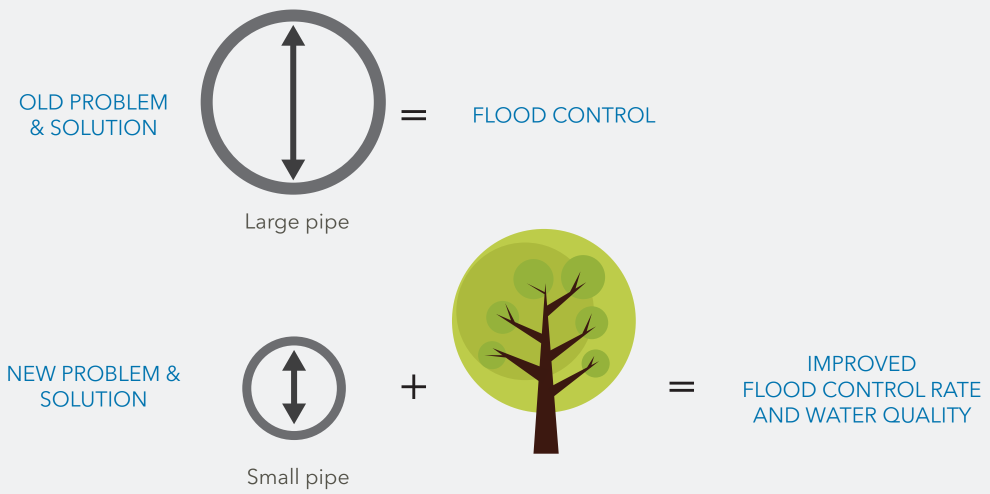
Water sensitive urban design & sustainable urban drainage systems.

Urban Trees can be invaluable in urban areas in assisting in managing urban water runoff. This guide visits the key points which must be considered in successfully integrating these beautiful elements in your WSUDS.

Much has been written on the general subject of SUDS, and the objective of this publication is not to replicate this, but to provide an overview of the use of trees in such systems, and the key parameters which must be considered to release the immense potential of trees in reducing stormwater runoff.

Traditional drainage of surface water runoff has been designed to convey rainwater, as rapidly as possible, from where it has fallen, to either a soakaway or a watercourse. This old method increases the risks of flooding, environmental damage and urban diffuse pollution, as run-off water usually carries contaminants including oils, heavy metals, pesticides, fertilisers, chemicals and other organic matter.

The implementation of sustainable drainage systems – demonstrated in outline as well as detailed applications and design submissions – is now demanded by authorities as a pre-requisite of planning considerations, from early site evaluations, design and environmental-impact assessments.



Right: *Canopy cover at St. Peters Square, Manchester*

THE **TREE** ASPECT

Large canopy trees in urban areas can bring a broad range of benefits if planted and established in accordance with best practice.

Trees have a vital role to play in managing storm water, but correct tree pit design and species selection is fundamental to this. Here we outline a few aspects that are critical to ensuring that trees can significantly reduce outflows, whilst becoming an attractive and hard working asset in the landscape. To outline:

Aesthetic – unarguably the largest living things on the earth, beautiful both in and out of season

Bio diversity – bringing birds and other wildlife into our cities

Shade – increasingly valued natural UV protection

Urban cooling – significant cooling through both shade and evapotranspiration

Health and crime reduction benefits – research statistically proven

Significantly increasing property values and retail footfall - we have excellent research results demonstrating this benefit

Wind speed reduction – trees reduce wind speeds for a distance from the tree of six times their height

Pollutant reduction – vegetation and microbes take up and transform pollutants

An established street tree can manage between 3-4 cubic metres of water in a storm event – even without a specialist SUDS tree pit.

Stormwater runoff reduction, attenuation and filtration

Vegetated SUDS – assists particle retention

Soil media – evidence suggests removes 50-80% hydrocarbons

More specifically, the trees' roles in urban water management are:

1. Canopy absorption and rainfall interception.
2. Dissipate water droplet energy and reduce temperature.
3. Evapotranspiration – through leaf stomata – producing cooling effect.
4. Root zone attenuation – 25% of the root zone can be available for attenuation.
5. Pollutant filtration – soil and roots can manage, sequest and breakdown pollutants.
6. Water transportation via deep rooting profiles to increase penetrative ground recharge.

> The challenge for the urban designer is that for trees to succeed and achieve their potential, they require access to **large volumes** of uncompacted soil. With space in cities being at a premium, and below ground congested with services and utilities, *specialist products* are required to overcome these challenges.

The success criteria:

To succeed in the role of WSUD's and become an integral part of urban LID / SUDS system, the tree pit design will require:

- Adequate load bearing root volume
- Quality soil
- Soil type that can cope with intermittent inundations without losing its essential structure
- Overflow provision to prevent prolonged water-logging
- Source control maintainable inlets
- Drainage to base
- Aeration to maintain soil health

Why is uncompacted soil so important?

As soon as a soil or other planting medium is compacted, the macro pores within the soil structure are eliminated. Not only is this detrimental to root growth, vital space for water attenuation and transport is removed.

Uncompacted sandy loam soil has an open structure with between 25-35% macro and micro pore structure available for water and air to fill.

The drainage process whereby the stormwater can percolate down, drawing air in also, is vital to long term soil and tree health.

The pitfalls:

The principal situations to avoid when using trees in LID / WSUDS are :

Prolonged water logging - most species will cope with 48 hours of water-logging but mortality rates rise with longer periods

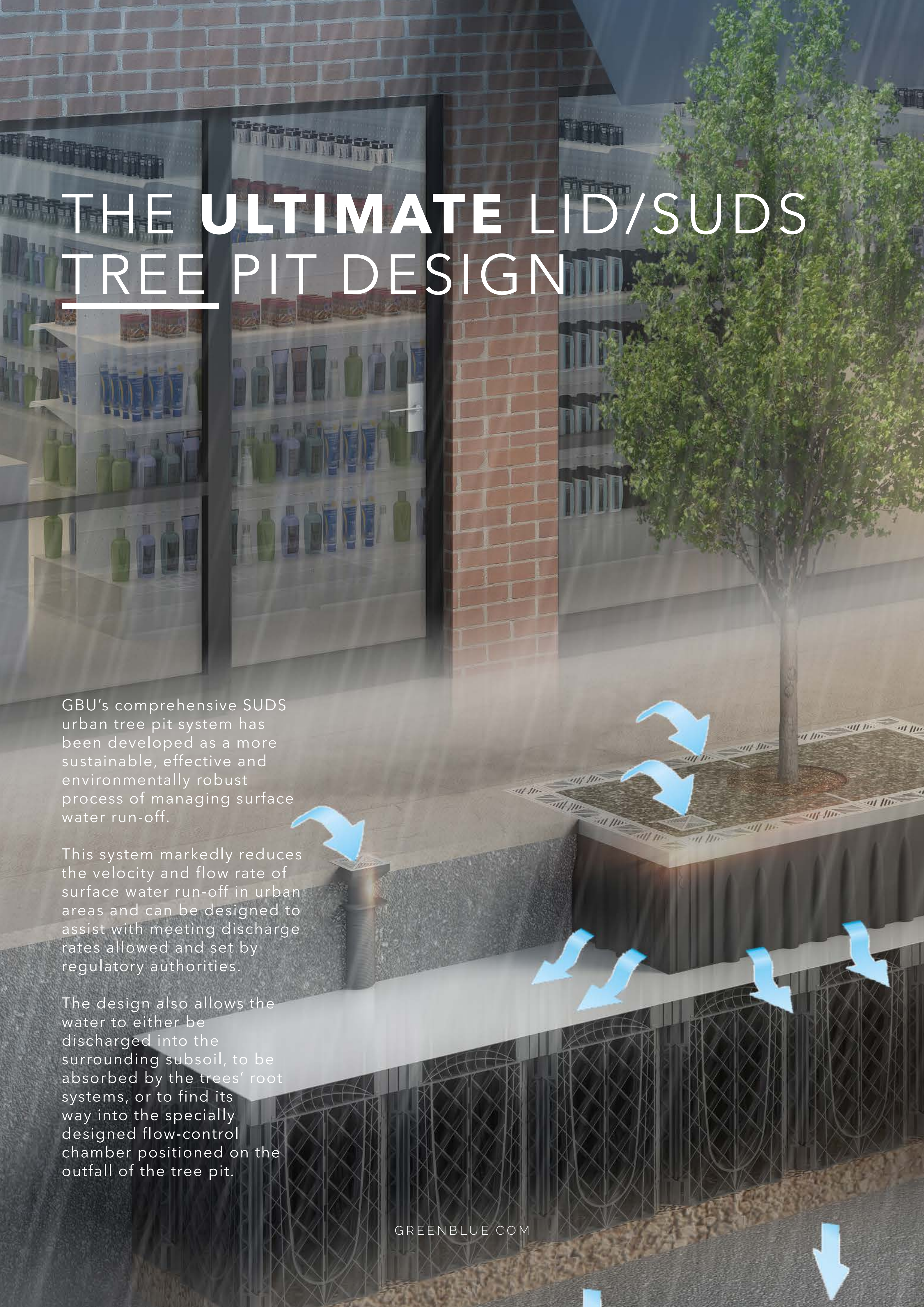
Anerobic soil - soil aeration is vital to maintain soil health and beneficial microbiological activity within the soil

Erosions from inflow - soil erosion could expose delicate root systems

Over-compaction of root zone - creating inaccessible areas for roots

Excessive contamination - average conditions are workable but excessive pollution could lead to tree failure

THE **ULTIMATE** LID/SUDS TREE PIT DESIGN



GBU's comprehensive SUDS urban tree pit system has been developed as a more sustainable, effective and environmentally robust process of managing surface water run-off.

This system markedly reduces the velocity and flow rate of surface water run-off in urban areas and can be designed to assist with meeting discharge rates allowed and set by regulatory authorities.

The design also allows the water to either be discharged into the surrounding subsoil, to be absorbed by the trees' root systems, or to find its way into the specially designed flow-control chamber positioned on the outfall of the tree pit.

Products manufactured from 100% recycled materials.

THE **PRINCIPAL** COMPONENTS

Current best practice LID / SUDS tree pit construction should incorporate the following components:

- Root Management
- Load bearing soil cell or panel structure
- Soil to SuDS bioretention specification
- Source control
- Outlet control
- Drainage
- Aeration

Please note: due to the very free draining nature of the soil media used in ArborFlow SUDS systems, it is important that the tree is regularly watered for the first two summers.

Maintenance of SuDS tree pit:

Essentially, to be of value in the urban landscape, these systems need to be low maintenance. However – there is no such thing as 'zero' maintenance in this field, so external area maintenance divisions need to be aware of what is needed to maintain a SuDs tree pit in its effectiveness. Generic clauses (additional to standard tree establishment maintenance) are:

I. **6 monthly** – check and clear water inlet points and soil aeration vents.

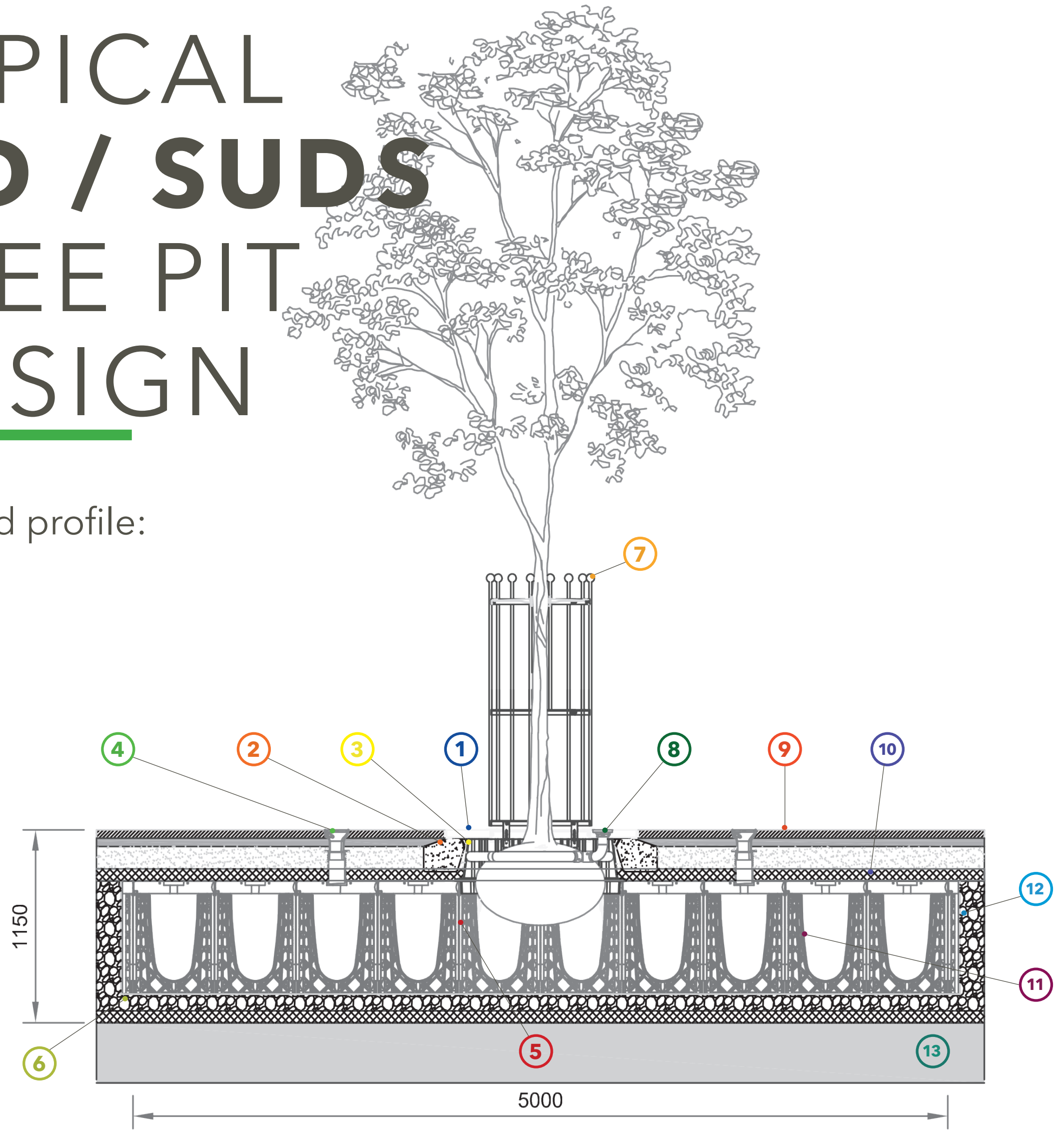
II. **Late November** – clear leaf debris from water inlet channels.

III. **12 monthly** – remove water inlet grilles, clean accessible channels.

IV. **Bi-annually** – inspect, check and clean filter media in SUDs trough systems.

TYPICAL **LID / SUDS** TREE PIT DESIGN

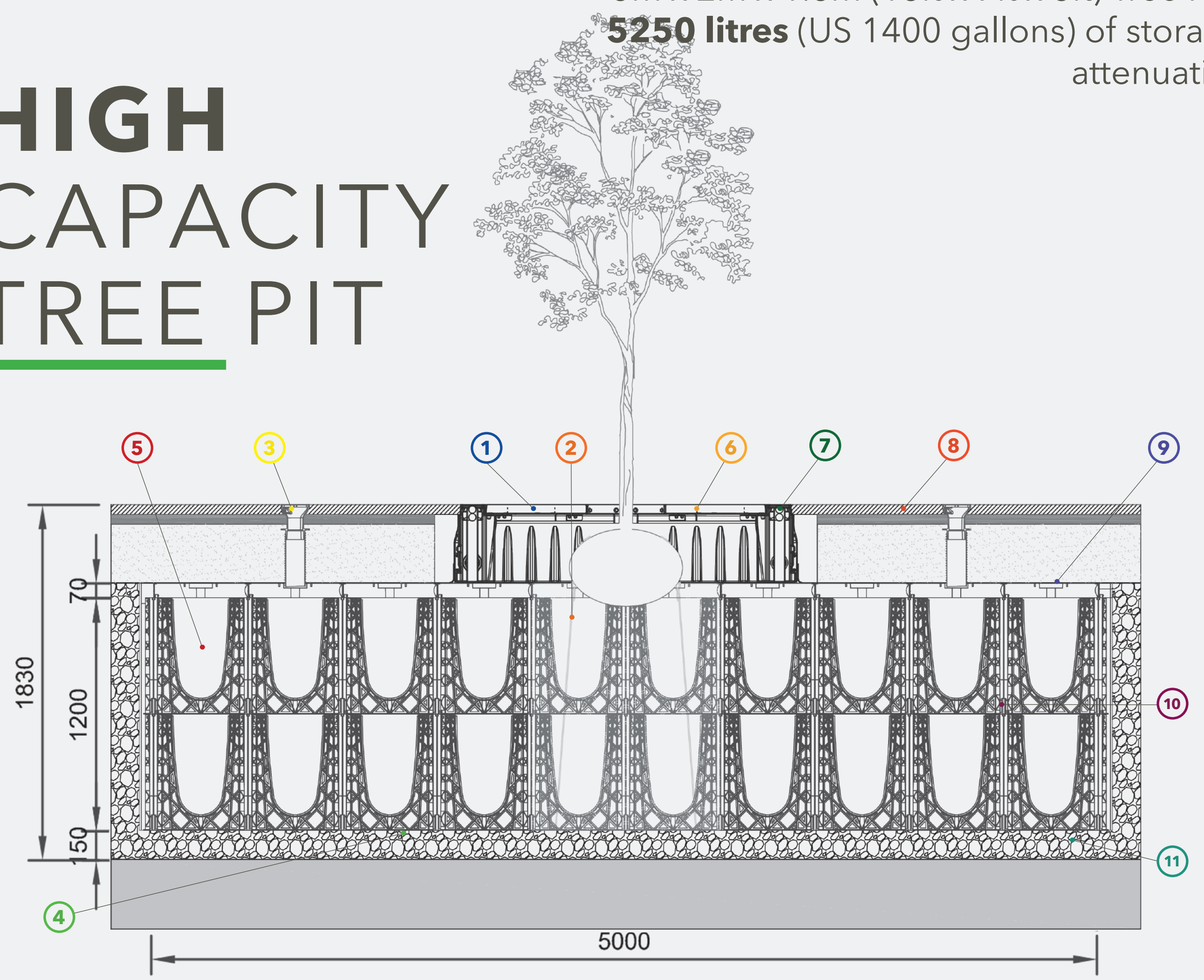
Standard profile:



1. ADUR12B 1200mm x 1200mm (47" x 47") tree grille c/w RootRain Hydrogrille irrigation inlet.
2. Galvanised tree grille support frame set on concrete haunch.
3. RD1000-RS RootSpace, RootDirector, medium, modular root barrier system.
4. RRARBV150A Arborvent 150 double inlet aeration/irrigation system with cast inlets fitted to RootSpace Airflow inlet.
5. SASLCB Arborguy strapped anchor system c/w ground anchors.
6. Drainage layer - 150mm (6") depth of clean angular stone around sides and base of RootSpace structure.
7. ULLSSP6A Ullswater vertical steel tree guard 1.8m high x 600mm diameter (6ft x 24") secured to grille.
8. RRHYDR1A RootRain Hydrogrille single inlet aeration/irrigation system with cast inlet.
9. Pavement/road construction.
10. GLTWGNA twinwall geonet laid over RootSpace structure.
11. RootSpace structure - 1 module deep x 10 modules across x 6 modules wide (1 x 2 x 2 module void below RootDirector) loaded with RootSoil 20 c/w Airflow deck.
12. GRN20 plastic open reinforcing mesh, 20mm (3/4") aperture laid below and around sides of RootSpace structure.
13. Sub-base and drainage installed below RootSpace to structural engineer's/engineer's requirement/detail.

HIGH CAPACITY TREE PIT

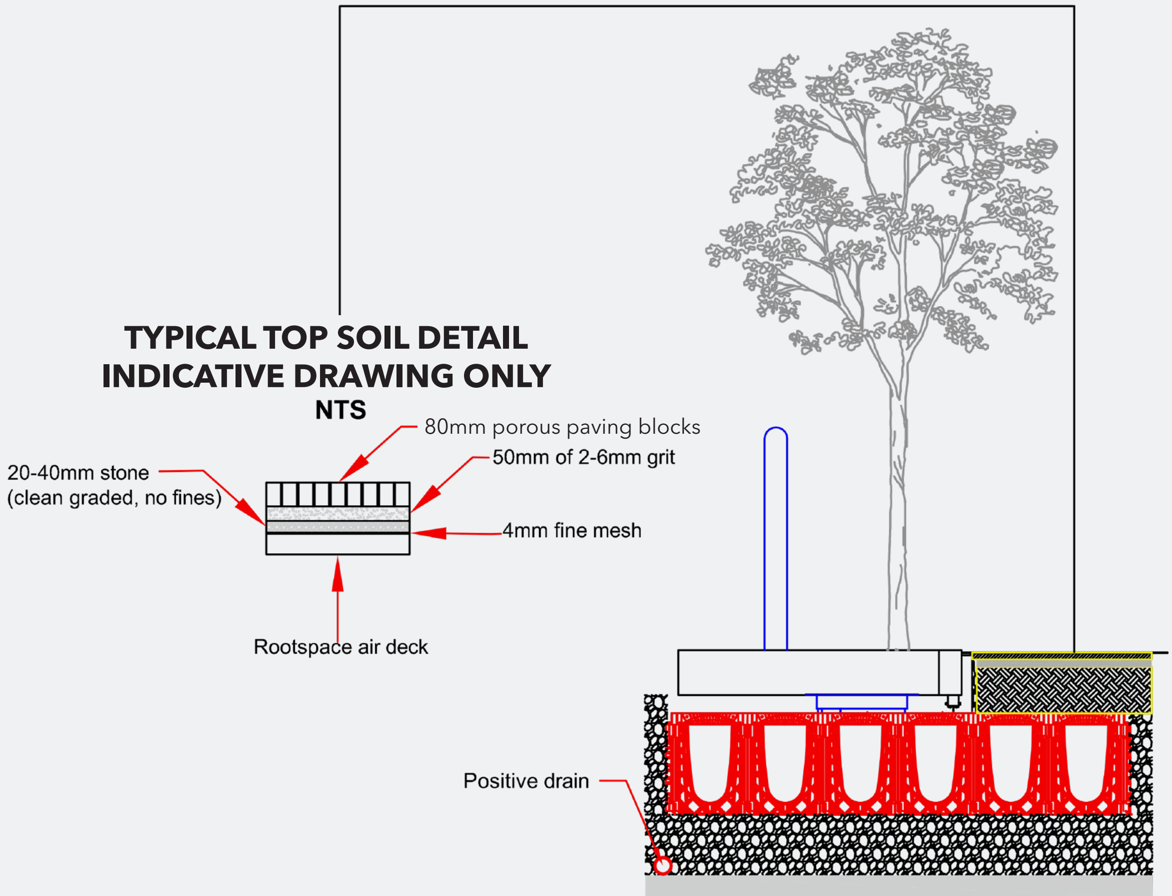
5m x 2m x 1.8m (16ft x 7ft x 6ft) Tree Pit = **5250 litres** (US 1400 gallons) of storage/attenuation.



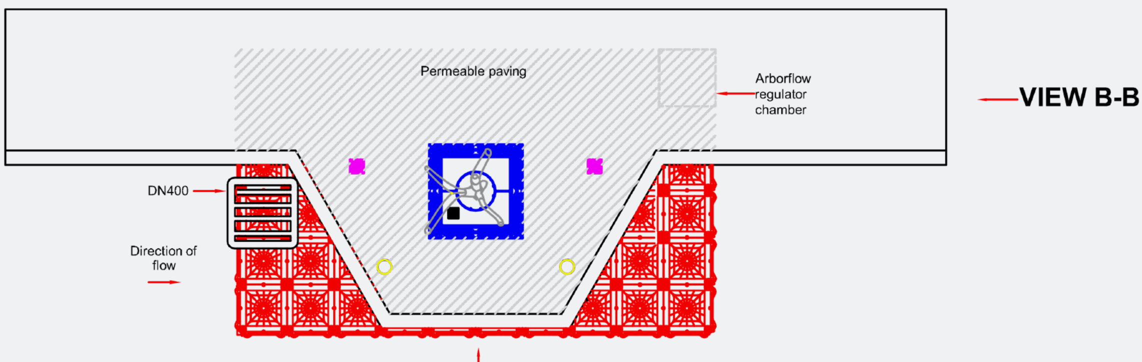
1. ArborFlow 100 series 1500mm x 750mm (60″ x 30″) SUDS modular array.
2. SASDMB Arborguy deadman strapped anchor system.
3. RRARBV150A ArborVent 150 double inlet aeration/irrigation system with cast inlets fitted to RootSpace Airflow Inlet.
4. Drainage layer - 150mm (6″) depth of clean angular stone around sides and base of RootSpace structure.
5. RootSpace structure - 2 modules deep x 10 modules across (1 x 2 x 2 module void below root ball) loaded with ArborSoil HyrdroSUBA to lower level of RootSpace - c/w Airflow deck.
6. ARBPC1507A 1500mm x750mm (60″ x 30″) tree grille.
7. Galvanised tree grille support frame recessed into and attached to ArborFlow 100.
8. Pavement/Road construction to engineer's details.
9. GLTWGNA twinwall geonet laid over RootSpace structure.
10. GRN20 plastic open reinforcing mesh, 30mm (1.25″) aperture laid below and around sides of RootSpace structure.
11. Sub-base and drainage installed below RootSpace to structural engineer's requirement/detail.

SEE PAGE 3, 14 OR 15 FOR TYPICAL SCENARIO

TRAFFIC CALMING BUILD OUT TREE PIT **DETAIL**



VIEW B-B



VIEW A-A

PLAN WITH CANOPY HIDDEN (NTS)

SEE PAGE 20 FOR TYPICAL SCENARIO

Case Study:

WSUDS INSTALLATION PROCESS

Installing RootSpace 600 and ArborFlow in Bletchley Town Centre.

Products used:

- 896 RootSpace Uprights
- 384 RootSpace Aeration Lids
- 8 ArborFlow Units
- 8 ArborGuy Anchor Kits
- 8 ArboResin Precast Grilles
- Soil, Geonet/CombiGrid and Mesh

1

RootSpace 600 is an easily assembled load bearing soil support system – lightweight for ease of handling and assembly.

2

The vertical panels are set out, interconnected and squared up by installing the air deck lids around the perimeter.

3

ArborFlow panels are designed for both root direction and water conveyance / attenuation.

4

The panels and corners can be assembled to create the specified tree pit size which will depend on tree root ball size and species selection.

5

It is good practice to have a ‘dry run’ to confirm tree pit positions before filling with soil.

6

Where large areas of RootSpace are used, further air deck lids should be installed at cross sections as shown to ensure that the structure remains square, before filling with soil media.

7

Soil filling is from the top, and is lightly firmed in 150mm (6”) layers by foot traffic – do not use compaction equipment.

8

RootSpace is covered with reinforced geotextile, and road stone compacted above to engineer’s requirements – shown here prior to the placing of the ArborFlow assembly.

9

ArborFlow tree pit surround installed and awaiting final soil filling and tree planting.

10

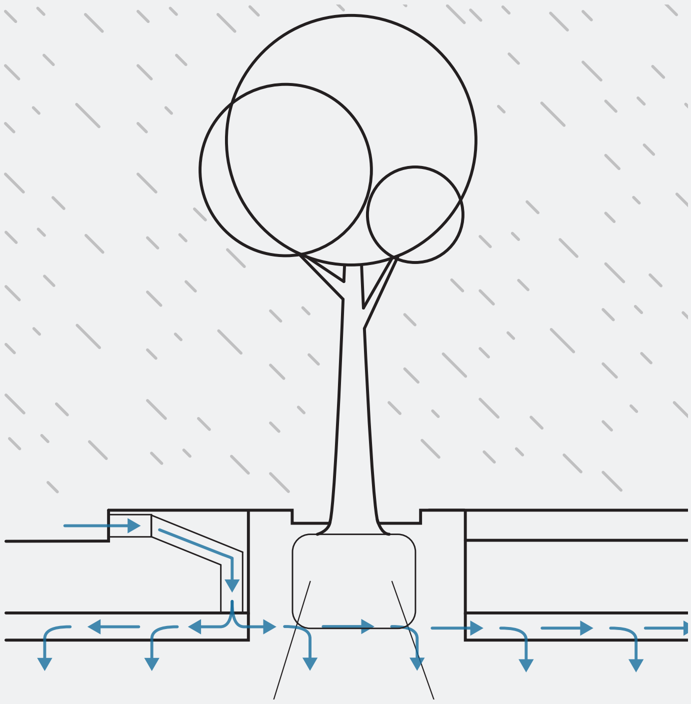
Trees planted the following winter – Acer Campestre, note porous resin bound tray surround giving additional water permeability.

SIX ALTERNATIVE METHODS FOR BRINGING WATER INTO TREE PITS

Kerb Inlet / Curb Inlet

Bringing water in at road level, and into the top of the tree pit via a channel or pipe.

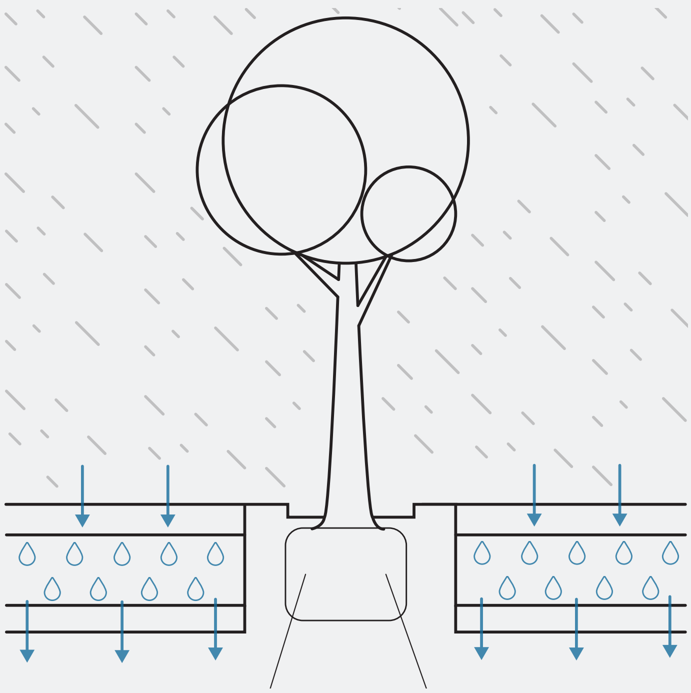
- Robust highway construction
- Inlet maintenance required
- Maximises attenuation value of tree pit



Permeable Paving

Water percolates through the surface - very even flow, first stage filtration, best for car parks and low traffic areas. Can lose some permeability over time.

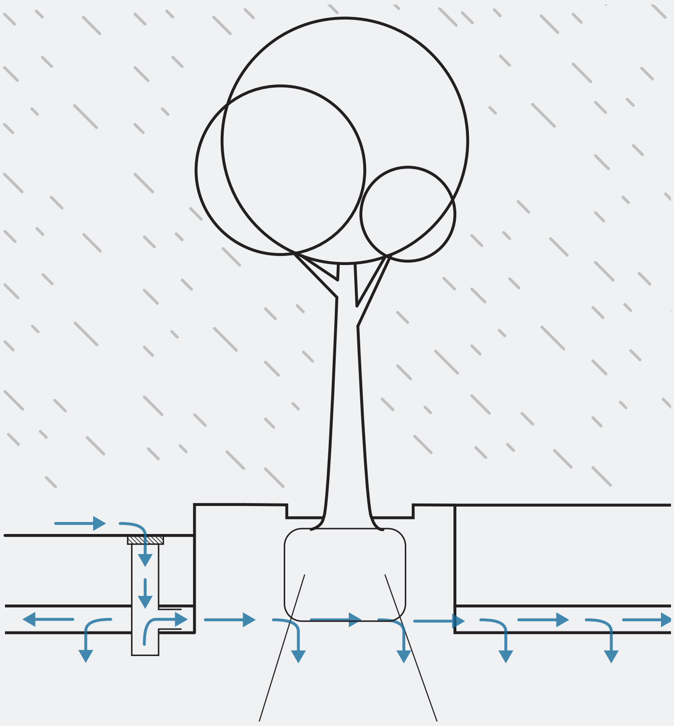
- Robust highway construction
- Inlet maintenance required
- Maximises attenuation value of tree pit



Traditional Gutter

Water is diverted to the tree pit from the gutter, directly into the Arborcell flood zone above the RootSpace air deck. Can be designed for overflow to divert back to storm drain when tree pit capacity is reached.

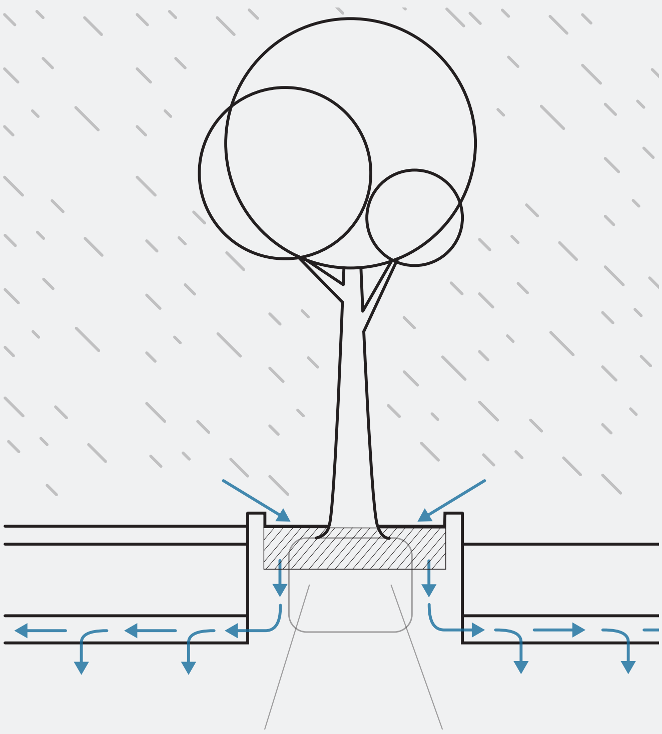
- Robust highway construction
- Standard non-skilled maintenance
- Large capacity, and a first stage silt trap



Weir Inlet

Classic SUDS approach brings water in at the surface - needs a mesh or stone weir to prevent soil erosion. Raised kerb/curb corrals the water to improve percolation into the tree pit. Easily maintained by non-skilled personnel.

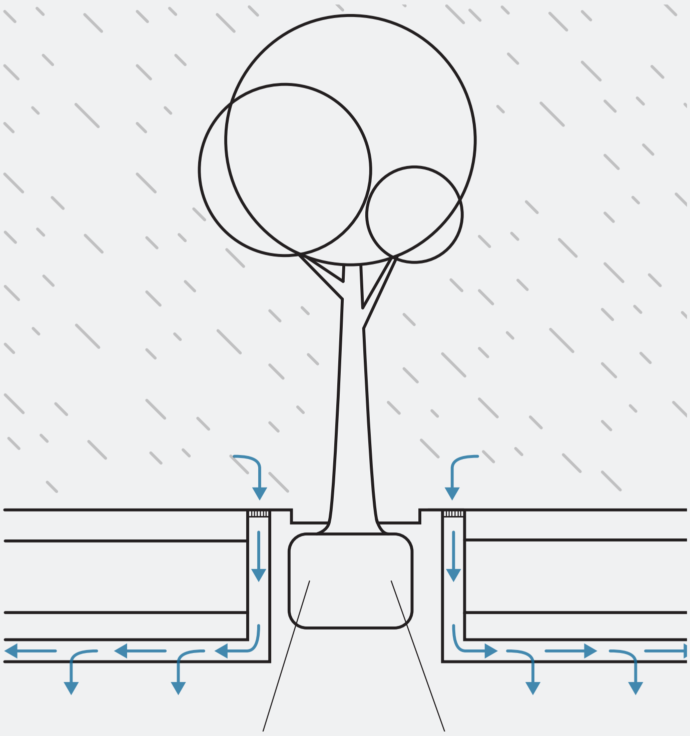
- Irrigates entire tree pit, including any under planting and ground cover
- Attractive landscape feature
- Visible SUDS send a sustainable message to communities



ArborFlow Surround

Maintainable drain directs water to the root zone directly, reduces possibility of high level waterlogging. Will need annual visit to maintain.

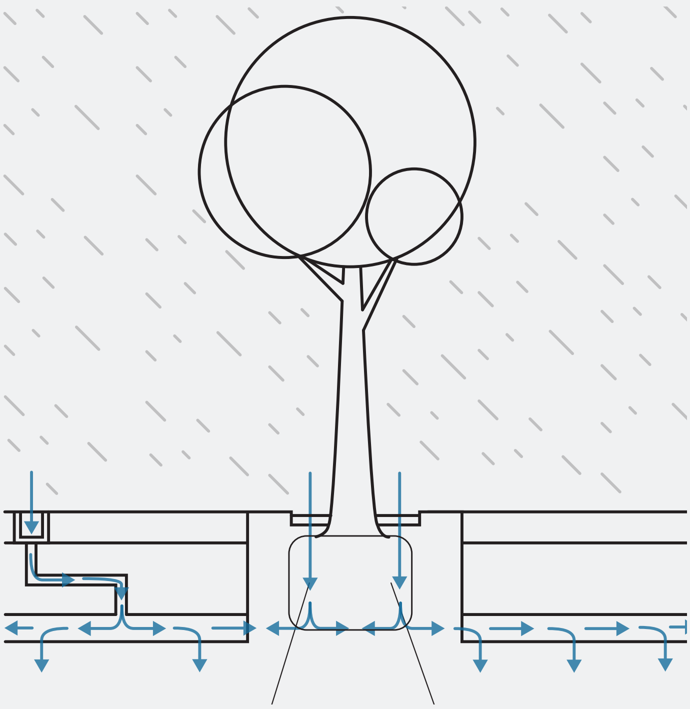
- Good instant flood capacity
- Root management feature - guiding roots to preferred rootzone
- Periodic maintenance visits to clear debris required, depending on location

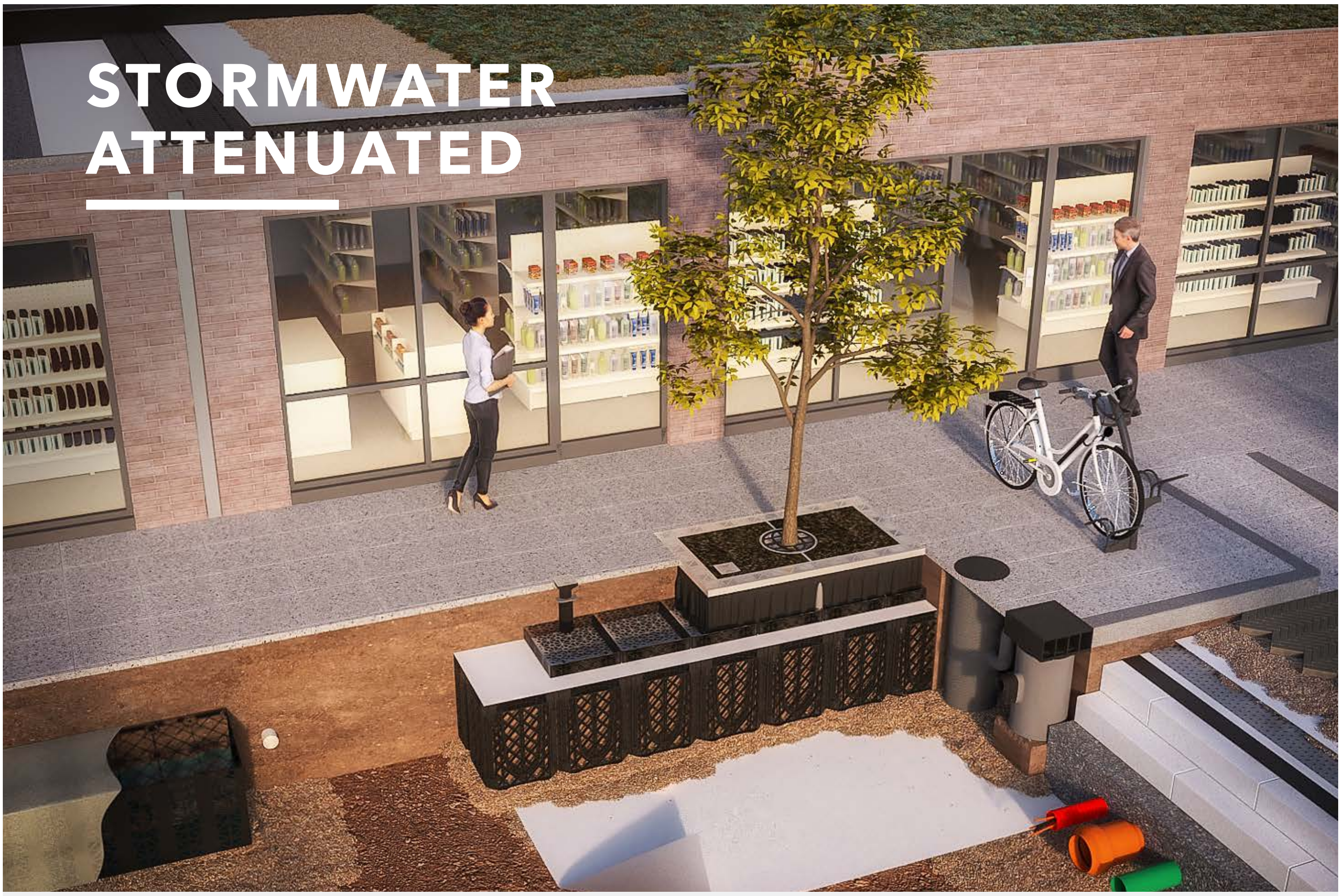


Slot Drain

Shown here in conjunction with permeable Arboresin, the traditional slot drain type inlet can be linked into the RootSpace zone directly or via silt trap making it a popular and effective choice for pedestrian and car park zones.

- Standard non-skilled maintenance
- Smart unobtrusive integrated solution
- Cost efficient





One tree within a 25m³ (880 ft³) GreenBlue Urban RootSpace system has **22%** of volume available for **stormwater attenuation**...

(source: Kenton Rogers - Treeconomics)

This is equivalent to **5,500 ltrs** (1,450 gallons) of storage space (or 5.5m³/195 ft³) with a 48hr recharge rate. This is enough to capture 10mm (1/2") of rain from 550m² (5,920 ft²) of impervious surface (Nisbett 2005) .

Treating the 10mm (1/2") rain event treats about 26% of the annual rainfall in London .

Annual rainfall is 671mm in London, with other cities like New York and Toronto being similar. 26% of this is approximately 176mm.

Treating 176mm per year from 550m² amounts to 96.8 m³ per year.

Multiplying this by the standard volumetric charge for having to treat the water (£1.516p/m³) gives a total of £146.75 (or about $200 USD) per annum.

This sum will be increased by RPI every year and will then be discounted to NPV.

TREES IN **WATER SENSITIVE** URBAN DESIGN

10 Key points for trees in water sensitive urban design.

1

Review catchment areas and access location rainfall data to define target attenuation volumes and long term storage requirements.

2

Ascertain whether ground recharge is acceptable for your project site. In the event of it being unacceptable, consider lining tree pits with an impermeable membrane. Note: Drainage will be very important, so allow for suitable drain exit.

3

Decide on the number of trees required and the species. This may be influenced by other site factors and space constraints. Tree species will necessarily be required to cope with repeated inundations, and prolonged dry conditions, as the SUDS tree pit is inherently a free draining design.

4

Design tree pits to accommodate the required soil volumes for each tree. (Consult our tree pit soil volume calculator if necessary) As an approximation, between 22-26% of the below ground soil volume will be available as water storage space. The tree pit water capacity can be increased by integrating ArborFlow panels and Aquamulti block storage – speak to the GBU design team for advice on this.

5

If not using one of our standard GBU SUDS tree pit templates, then ensure there is appropriate uncompacted soil volume, root management, suitable bioretention soil type, drainage and soil aeration.

6

Where possible, link tree pits together below ground to increase the effectiveness of the system, and increase available rooting volume for the trees.

7

Decide on suitable water inlets depending on location. Where possible, avoid reliance on a single inlet point, but incorporate multiple inlets, and plan for exceedance flow in the event of a severe storm. Consider incorporating permeable paving above the tree pit system.

8

Consider both weir inlets which keep water flowing in at surface level, and traditional drain inlets with silt traps if required. There will be maintenance considerations here.

9

Decide where tree pits will ultimately drain to, once they have reached capacity as prolonged water logging will kill the tree. Some tree pits will include longer term storage volume below the drainage invert point for the tree to draw on through capillary action, however there must be sufficient well drained soil above this point for the roots to access aerated soil.

10

We would suggest running your completed design past our tree pit design support team for comment and input – the first consultation is completely free of charge.

Get in touch

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OPEN VEGETATED **RAINGARDEN** & **SWALE** TREE PLANTING

Stormwater runoff intercepted by this system is treated via a number of natural processes including sedimentation, physical filtration by soil and plants, chemical adsorption, biological processing and bacteria within the soil.

The benefits:

- Lowest cost specialist SUDS tree pit.
- Cell layer beneath paving can increase water storage, helping to maintain ground porosity.
- Root management - optional here - assist in diverting roots to preferred root zone to design out surface root heave and improve drought tolerance.
- Base drainage to prevent prolonged water logging.
- Specific soil formula balanced for water attenuation and tree nutrient purposes.

Above: *Bioretention raingarden tree pit located in Bridget Joyce Square, London.*

SWALE **SUDS** TREE PLANTING

Advantages:

- Can be planned as landscaping features.
- Very effective in removing urban pollutants.
- Can reduce volume and rate of runoff.
- Flexible layout to fit into landscape.
- Well-suited for installation in highly impervious areas, provided the system is well-engineered and adequate space is made available.
- Good retrofit capability.

Disadvantages:

- Requires landscaping and management.
- Susceptible to clogging if surrounding landscape is poorly managed.
- Not suitable for areas with steep slopes.
- Regular inspection.
- Litter/debris removal.
- Replacement of mulch layer.
- Vegetation management.
- Reduction in usable above-ground space.

Key maintenance and requirements:

- Regular inspection.
- Litter/debris removal.
- Replacement of mulch layer.
- Vegetation management.
- Soil spiking and scarifying.

Performance	SWALE Tree Pit	Paved Tree Pit	Site Suitability	SWALE Tree Pit	Paved Tree Pit
Peak flow reduction	Medium	Good	Residential	Yes	Yes
Volume reduction (high with infiltration)	Medium	Good	Commercial/industrial	Yes	Yes
Water quality treatment	Good	Medium	High density	No	Yes
Amenity potential	Good	Good	Retrofit	Yes	Yes
Ecology potential	Medium	Medium	Contaminated sites/ sites above vulnerable groundwater (with liner)	Yes	Yes
Treatment Train Suitability			Cost Implications		
Source control	Yes	Yes	Land-take	High	Low
Conveyance	No	No	Capital cost	Low	High
Site systems	Yes	Yes	Maintenance cost	Medium	Medium
Regional system	No	No			
			Pollutant Removal		
			Total suspended solids	High	Medium
			Nutrients	Low	Medium
			Heavy metals	High	Medium

RAIN GARDENS & **TREES**

These examples illustrate good practice for street situations, including retro-fit scenarios.

Figure 1 *Traffic calming build outs can provide urban planners with an excellent opportunity to simultaneously address traffic flow, provide green infrastructure, and stormwater management.*

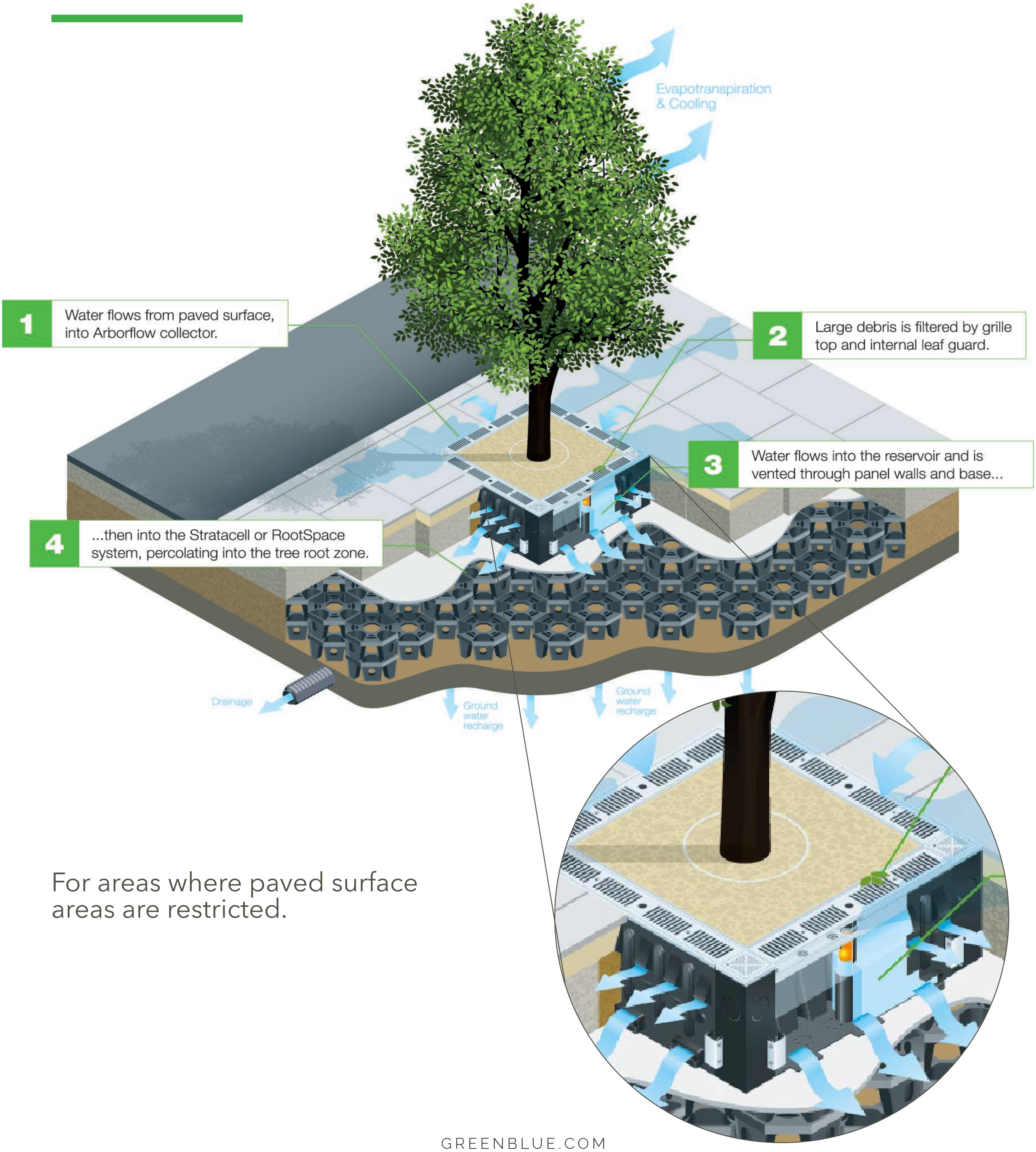
FIGURE **1**

FIGURE **2**

Figure 2 *Taken before groundcover planting, the key components of this kind of SUDS feature can include weir plates, catchment kerbs/ curbs, bioretention soil, and overflow provision. The soil and water volume requirements can be reached by using Stratacells or RootSpace beneath pavements and roadways.*

This buildout is designed to intercept storm flow, clean and store water, and when attenuation and long term storage capacities are reached, allow for exceedance flow on to the next stage to safeguard tree health.

THE **ARBORFLOW** MODULE



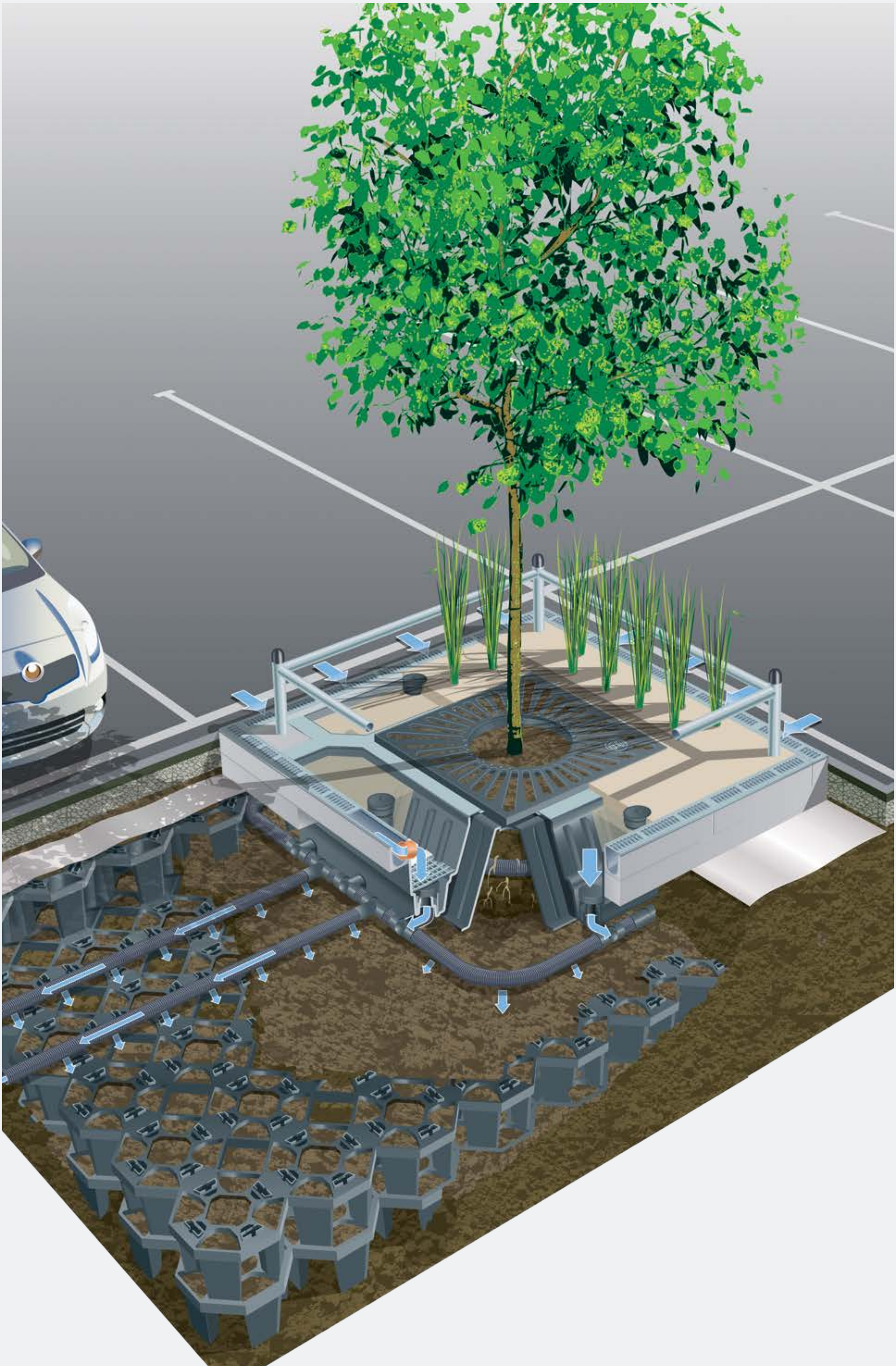
For areas where paved surface areas are restricted.

PAVED SURFACE **ARBORFLOW 100**

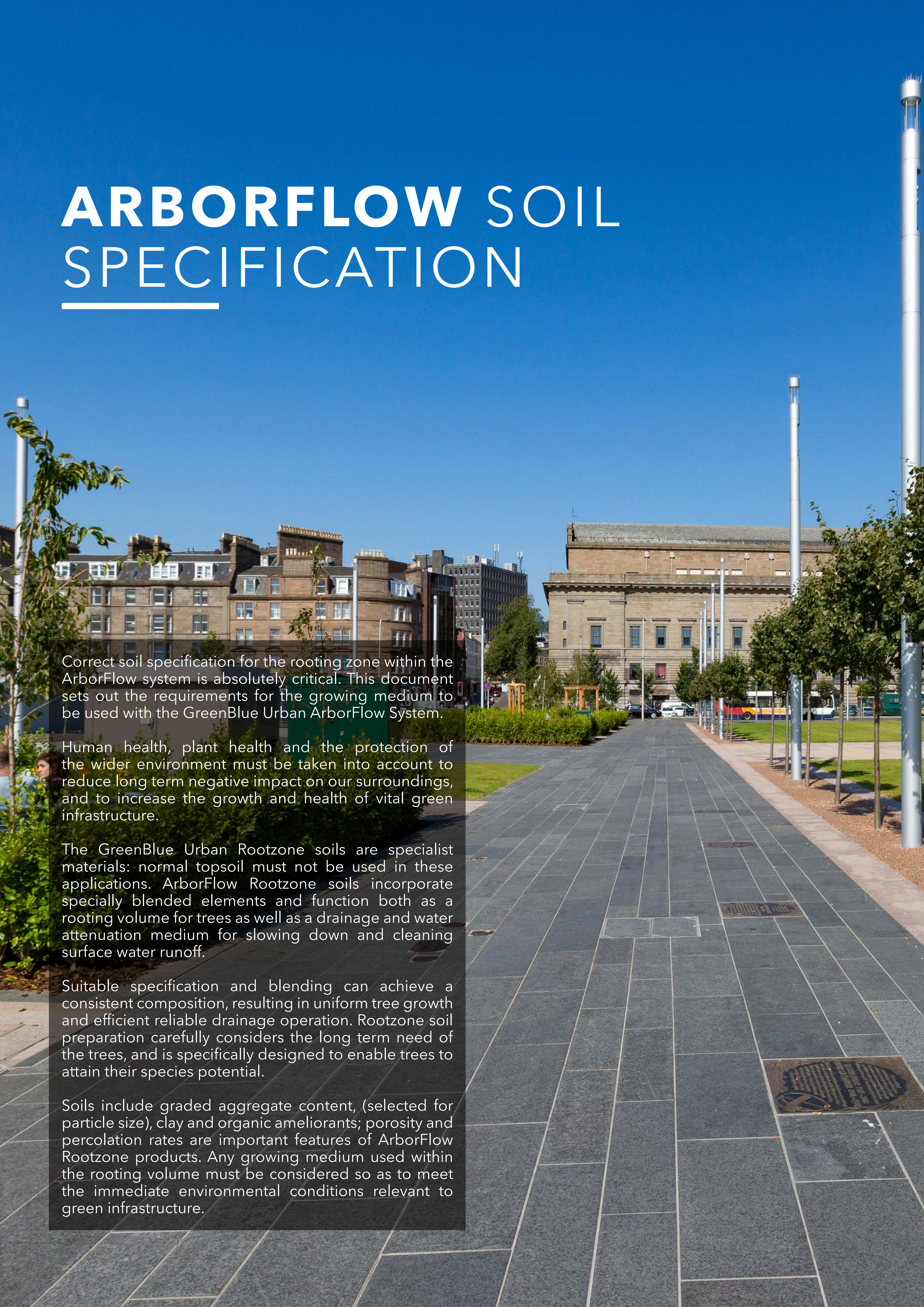
Products manufactured from 100% recycled materials.

The sustainable, efficient and environmentally robust process of managing surface water runoff.

- Compact design for lower volume applications.
- Cell support to provide optimal growing conditions for tree roots and maintain soil porosity.
- ArborFlow Compact SUDS panel – increase pit infiltration, water dispersion, attenuation, aeration and flood detection.
- Root management integral – diverting roots to optimal root zones – preventing paving heave from root activity and improving drought tolerance.
- Active drainage – preventing prolonged water logging.
- Modular system – tree pit size can be increased in interlocking sections where space permits – making best use of available ground volumes.
- Specific soil formula balanced for water attenuation and tree nutrient purposes.



ARBORFLOW SOIL SPECIFICATION



Correct soil specification for the rooting zone within the ArborFlow system is absolutely critical. This document sets out the requirements for the growing medium to be used with the GreenBlue Urban ArborFlow System.

Human health, plant health and the protection of the wider environment must be taken into account to reduce long term negative impact on our surroundings, and to increase the growth and health of vital green infrastructure.

The GreenBlue Urban Rootzone soils are specialist materials: normal topsoil must not be used in these applications. ArborFlow Rootzone soils incorporate specially blended elements and function both as a rooting volume for trees as well as a drainage and water attenuation medium for slowing down and cleaning surface water runoff.

Suitable specification and blending can achieve a consistent composition, resulting in uniform tree growth and efficient reliable drainage operation. Rootzone soil preparation carefully considers the long term need of the trees, and is specifically designed to enable trees to attain their species potential.

Soils include graded aggregate content, (selected for particle size), clay and organic ameliorants; porosity and percolation rates are important features of ArborFlow Rootzone products. Any growing medium used within the rooting volume must be considered so as to meet the immediate environmental conditions relevant to green infrastructure.

GreenBlue Urban

RECOMMENDED SOIL SPECIFICATION FOR **BIO-RETENTION** TREE PITS

Rootzone:

Purity: free of pests, disease, and hostile fungus.

Foreign matter: on visual inspection, free from non-soil material, brick and other building materials and wastes, sharps, hydrocarbons, plant matter, weed roots, stolons, rhizomes, and any other foreign matter or material or substance that would render the rootzone unsuitable for landscape use.

Contamination: do not use rootzone contaminated with rubbish or other materials that are:

Corrosive, explosive or flammable.

Hazardous to human or animal life.

Detrimental to healthy plant growth.

Give notice: If any evidence or symptoms of contamination are discovered in the rootzone to be used.

Right: *Goldhawk Road, London Borough of Hammersmith & Fulham.*

ARBORFLOW ROOTZONE SPECIFICATION

Parameter	Unit	ArborFlow Rootzone
Clay (<0.002mm)	%	10
Silt (0.002-0.05mm)	%	11
Sand (0.05-2.0mm) of which at least 45% shall fall into the fine to medium sand range (0.15mm-0.5mm)	%	79 (of which 59% is fine to medium sand)

Class Texture		**Sandy Loam**
Stones (2-20mm)	%DW	4.2
Stones (20-50mm)	%DW	0
Stones (>50mm)	%DW	0
pH value	Unit	8
Electrical Conductivity (1:2.5 water extract)	µS/cm	469
Electrical Conductivity (1:2.5 water extract)	µS/cm	2499
Exchangeable Sodium	%	3.2
Percentage		
Organic Matter	%	7.5
Total Nitrogen	%	0.22
Carbon: Nitrogen ratio	-	11.1
Extractable Phosphorous	mg/L	28.2
Extractable Potassium	mg/L	513
Extractable Magnesium	mg/L	91.1
Calcium Carbonate	%	1.06%
Saturated Hydraulic Conductivity	mm/hr	> 10mm/hr (Estimate based textural classification)

Give notice if any evidence or symptoms of contamination are discovered in the rootzone to be used.

Parameter	Unit	Arborflow Rootzone
Inorganic Arsenic	mg/kg	20.5
Boron (soluble)	mg/kg	1.9
Cadmium	mg/kg	1.54
Chromium (III)	mg/kg	22.4
Chromium (VI)	mg/kg	<0.1
Copper	mg/kg	41.0
Lead	mg/kg	95.3
Mercury	mg/kg	<0.2
Nickel	mg/kg	32.9
Selenium	mg/kg	0.90
Zinc	mg/kg	144
Phenol	mg/kg	<1
Benzene	mg/kg	<0.02
Toluene	mg/kg	<0.02
Ethylbenzene	mg/kg	<0.04
Xylene -m	mg/kg	<0.2
Xylene - o	mg/kg	<0.1
Xylene - p	mg/kg	<0.2
Aliphatics C5-C6	mg/kg	<0.2
Aliphatics C6-C8	mg/kg	<0.4
Aliphatics C8-C10	mg/kg	<4
Aliphatics C10-C12	mg/kg	<4
Aliphatics C12-C26	mg/kg	<4
Aliphatics C16-C35	mg/kg	10
Aromatics C5-C7	mg/kg	<0.02
Aromatics C7-C8	mg/kg	<0.02
Aromatics C10-C12	mg/kg	<4
Aromatics C12-C16	mg/kg	<4
Aromatics C16-C21	mg/kg	<4
Aromatics C21-C35	mg/kg	28.6
Acenaphthene	mg/kg	<0.05
Acenaphthylene	mg/kg	<0.05
Anthracene	mg/kg	<0.05
Benzo(a)anthracene	mg/kg	<0.1
Benzo[a]pyrene	mg/kg	<0.1
Benzo(b)fluoranthene	mg/kg	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1
Benzo(k)fluoranthene	mg/kg	<0.1
Chrysene	mg/kg	<0.1
Dibenzo[a,h]anthracene	mg/kg	<0.1
Fluoranthene	mg/kg	0.1
Fluorene	mg/kg	<0.05
Indeno(1,2,3-cd)pyrene	mg/kg	<0.1
Naphthalene	mg/kg	<0.05
Phenanthrene	mg/kg	<0.1
Pyrene	mg/kg	<0.1

Research Study:

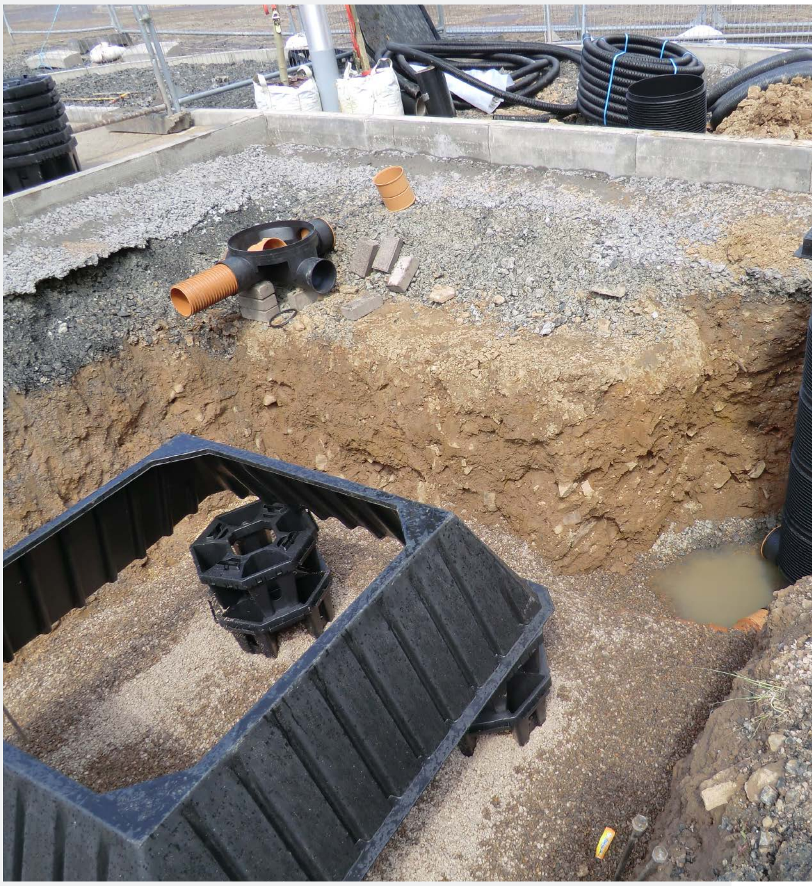
TRIAL TREE PIT IN **DUNDEE**

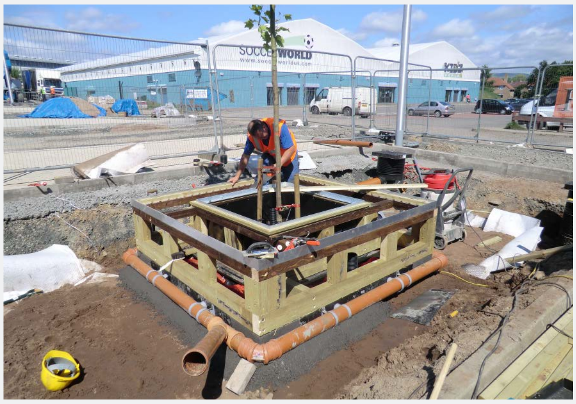
Critical research and development for SUDS tree pits carried out by GreenBlue Urban with Abertay University.

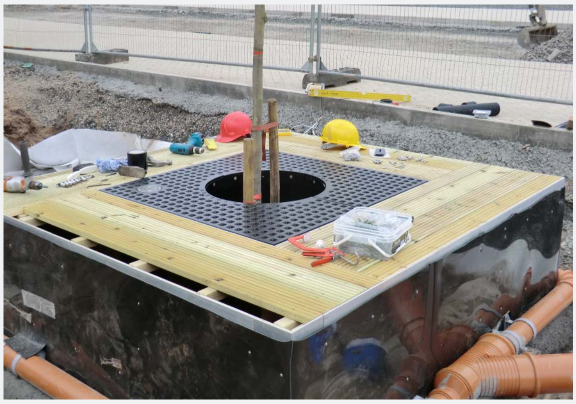
Report Extract:

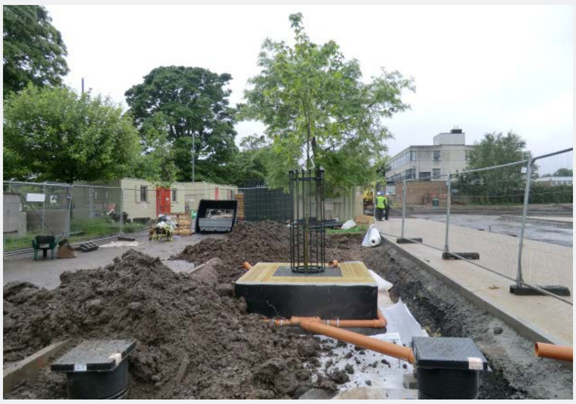
In the 2017 progress report on this site, Abertay University states that "The estimated design peak runoff of the entire site for a 1 in 30 year, 1 hour event has been calculated at 8.54 l/s using the standard soil value for specified bio-retention unit soil. This means that in order to reduce this to the equivalent of a 1 in 5-year greenfield event, the system would have to provide a 41.45% reduction in flow rate, over the entire car park.

As installed, this system provides primary attenuation of storm flow from a catchment totalling approximately 148.5 m2 (Table 1), which is 11.34% of the total car park area with an average flow reduction of 88%, which is greater than that required. If flow reduction is assumed to be directly linked to the area of discharged then one system could attenuate the flow of an area of approximately 218 m2 whilst still meeting the 41.45% reduction criteria, meaning that 6 systems would be required to drain the entire car park."









During installation – showing tree surround support frame, and SUDS containment chambers prior to filling with filter media. This trial tree pit gives a soil volume of 13.25 cubic meters and combined attentuation volume of 3850 litres.

This construction is currently being monitored by the University Abertay Urban Water technology Centre. The tree pit provides an 'off line' drainage.

STORMWATER INTERCEPTION VOLUME

~ 1 Inch Rainfall Event

Xiao Q., and E.G. McPherson, 2003. Rainfall interception by Santa Monica's municipal urban forest. Urban Ecosystems.

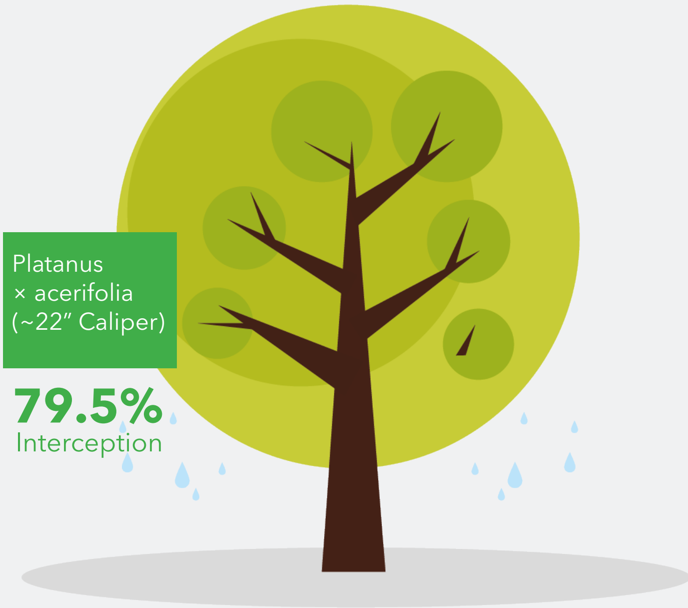
2"/50mm Caliper Jacaranda versus 22"/560mm DBH Plane Tree

Jacaranda Acutifolia (~2" Caliper)

15.9% Interception

Platanus × acerifolia (~22" Caliper)

79.5% Interception

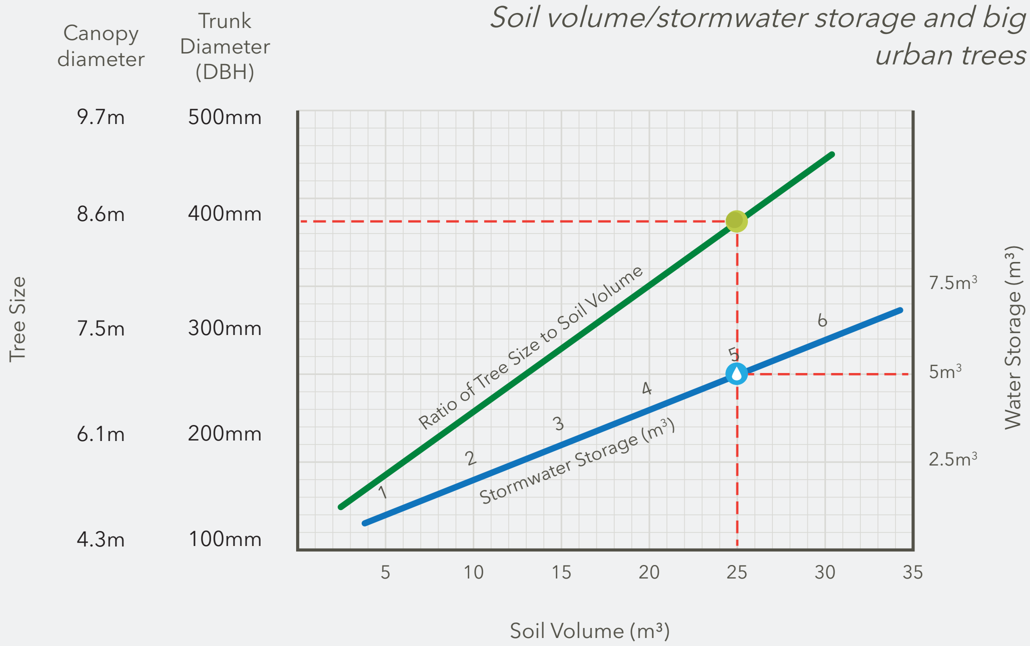


Soil volume/stormwater storage and big urban trees

Example

A 375mm diameter tree trunk (8.3m canopy diameter) requires 25m³ of soil.

25m³ of soil stores 5m³ of stormwater.



SOIL FOR FILTERING

Cumulative percent removal by depth, Laboratory/Field summary.

Bioretention soil mix: 75% large sand, 10% fine sand, 7% silt, 5% compost, 3% clay

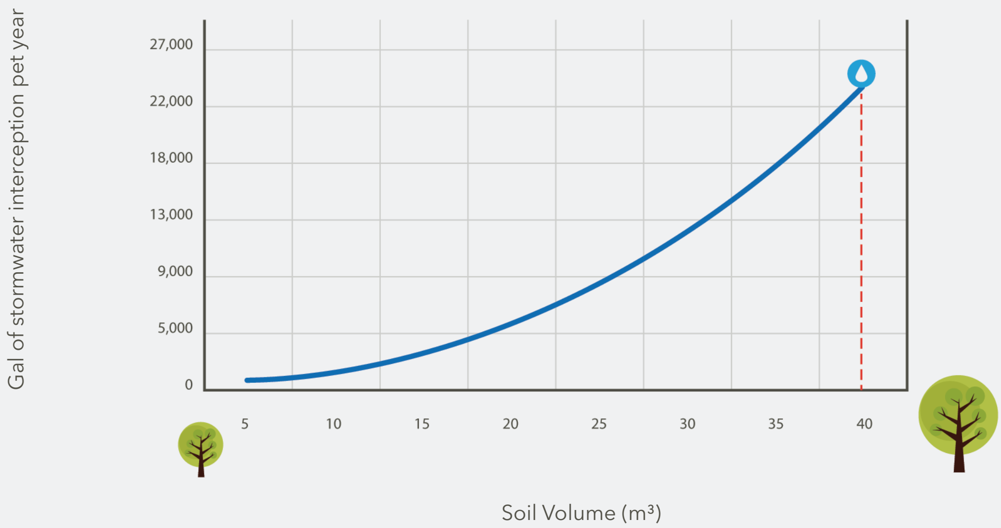
Soil Depth	cU Copper	pB Lead	Zn Zinc	P Phosphorous	TNK Keldahl Nitrogen
300mm / 12"	90	98	87	0	37
600mm / 24"	93	99	98	73	60
900mm / 36"	93	99	99	81	68

Data on bioretention removal rates of pollutants such as ammonium and total nitrogen is variable, so has not been included here. Adapted from Prince George's Country Bioretention Manual.

MODELLED VALUE OF STORMWATER INTERCEPTION

Bioretention soil mix: 75% large sand, 10% fine sand, 7% silt, 5% compost, 3% clay

Stormwater Interception by Hakberries versus Age of Tree



THE **VALUE** OF **URBAN TREE** BENEFITS

The enormous economic benefits an urban tree can bring over the course of **50 years**.

Energy & the Environment:

The net cooling effect of a large, established, healthy tree is equivalent to 10 room size air conditioners operating 20 hours a day.

Trees properly placed around buildings as windbreaks can save up to 25% on winter heating costs.

As few as three trees properly positioned can save the average household between £70 and £180 (or $95-$250 USD) annually in energy costs.

Fifty million shade trees planted in strategic, energy-saving locations could eliminate the need for seven 100-megawatt power plants.




ECO-SYSTEM **BENEFITS**

Tree with **soil cells** + **bioretention soil**:

Total benefits over 50 years:
£29,486 (approx. $39,900 USD)

Total costs over 50 years

(installation plus maintenance):
£11,535 (approx. $15,600 USD)

Net lifecycle benefit value over 50 years:
£17,950 (approx. $24,315 USD)

WATER RESILIENT CITIES

Interreg
EUROPESE UNIE
Vlaanderen-Nederland
Europees Fonds voor Regionale Ontwikkeling

GreenBlue Urban are pleased to support the EU Interreg project named Water Resilient Cities This project aims to develop new capabilities and increase awareness of the issues of retrofitting strategic SUDs in our towns and cities to help mitigate climate change.

As part of the project output, GBU are establishing a network of private and public-sector partners across to share knowledge and develop best practice principles; including lead partner Plymouth City Council.

Interactive workshop sessions in Mechelen , Kortrijk - Belgium and Condette - France have seen the most important work surrounding integrating green infrastructure and sustainable urban drainage into our towns and cities most importantly how we communicate the added value of SUDs to stakeholders and end users who live, work and play in urban environments with little prior knowledge as to the important role green infrastructure, particularly tree pits, can play in managing storm water and climate proofing our towns and cities.

Plymouth Pilot Pits

Working alongside lead partner Plymouth City Council we are now into the initial phases of implementing pilots as part of our involvement in the Water Resilient Cities project. Works have already begun on site in the iconic and key commercial quarter of the city, Armada Way. Armada Way is situated in Plymouth's city centre.

So why this area and what are the benefits of piloting SUDs tree pits solutions? It is critical to ensure that such projects relate to an overarching vision for a city's future development and that the community are engaged.

A representative of the design team on this project provided the following comments to contextualise this, explaining that the council "wishes to encourage a greater diversification of uses within the public realm to attract and support new residential, office and evening economy uses into the city centre. We want to connect and show off the city's best assets.

The city wants to regenerate the public realm such that it's built to last, reducing maintenance costs and generating revenue." The rationale for integrating SUDs was crucial: "We want to embed SUDs into the public realm wherever possible, but it has to be multifunctional as well as being attractive, supporting wildlife and green infrastructure, and encouraging children's play.

We need to find a way of channelling rain water from existing and new development roof tops, plus surface water run-off from hard surfaces in the associated catchments to our new SUDs system to maximise its potential."

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