Greater Manchester's Sustainable Drainage Design Guide

Streets for All Supplementary Technical Guidance




GMCA GREATER MANCHESTER COMBINED AUTHORITY

Transport for Greater Manchester

NATURAL COURSE OUR WATER, OUR FUTURE

North West Regional Flood & Coastal Committee

United Utilities

Version	Date	Details of amendments
1.1	09/12/2024	First issue as adopted by the Greater Manchester Combined Authority.

This document is subject to periodic review. It is a controlled document which becomes uncontrolled when printed. To access the latest version, visit **tfgm.com/strategy/streets-for-all**

Using this guidance

Figure 1.1

Disclaimer

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This guide is not intended to provide any legal, professional, or technical service. Whilst every effort has been made to ensure accuracy, no liability or responsibility of any kind (including liability for negligence) can be accepted for any loss or damage arising from its use.

The guide does not replace existing local authority design assurance, audit or related processes. It is for the Local Highway Authority and designer of a scheme to ensure compliance with regulatory requirements, including under the Construction Design Management Regulations (2015) and the Equality Act (2010).

All figures and statistics are accurate to the best of the authors knowledge at the time of writing.

Feedback and enquiries

Users of this document are encouraged to raise any queries and / or provide feedback on the content and usage of this document by emailing **gmstreetdesignguide@tfgm.com**

Acknowledgements

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Front cover photos kindly provided by Planit-IE, GreenBlue Urban, United Utilities and Transport for Greater Manchester.

Contents

Stockport Interchange. Credit: United Utilities

1. Introduction

1.1. Introduction

Greater Manchester experiences more than its fair share of rainfall, and managing rainfall is becoming an increasingly challenging task for the city region that cannot afford to be ignored. Rainwater management needs to be improved for the existing systems to cope with the increasing consequences of flooding, pollution, combined sewage overflows, and drought.

Grey solutions are possible, but with a changing climate, this approach risks overloading the aging drainage system causing floods on streets, and in homes and businesses. These floods can be a danger to people, damage vital infrastructure and cause economic harm.

Traditional engineered solutions are no longer the only option. Green and blue infrastructure solutions are a way to adapt to a changing climate that reduce flood risk in a more natural way, and at the same time create greener streets and spaces which help to clean the air, store carbon, and improve health and wellbeing.

Greater Manchester's streets are changing.

Every year across the city region there is investment in improving the street network, public spaces and town centres. Greater Manchester's investment in transport infrastructure schemes continues to grow with an anticipated pipeline to March 2032 of projects valued between £3.5bn and £4bn. This provides a vast opportunity to improve how rainwater is managed within streets and public spaces to reduce levels of local surface water flood risk. As part of an ambitious programme of change, use of limited street space is being optimised to deliver the Streets for All vision to make streets better places to live, spend time in and travel along.

Action must be taken to reduce the risk to people in Greater Manchester by sustainably managing rainwater across our streets and public spaces, using Sustainable Drainage Systems (SuDS) to build resilience against climate change and boost the ecological diversity of our urban environment.

"We will ensure that our streets are welcoming, green and safe spaces for all people, enabling more travel by walking, cycling, and using public transport while creating thriving places that support local communities and businesses."

Greater Manchester Transport Strategy 2040.

Regent Street, Altrincham. Credit: United Utilities.

1.2 Using the guide

Purpose

The purpose of this document is to provide guidance on the design, delivery and maintenance of SuDS in the context of Greater Manchester.

Greater Manchester's Sustainable Drainage Design Guide for Streets has been adopted by the Greater Manchester Combined Authority (GMCA) for use in streets, public realm, highways and other schemes as appropriate. It forms part of the Greater Manchester Streets for All Design Guidance.

The purpose of the guide is to:

- Support the delivery of SuDS at scale across the city region.
- Answer common questions around SuDS which may be preventing more widespread delivery and adoption.
- Promote well-considered holistic SuDS design through:
  - providing standard details for common SuDS features.
  - design and infrastructure options for designers to consider across a range of Greater Manchester street contexts.

The guide primarily focuses on delivering retrofit SuDS into the complex built environment through the delivery of street improvement projects.

Those involved in the development of new streets and places should also have regard to the principles of this guide, in conjunction with the CIRIA SuDS Manual to inform drainage design of new streets and places.

The guide brings together key technical design parameters and considerations from across a range of sources and considers them within the Greater Manchester context. Given that this information will change over time, the guide will be subject to periodic review and update.

The guide supports schemes that deliver SuDS on streets and urban spaces across Greater Manchester, while being:

Buildable — Achievable technically, financially, and with stakeholder and community support.

Adoptable — Meet the technical requirements of the adopting authority.

Maintainable — Ongoing maintenance is fully considered in scheme development, specification and construction e.g. choice of materials, cleansing.

Value for money — Grounded in the particular context of the street, using context appropriate materials. While there is a place for 'flagship' schemes, the emphasis is on measures which use standard, or off-the-shelf, materials and features. This means that the principles of the guide can be applied and realised on more streets, more widely.

Application

This guide is for use by all stakeholders involved, or with an interest in, the design, delivery and maintenance of the highway and SuDS, including:

- The 10 Greater Manchester local authorities, particularly in their role as Local Highway Authority, Local Planning Authority and Lead Local Flood Authority.
- Transport for Greater Manchester.
- Organisations responsible for managing water and wastewater.
- Utility and infrastructure providers
- Engineering and design consultants supporting scheme design.
- Developers and other land holders and managers.

Its use is a requirement for schemes funded through the GMCA.

The guide does not replace existing local authority or Greater Manchester design assurance, audit or related processes and it is for the local authority to ensure compliance with regulatory requirements. It does not replace the advice or expertise of SuDS professionals or existing technical guidance. It should be used in combination with current legislation, regulations, and existing local authority design standards and guidance.

Development of the guide

Co-design principles have been applied in the production of the guide, as an essential part of ensuring this is truly a Greater Manchester guide, available for application across all 10 local authorities in Greater Manchester. To support development of the guide, a series of workshops were undertaken engaging the 10 local authorities and other key stakeholders to understand the current challenges to delivering SuDS on retrofit schemes, helping to scope the key content that the guide needed to include.

The guide was drafted by organisations involved in the design, delivery and maintenance of SuDS across Greater Manchester and was supported by a multi-disciplinary Working Group with representation from all 10 local authorities. The group helped to shape the direction of the guide as well as reviewing and providing feedback.

Podium Park, Stockport. Credit: United Utilities

1.3 Policy context

When considering the design of SuDS on streets, there is no shortage of guidance and advice. This guide aims to highlight opportunities that SuDS offer in meeting multiple legislative requirements via one infrastructure solution.

It sits within the wider context of existing local and national policies, strategies, and standards, including:

2019

GM 5 Year Environment Plan

GMCA and the 10 GM local authorities to embed climate change resilience adaptation in all policies and increase the resilience of critical infrastructure.

2021

GM Streets for All Strategy

Sets out the vison to make our streets greener, more welcoming places to travel through and spend time in.

2023

National Policy Planning

Sets a clear expectation for developments to provide SuDS for the management of runoff from 'major development', which should provide multi-functional benefits for water quality, water quantity, biodiversity, and amenity.

2024

Biodiversity Net Gain

Mandatory requirements for Biodiversity Net Gain (BNG) came into effect.

2024

GM Streets for All Design Guide

This guide will inform designs, with the aim of ensuring they are safe and accessible for all, as well as greener and more comfortable places to be.

Places for Everyone

Sets out expectation for developments to manage surface water runoff through SuDS and as close to source as possible growth.

Intergrated Water Managment Plan

Will create value through how collaborative schemes are delivered, integrating spatial opportunities to deliver better outcomes and values.

2025

Schedule 3 of Flood and Water Management Act

Legislation for SuDS in all new developments is expected to come into force in 2025.

2025

GM Local Nature Recovery Strategy

GMCA are the responsible authority for delivering the Local Nature Recovery Strategy in Greater Manchester, a new plan to help nature recover across the region.

GM Local Transport Plan Refresh

Our strategic transport plan set out a commitment to deliver measures to ensure the transport system is resilient to climate change.

Figure 1.2

George Street, Altrincham. Credit: Planit-IE

1.4 SuDS key principles

What are SuDS?

Instead of putting rainwater into pipes under the ground, SuDS are designed to manage surface water runoff locally (as close to where it falls as possible) by capturing, using, absorbing, storing, and transporting rainfall in a way that mimics nature.

SuDS can reduce the volume of water entering the drainage systems by providing spaces for storage of rainwater where it falls and encouraging it to infiltrate into the ground. Installing SuDS helps reduce the burden on the drainage system. They are crucial to not only boosting the resilience of spaces but also creating places where people want to live and work. They can help reduce local flooding issues and respond to the climate and ecological emergencies, whilst at the same time improving the quality of places for the people that use them.

SuDS are a way of mimicking natural drainage in the built environment. Traditional pipe drainage collects and conveys water away as quickly as possible. SuDS offer an alternative that better mimics nature. Rather than channelling rainwater directly into sewer systems or water courses, SuDS manage rainfall where it falls by creating natural spaces to control and store rainwater locally in the built environment.

SuDS capture, store, and encourage the infiltration of rainwater, reducing the likelihood of flood events by protecting the existing drainage system from being overwhelmed during heavy rainfall. Natural vegetation helps slow and attenuate rainwater flows, trap silts and pollutants, and promotes infiltration. The stored rainwater also provides opportunities for plants to use water and for evapotranspiration.

SuDS is a general term, made up of the use of a wide variety of green and blue infrastructure 'features' such as rain gardens, swales, detention basins and SuDS-enabled tree pits. SuDS features can be tailored to different scales and used individually or collectively. As well as protecting the drainage system and reducing flood risk, SuDS enhance the urban environment, providing green spaces for communities, opportunities for leisure and recreation, as well as capturing air pollutants and storing carbon.

Adopting a SuDS approach offers greater flexibility in drainage management, with the philosophy of releasing water slowly and storing it safely during storm events. In contrast, continuing to invest in conventional drainage systems will require larger and larger pipes over time, at a significant cost. Embracing SuDS not only protects against flood risk and reduces strain on the drainage system, but also aligns with wider ambitions to create a greener and more sustainable city region to live, work and visit.

Four pillars of SuDS

The four pillars of SuDS set out the principles for good SuDS design. Collectively taking into consideration these pillars when designing SuDS will enable the effective management of water through reducing flood risk, maintaining the natural water cycle, and preventing pollution along with creating better places for people and nature. See Chapter 2 for further detail.

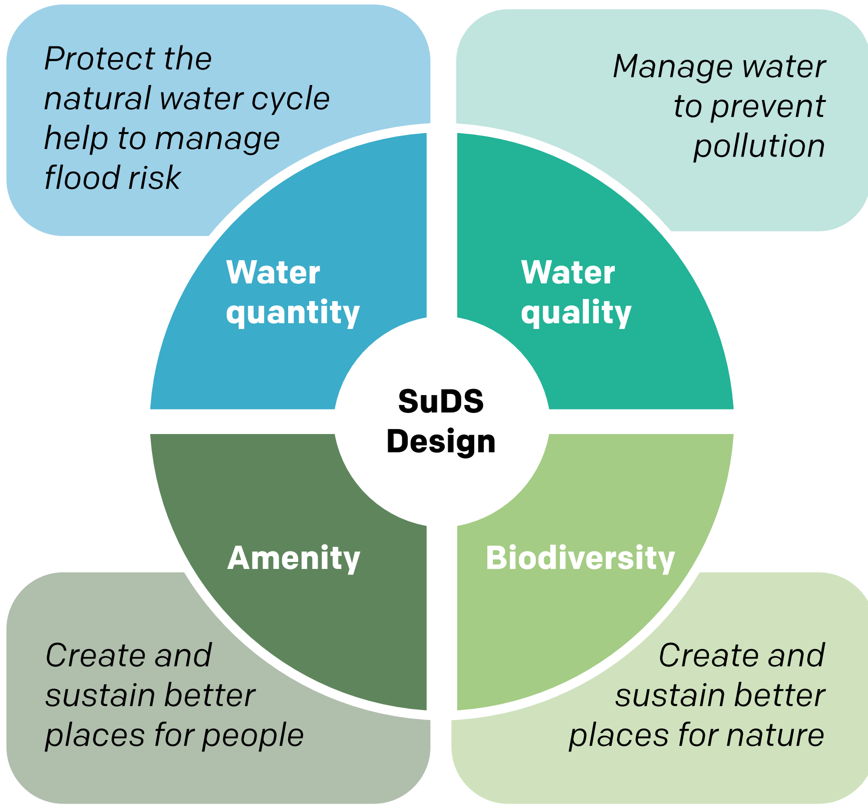


Figure 1.3

High level principles for each pillar are presented below:

Water quantity

- Ensure SuDS features are appropriately sized based on their incoming catchments.
- Provide storage for different storm events.
- Consider exceedance flow routes.

Water quality

- Treat runoff on the surface.
- Ensure runoff draining to individual SuDS features has a manageable level of contamination.
- Consider the surrounding environment.

Amenity

- Aim to achieve multifunctional SuDS solutions.
- Respect street character and consider the impacts of SuDS on how the street functions.
- Make provision for community awareness and education.

Biodiversity

- Appropriate selection of SuDS features for habitat maintenance and creation.
- Prioritise solutions that provide biodiversity.

Management train

SuDS schemes do not only operate as individual features, but also as an interconnected system designed to manage, treat, and make best use of surface water, from where it falls as rain to the point at which it is discharged into the receiving environment beyond the boundaries of the site.

This concept is called a Management Train and describes the use of a sequence of SuDS features that collectively work to control and reduce runoff, flow rates and to reduce concentrations of pollutants.

In the Management Train, SuDS features can be thought of as a series of cascading buckets whereby surface water only moves on once the amount a feature can hold is exceeded.

It typically involves:

Prevention: Prevent and minimise pollution and surface water run off at site through effective site design and housekeeping.

Source Control: Control of surface water at or close to the source such as through green roofs, rain gardens and rainwater harvesting.

Site Control: Water managed across a site or local area through a network, for example by routing water from roofs and pavements to soakaways or detention ponds.

Regional Control: Managing water from several sites. Typically, through larger landscape features such as retention ponds or wetlands.

Figure 1.4

Drainage hierarchy

Another key principle of SuDS is the 'Drainage Hierarchy.' Where surface water cannot be prevented or used as a resource, discharge should occur in the following priority order:

It is not an all or nothing approach. On sites where full infiltration is not possible, partial infiltration can occur with the remaining water being discharged further down the hierarchy.

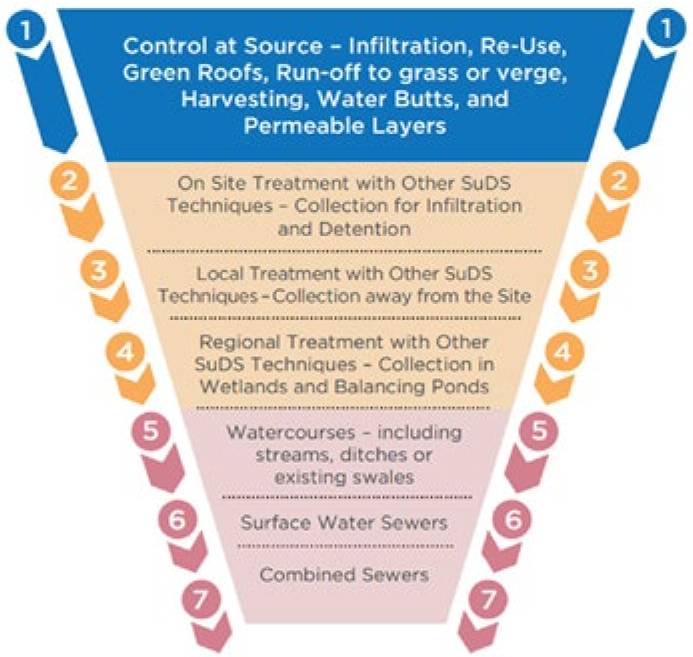
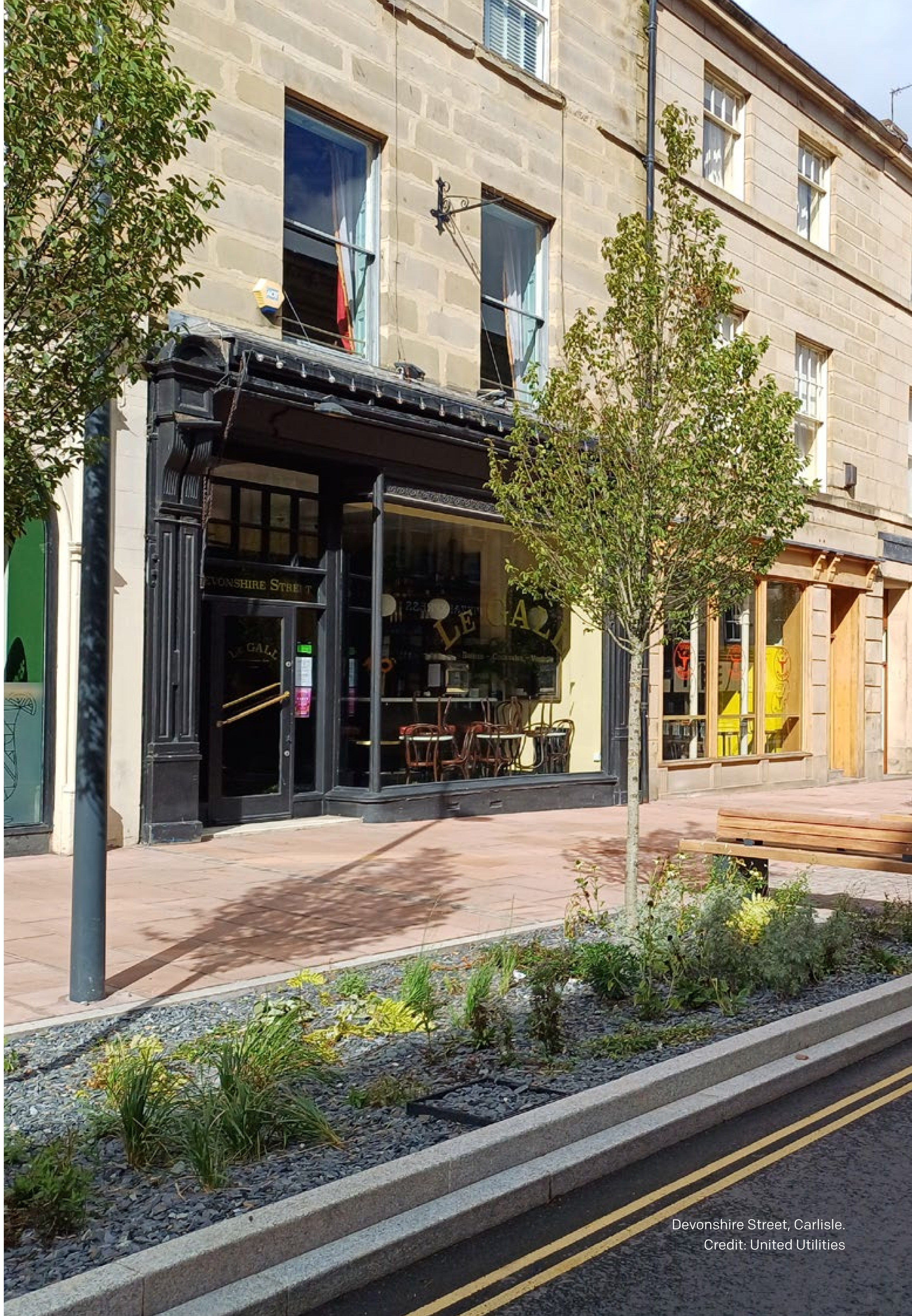


Figure 1.5 Credit: Stockport Metropolitan Borough Council



Devonshire Street, Carlisle.
Credit: United Utilities

1.5 Benefits of SuDS

Integrating green SuDS into our streets and public spaces can support the delivery of a safer and more sustainable future for Greater Manchester. SuDS provide a range of benefits for residents, local businesses, and wildlife.

Water quality

SuDS trap and remove pollutants before returning cleaner water.

- Nitrates can be reduced by 19-79%, total phosphates from 40-85% and total suspended solids from 36-95%.

Air quality

SuDS can help to improve air quality by trapping and absorbing pollutants.

- Hedges as a roadside barrier were found to result in a 15-61% reduction in ambient pollution concentrations behind the barrier, and a 7-15% reduction in particulate matter (PM10).

Local Temperatures

SuDS help regulate temperatures.

- Reduction in surface temperature from shading by a tree canopy can be between 10-12°c, and average reduction in air temperature under tree canopies of around 3°c.

Health and wellbeing

SuDS can provide much needed green spaces for people to access nature.

- Each additional tree per km of street was associated with 1.38 fewer antidepressant prescriptions per 1000 population per year.

Crime

SuDS can increase greenness of neighbourhoods reducing crime.

- Reduction in crime levels of 1.2% for every 1% increase in tree canopy cover.

Road safety

SuDS can help provide a buffer between pedestrians and motor vehicles.

- Tree-lined streets are reported to make the street feel narrower and encourage slower driving.

Noise

SuDS can act as a vegetative barrier to sound.

- An average 4-decibel reduction in noise per m^2 of green space.

Amenity

SuDS can provide attractive areas in typically grey urban environments.

- Provision of usable play and recreational space.
- 85% of people considered that the quality of open public space has a direct impact on their lives and the way they feel.

Statistics sourced from IGNITION project nature-based solutions evidence base, SuDS summary (July 2020 edition)

1.6 Types of SuDS

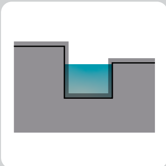
The term SuDS encompasses a wide range of drainage features. This page provides a brief overview of different types of SuDS, both green and grey.

Grey SuDS

Permeable paving

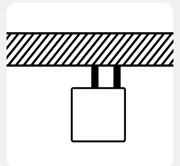
Paving formed of materials impervious to water but contains voids across the surface allowing a pathway for runoff (i.e., block paving).

Filter drain



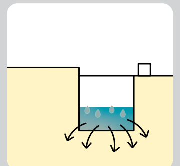
Linear trenches or channels filled with a permeable material that allows water conveyance and storage but also traps pollutants. Can be used to manage runoff from roads, car parks and other impervious surfaces.

Infiltration trench



Linear trenches or channels filled with a permeable material designed to capture and infiltrate rainwater runoff.

Soakaway



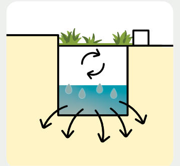
Typically consists of a basin or pit filled with permeable material. They are designed to receive and temporarily store stormwater runoff whilst allowing it to infiltrate.

Rainwater harvesting

Rainwater is collected from roofs or other impermeable areas and stored in an overground or underground tank or water butt.

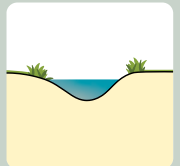
Green SuDS

Rain garden



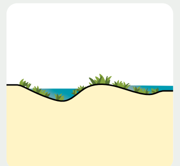
Specially designed garden bed or landscape area which collects rainwater from adjacent surfaces and provides space for storage and filtration run off prior to slow release.

Detention basin



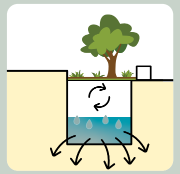
A typically larger, shallow depression designed to collect and temporarily store rainwater from nearby pavements and roads, or driveways.

Swale



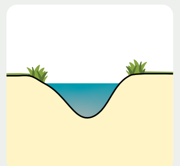
Shallow, vegetated channel designed to slow down, convey and filter runoff.

SuDS-enabled tree pit



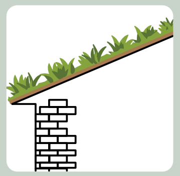
Visually like a typical street tree but differs below ground. Runoff from the surrounding area is channelled into the tree pit, which are specially designed and engineered to maximise the storage of water.

Retention area



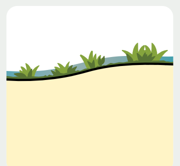
Depressions with a permanent body of water, with space to store additional water during storm events.

Green roof/wall



Planted soil layer is constructed on a roof or wall to create a living surface. Water is stored in the soil layer and absorbed by vegetation.

Filter strip



Linear strips of sloping vegetated ground for taking runoff away from impermeable areas and promoting filtration and infiltration.

2. Designing SuDS in Greater Manchester

2.1. Common questions

This section sets out common questions about delivering retrofit SuDS with advice and recommendations on how to overcome these challenges, which are often relatively straightforward, cost-effective solutions.

Liverpool Street, Salford. Credit: Salford City Council

Working with the existing streetscape

"I'm working within the constraints of the existing cross-section and would like to deliver SuDS. Do SuDS require large amounts of space to be effective?"

Designers should look to reallocate carriageway, existing green space or verges, to provide the space needed for SuDS e.g. traffic islands, wide running lanes, bus stop lay-bys.

Rain gardens, swales and tree pits can all be incorporated as compact, shallow features. These features can also be delivered opportunistically part of smaller-scale street improvement projects, without the requirement for major civils works.

SuDS can also provide multiple functions within the space they occupy, such as traffic calming, a buffer between cycle facilities and the carriageway, and opportunities for play.

While larger features may have greater benefits, a feature of any size will provide a betterment.

East Ordsall Lane, Salford. Credit: Salford City Council

Utilities

"Even if there is space above ground, utilities and other infrastructure below the surface could mean the depths required for SuDS are not available?"

As with the implementation of any proposed infrastructure, utilities can present challenges. Where utilities are encountered, many SuDS features can be designed to accommodate utility corridors in their construction. Permeable paving can incorporate an impermeable portion through which services may run. Similarly, rain gardens may feature areas of reduced depth to integrate utilities, with depths increased in other areas to compensate. Engineered storage solutions may also be used to increase attenuation volumes while ensuring feature depths remain shallow.

Grangetown, Cardiff. Credit: Mott Macdonald

Existing trees

"Will the installation of SuDS affect existing trees?"

SuDS can be successfully integrated around existing trees. Where attenuation and infiltration within the rooting areas of existing trees is proposed, advice on best practice design and construction methodology for tree preservation should be sought.

A rain garden may sit adjacent to existing tree planting and, although the existing tree pit does not provide additional attenuation, both features in tandem provide improved amenity and biodiversity at the surface

New Bailey, Salford

Groundwater levels

"If the site has a high water table, could the SuDS features enable groundwater flooding and be damaged?"

A benefit of SuDS is that installations can be much shallower than traditional drainage systems, therefore problems that would have been encountered through the installation of traditional drainage may be avoided by instead employing SuDS solutions.

Where a high water table (<1m to surface) exists, the risk of damage and flooding may be reduced through the selection of shallow SuDS features as well as the use of impermeable liners or compacted native impermeable material to isolate the system from the groundwater.

Liverpool Street, Salford. Credit: Salford City Council

Infiltration

"If infiltration testing on site has failed, will the SuDS be able to drain?"

It is important to interrogate the results of testing to ascertain how they sit within the wider context of the site. For example, where testing has been undertaken at a shallow depth, it may be the case that shallow impermeable soils lie over a more permeable layer with greater infiltration potential at an increased depth. The depth of the SuDS could then be increased to make use of increased infiltration rates.

In constrained streets, the SuDS network may drain to a deep infiltrating component in a particular area of the highway to reduce the extent of excavation, however, such arrangements need to consider impacts on existing building and pavement foundations and should be discussed due to potential impacts on groundwater abstraction.

Regardless, the design of SuDS features can be adapted to allow them to operate with partial or no infiltration through the introduction of underdrains and impermeable liners.

Oval, Lambeth

Close proximity to buildings and pavements

"Could SuDS affect the foundations of pavements and buildings because they allow water to drain into the ground?"

Impermeable liners may be introduced where the sub-base of SuDS features abuts adjacent pavement foundations to direct water away from these, however it is important that existing drainage paths reducing the build-up of moisture within the foundation are not cut off as a result.

Cavendish street, Manchester

Contaminated ground

"Site investigations have found contaminated ground. Could the installation of SuDS expose this contamination and, once installed, SuDS mobilise these pollutants and contaminate groundwater?"

The shallow nature of SuDS features in comparison to traditional drainage can reduce the risk of exposing contaminants during construction due to reduced excavation. Remediation of existing ground may be required, but this would be no different to what would be necessary for a traditional drainage installation. In most cases, contaminated ground will not preclude the use of SuDS and standard practices can be employed to facilitate their usage. Infiltration may still also be feasible.

Grey to Green, Sheffield. Credit: Robert Bray Associates.

Contaminated runoff

"SuDS are designed to attenuate and remove contaminants from runoff. Where SuDS are located in public open spaces, potential exposure to contaminated water could present a health and safety risk?"

The water contained within SuDS features presents no greater risk than the water that collects in puddles on streets, with the benefit that some pre-treatment may have already taken place.

In features designed to maintain a permanent body of water, the risk of the presence of toxins such as blue-green algae and leptospirosis is no higher than it would be for typical ponds, lakes and canals. Similarly, the risk should typically be reduced where pre-treatment is present.

Grey to Green, Sheffield.

Pollard St. / Gt. Ancoats St, Manchester.
Credit: Manchester City Council

Trinity Way, Salford. Credit: United Utilities

Maintenance

"Are SuDS more difficult to maintain than traditional drainage?"

Although SuDS require a maintenance regime that is different to traditional drainage, it is not necessarily more difficult and many of the tasks associated with SuDS maintenance are no more challenging than those that would be carried out for regular landscaping.

In fact, there are a number of typical drainage features, such as combined kerb drainage units and linear drains, that are prone to blocking and can require subcontractors specialising in drainage maintenance, that if replaced with SuDS utilising overland flow inlets, would only require visual inspections and litter picking as regular maintenance requirements.

As SuDS installations become more commonplace and greater their long-term performance is better understood, it has been reported in some instances that SuDS are continuing to function well despite having had minimal maintenance carried out during their lifetime.

Litter

"Do SuDS attract more litter?"

Much of the litter seen in SuDS features would likely have been dropped and require removal regardless of the whether the feature was installed or not. As land is typically designed to slope towards SuDS features, there is a greater likelihood of litter being conveyed to these features (particularly wind-blown refuse) making it appear as if littering has increased.

Extreme weather events/ flooding

"SuDS allow runoff to pond on site. Does this increase the risk of local flooding in storm events greater than what they are designed for?"

Although SuDS may temporarily allow water to pond as part of their design, this is done in a controlled manner and mechanisms such as overflows are incorporated to ensure local flooding is prevented.

SuDS designs will also account for exceedance flows and ensure these are safely managed by directing them away from buildings and other hazardous areas towards locations suitable for temporary storage, such as highway channels.

2.2 Stages of design development

Key collaborators and stakeholders

Delivering SuDS requires a multidisciplinary approach which is reflected in the variety and scale of collaborators, stakeholders and funders. In street environments, typical contributors to SuDS design include:

- Drainage and highway engineers.
- Landscape architects and urban designers.
- Geological or geotechnical consultants.
- Ecologists and arboriculturists.
- Combined and local authorities, in particular the Lead Local Flood Authority and Local Highway Authority.
- Public bodies, such as the Environment Agency and Internal Drainage Board, and non-governmental organisations such as the Canal and River Trust.
- Statutory undertakers (e.g. United Utilities, Cadent Gas, Electricity North West) and private owners of utilities.
- Private developers.
- The local community.

This list is not exhaustive and may change throughout the project, with some collaborators and stakeholders having greater or lesser involvement at different stages of the design process. It is important to identify all potential stakeholders at project inception and map out a plan considering how and when engagement will happen.

The roles and responsibilities of these key stakeholders during each stage of the design process is described within this section.

Design stages

In the most successful SuDS designs, surface water management considerations influence the wider proposals. It is important to consider the implementation of SuDS from the outset of a project, often as early as the project definition.

Involving residents and stakeholders in the design process allows them to share their views, and input into scheme development which can lead to better designs.

For highways schemes incorporating retrofit SuDS, there is a statutory requirement for Local Highway Authorities to undertake a formal period of public consultation at a formative stage before any decisions have been made.

For new developments incorporating SuDS, Local planning authorities are required to undertake a formal period of public consultation, prior to deciding a planning application.

Four design stages of SuDS are generally adopted on projects and in most design guidance. These stages are:

1. Setting objectives.
2. Concept design.
3. Outline design.
4. Detailed design.

Stage 1: Setting objectives

Prior to developing SuDS proposals, the aims for the scheme should be established between the client, the design team, and other stakeholders.

This may initially be the client's own requirements and targets, as well as aims outlined in local or regional guidance and strategies such as Local Plans, Strategic Flood Risk Assessments or Surface Water Management Plans.

The brief should be informed by a site appraisal and initial engagement with the various stakeholders, including the local community.

Meetings between the design team and stakeholders are an opportunity to explore options for potential funding pathways, from which benefits of the proposed SuDS scheme can be maximised and distributed amongst the various stakeholders. Authorities, public bodies and statutory undertakers should encourage developers to apply for relevant funding mechanisms, where these are available.

Furthermore, acceptance of proposals by the local community is key to a scheme's success. It is vital to inform the existing community of the emerging aims, provide a simplified explanation of SuDS in general, and collate their feedback, which should be addressed and implemented in the production of the design brief.

Typical activities and outputs include:

- SuDS design brief
- Stakeholder engagement
- Initial site appraisal

Key responsibilities for various stakeholders include:

Stakeholder	Key Responsibilities
Client	• Present ideas. • Organise meetings. • Prepare community engagement strategy. • Obtain and provide legal information.
Design Team	• Understand the client brief. • Carry out high-level assessments of the site. • Develop objectives. • Submit enquiries and organise meetings with relevant local authorities, public bodies and statutory undertakers. • Explore potential partnership funding opportunities. • Assist with community engagement strategy.
Local Authorities	• Respond to enquiries. • Provide input on proposed scheme. • Advise on potential partnership funding opportunities.
Public Bodies	• Respond to enquiries. • Provide input on proposed scheme. • Advise on potential partnership funding opportunities.
Statutory Undertakers	• Respond to enquiries. • Provide input on proposed scheme. • Provide information on existing assets. • Advise on potential partnership funding opportunities.
Local Community	• Early engagement with the local community.

Stage 2: Concept design

At the concept design stage, preliminary options for the proposed SuDS scheme should be produced and tested.

Proposals will be informed by the development of a site characterisation. As the options progress, they should be used to aid pre-development discussions or, where planning permission is required, pre-application discussions. The designs should also be reviewed against the design brief with initial costing of options undertaken.

Typical activities and outputs include:

- Concept design
- Site characterisation
- Surveys
- Design review and costing

Key responsibilities for various stakeholders include:

Stakeholder	Key Responsibilities
Client	• Monitoring of design against proposed brief. • Updating of brief, if required. • Input on proposed adoption and maintenance arrangements for highways and sewers. • Undertake/review costing exercise. • Continued community engagement.
Design Team	• Scope and procure on-site investigations. • Produce existing site characterisation. • Develop SuDS design with consideration of highway arrangement. • Assess how proposed development characteristics affects the site. • Identify and coordinate pre-application/pre-development discussions and required technical/legal agreements. • Input to design reviews.
Local Authorities	• Provide pre-application advice (if required). • Assess options. • Provide additional data for site characterisation. • Advise on required approvals.
Public Bodies	• Provide pre-application advice (if required). • Assess options. • Provide additional information for site characterisation. • Advise on required approvals.
Statutory Undertakers	• Provide pre-application advice (if required). • Assess options. • Advise on required approvals.
Local Community	• Provide input to design. • Attend consultations and provide feedback on proposals.

Stage 3: Outline design

In the outline design stage, the preferred concept design option is selected and developed in more detail. Assumptions made or preliminary results obtained at the concept design stage, such as existing sewer capacities and infiltration rates, are validated to confirm the design's feasibility.

Based on the above details, approval in principle of the SuDS design (including preliminary maintenance arrangements) should be finalised with the Lead Local Flood Authority, Local Highway Authority, statutory undertakers and any other relevant stakeholders.

The conclusion of the outline design stage is typically the point at which a development will be submitted for outline planning, if this is requested or required. As part of a planning application submission, details of the drainage scheme will need to be submitted, including relevant justification for the solution selected

The outline design stage may sometimes be incorporated into the conceptual or detailed design, dependent on the scale and complexity of the works.

Typical activities and outputs include:

- Outline design
- Surveys
- Health and safety assessments
- Operation and maintenance plans
- Design review and costing

Key responsibilities for various stakeholders include:

Stakeholder	Key Responsibilities
Client	• Continued monitoring and updating of design brief. • Continued community engagement.
Design Team	• Provide further detail to SuDS design. • Hydraulic modelling of proposed network to understand performance. • Production of outline maintenance plans and preliminary health and safety risk assessments. • Scope and procure further site investigations, where identified. • Production of planning documentation (if required). • Submit design information and application forms for approval in principle of design.
Local Authorities	• Assessment of proposals for approval in principle. • Provide application comments and draft planning conditions (if required).
Public Bodies	• Assessment of proposals for in-principal approval. • Provide application comments and draft planning conditions (if required).
Statutory Undertakers	• Assessment of proposals for in-principal approval. • Provide application comments and draft planning conditions (if required).
Local Community	• Provide input to design. • Attend consultations and provide feedback on proposals.

Stage 4: Detailed design

The detailed design phase comprises the finalisation of all elements of the proposed scheme to agree approvals, permits, adoption arrangements and necessary diversions with authorities and undertakers and to prepare the design for issue to contractors for tendering and discharge planning conditions (where required).

Typical activities and outputs include:

- Detailed design
- Approvals and permits

Key responsibilities for various stakeholders include:

Stakeholder	Key Responsibilities
Client	• Assess detailed design against agreed design criteria. • Continued community engagement. • Collate tender documentation.
Design Team	• Expand outline design with full details on individual SuDS features. • Input to collation of tender documentation. • Detailed hydraulic modelling of entire network. • Develop final maintenance plan. • Coordinate and agree approvals and permits. • Production of full planning/discharge of conditions documentation (if required).
Local Authorities	• Assess proposals as part of technical approvals and review of permit applications. • Provide application comments and review discharge of conditions information (if required).
Public Bodies	• Assess proposals as part of technical approvals and review of permit applications. • Provide application comments and review discharge of conditions information (if required).
Statutory Undertakers	• Assess proposals as part of technical approvals and review of permit applications. • Provide application comments and review discharge of conditions information (if required).
Local Community	• Attend consultations and provide feedback on proposals. • Identify opportunities to deliver community activities e.g. SuDS planting day with local school.

Approvals and Permits

Detailed proposals are required to be formally submitted to relevant stakeholders as part of the final design stage to obtain their approval. The exact approvals and permits required are project-specific and vary depending on the exact nature of proposals, however, some typical approvals that may be required within street environments are detailed in the following table:

Approval or Permit Name	Description	Responsible Party
Section 104 Agreement	Agreement of technical details for elements of a SuDS network to be offered for adoption.	Statutory Undertaker
Section 106 Agreement	Agreement of technical details and construction methodology for proposed connection(s) of the SuDS network to the public sewer.	Statutory Undertaker
Section 38 Agreement	Agreement of technical details and construction methodology relating to a highway to be offered for adoption.	Local Highway Authority
Section 278 Agreement	Agreement of technical details and construction methodology where proposals modify an existing adopted highway.	Local Highway Authority
Environmental Permit	Agreement of technical details and construction methodology relating to works on or near main rivers.	Environment Agency
Ordinary Watercourse Consent	Agreement of technical details and construction methodology relating to works on or near all other watercourses.	Lead Local Flood Authority
New Roads and Street Works Act 1991 (C4 – Detailed Estimates)	Agreement of final design, timescales and detailed cost estimates of proposed utilities diversions.	Statutory Undertaker

2.3 Design considerations

In order to provide systematic management of attenuation, an effective Management Train, and to maximise multifunctional benefits, good SuDS design does not rely solely on individual features but considers the system in its entirety.

Through the relative positioning and linking of individual features, a SuDS network can provide greater benefits than if introduced individually.

Within retrofit situations, it is also important to consider the most efficient ways to augment existing highways and drainage infrastructure using SuDS. For example, a well-designed feature is of no use if it is placed in an area where rainwater does not drain to.

This section provides general design considerations from a site-wide perspective and should be read in conjunction with the example SuDS features presented in Section 3.2, as well the urban street scenarios presented in Section 3.3.

Retrofit considerations

Without the luxury of a 'blank canvas', proposals will need to consider how to maximise the usage of available space. There may be a need to consider how works to the existing street can be minimised, for example, due to cost implications and/or maintenance reasons. As such, choosing flexible and scalable SuDS features suited to challenging and constrained environments will enable the delivery of more SuDS on more streets across Greater Manchester.

Additionally, from a sustainability perspective, it is important to consider how existing infrastructure can be used where appropriate, for example, through the reuse of drainage or re-purposing of existing features within the streetscape.

Oldham town centre

Working with the existing streetscape

Assessment of the existing streetscape can provide a good starting point for logical placement of SuDS.

Topography

The position of proposed SuDS installations must consider the surrounding topography and should be placed at low points relative to surroundings to ensure that runoff will drain into features and does not bypass them, except where it is designed to. The topography can be locally manipulated through the introduction of channels or rills to direct surface water runoff into SuDS.

Designers should consider how the existing topography can be utilised to maximise attenuation of runoff, for example, roads may function as additional exceedance storage in especially severe events (storms with a return period of greater than 1 in 30), where this is deemed safe to all users.

Reusing existing drainage

With respect to the existing topography, existing drainage inlets such as gullies and channels are ideal locations for SuDS, as the surrounding surfaces should already drain towards these inlets. Reprofiling of the carriageway can be minimised where SuDS features are implemented in these locations.

The existing inlet may also be repurposed as an overflow for the SuDS feature, providing an exceedance route in more severe storm events. Where the inlet does not sit within the footprint of the SuDS feature, the design should consider alternative ways to incorporate it as an overflow, for example, by ensuring the SuDS feature is positioned upstream at a higher level so that it 'spills over' into the inlet.

Utilities

The location of below ground services and drainage should be identified to ensure SuDS features are coordinated with assets and any existing easements or wayleaves.

As utilities are generally positioned in footpaths, reclaiming areas of carriageway for the installation of SuDS will typically reduce the risk of clashes, whilst helping rebalance the use of streets in favour of pedestrians.

It is often the case that proposed root zones for tree planting will clash with existing utilities, however, protection for both long-term root growth and below ground infrastructure can be provided with root barriers.

There are solutions to allow utilities to run within SuDS installations and clashes should not immediately preclude any proposed positioning or designs, however, it is important to note that such arrangements will typically require agreement with the asset owners.

Where the responsible authority knows of the existence of SuDS in areas likely to be affected by Statutory Undertaker's work, they must inform the undertaker, so that appropriate excavation and reinstatement methods can be agreed.

Future changes to streets

Consider how future schemes planned for implementation within streets might impact the proposed SuDS scheme. For example, a planned junction with a future development might result in additional drained area that must be accounted for to future-proof the SuDS design. Alternatively, traffic calming may be proposed in the form of road humps or plateaus, resulting in a change of overland flow paths away from a typical inlet arrangement meaning there is a need for runoff to continue to drain towards SuDS features despite these changes.

Other considerations

Safety

Safety should be a key consideration for all aspects of a SuDS design through all stages of design, in part due to the wide range of users it impacts and coupled with the risk of flooding and potential flowing surface water within public spaces. Options to mitigate these risks could mean physical interventions, such as selecting low level planting within rain gardens to maximise site distances near junctions or excluding permanent water bodies and minimising temporary water depths within basins when located near schools.

Education is also an important part of risk mitigation, which can be delivered through a range of methods, for example the use of graphic boards explaining the function of a SuD and associated risks or hosting educational talks.

The design process should be set up to engage the contractor at the earliest possible convenience as periodic buildability reviews will help eliminate or mitigate risks during construction and even maintenance.

Best practice SuDS designs must incorporate health and safety assessments that identify the likelihood and hazard presented by any risks during construction and operation and implement measures that make SuDS as safe as necessary, not as safe as possible. Through measures such as control of gradients, depths, choice of location (including considerations of natural surveillance) and signage, health and safety risks can be sufficiently mitigated without impeding other benefits provided by SuDS.

Each local authority will have their own requirements and processes for the adoption of assets within the highway boundary, which is likely to consist at the very least of a road safety audit and public safety risk assessment.

Grangetown, Cardiff. Credit: Mott Macdonald

Legal boundaries

Where SuDS are proposed within an existing adopted highway, there will be a requirement for proposals to be technically approved by the Local Highway Authority which may have implications on what SuDS features can be utilised as well as their design.

The Local Highway Authority requirements can also affect the areas that can be drained by each feature. For example, highway authorities will typically not allow unadopted areas to drain into adopted highway drainage, including SuDS, unless this has specifically been agreed.

It is important to undertake early engagement to reach a mutually beneficial solution.

Connecting SuDS

It is preferable to allow runoff to be conveyed into or between SuDS at the surface, however, existing streets may feature above ground features that prevent this from being easily achieved.

Combined drainage kerbs and 'chute gullies' that discharge into shallow pipes can be used to discharge impermeable areas into adjacent SuDS features at the surface where above ground obstacles block direct flow, however, civil engineering input will be required to ensure this pipe can be adequately protected from damage and will not have undesirable side effects on the surface finish of proposed paving.

An option for conveying flow between features that has been successfully applied on other projects is the use of channel drains to connect the outlet of one component to the inlet of another. These drains also drain adjacent impermeable areas and function as additional inlets into the drainage system.

Controlling flows

Instead of specifying one flow control device that restricts the runoff from the entire site to a specified discharge rate, it is often preferable to provide multiple smaller flow controls for individual catchments or features that have restricted rates that sum to the site-wide restricted rate.

In the design of flow controls, it is necessary to strike a balance between achieving as low of a flow rate as possible and ensuring the risk of blockages is not unreasonably high.

A number of publications and guidance have previously specified minimum orifice sizes for SuDS designs that have been widely adopted across the industry, however, many designs have erroneously used values referring to larger, site-scale controls for controls that restrict outflow from individual features. Furthermore, developments in flow control technologies are progressively allowing smaller orifice sizes to be specified without an increase in blockage risk.

Oval, Lambeth. Credit: Sustrans

2.4 Hydraulic principles

The hydraulic design of SuDS is mainly carried out by drainage engineers. However, it is beneficial to understand its fundamentals to appreciate how design decisions may impact on the SuDS strategy. A basic understanding of hydraulic design is useful where masterplans or design briefs are produced prior to the appointment of a drainage engineer.

In this section, a primer on hydraulic principles of SuDS is provided.

Design philosophies

Water quantity

Designing for water quantity involves controlling how fast surface water is discharged (the peak runoff rate), as well as how much surface water is discharged (the peak runoff volume) from a site.

SuDS designs aim to reduce these values to limit or reduce the impact of development on surrounding flood risk. By limiting peak runoff rates and volumes, water must be temporarily attenuated, or stored, on site. The rates and volumes proposed are therefore closely linked to the storage requirement.

In broad terms, designing for water quantity requires:

1. Calculation of existing discharge rates and volumes.
2. Calculation of proposed discharge rates and volumes.
3. Assessment of storage required to achieve the proposed discharge rates and volumes.

Steps 2 and 3 may sometimes be reversed, with an estimate of storage obtained first and the feasible discharge rates this can achieve calculated afterwards.

Restricting runoff

The aim should always be to restrict peak runoff rates and volumes as close to greenfield values as possible. This should apply up to the 1% annual exceedance probability (AEP) event. This must not be viewed as a barrier to the implementation of SuDS as the provision of any retrofit SuDS will be an improvement on the existing drainage scenario.

If the restriction of discharge rates to greenfield values is not possible in more severe storm events, significant benefits are achieved where flows are restricted to equivalent greenfield values in storms with more frequent return periods.

Similarly, a system may be designed to discharge runoff at greenfield rates for as long as possible during a storm, with a short period where exceedance flows discharge unrestricted into the downstream network to prevent on-site flooding (which should be less than the existing peak rate).

When designing streets, targeting specific rates can hinder design development and it may be beneficial to first consider the maximum possible integration of SuDS. Proposed discharge rates and associated betterments can then be determined from this initial design.

Providing attenuation

In order to mitigate the increased flood risk resulting from restricting runoff rates and volumes, there is a need to provide temporary storage of water within the SuDS network.

Effects of climate change

When assessing attenuation requirements, consideration must be given to the effects of climate change. Rainfall intensity during the 3.33% AEP and 1% AEP events should be increased in line with climate change allowances. These allowances do not apply when determining existing discharge rates and discharge volumes.

Water quality

Designing for water quality involves the specification of SuDS features which adequately cleanse and filter pollutants arising from runoff draining into the system. This ensures both groundwater and surface waters are protected from pollution, dependent on the outfall of the system.

Even where SuDS outfall to sewers, water quality treatment must be provided as surface water sewers may ultimately outfall to waterbodies and combined water sewers may have overflow mechanisms.

Water quality design should meet the following criteria:

1. Interception should be provided to prevent runoff from the SuDS system for the first 5mm of rainfall.
2. Runoff should flow through SuDS features providing major treatment/filtering up to the 100% AEP event.

Above the 100% AEP event, increased volumes of rainfall will often dilute pollutants and decrease their potential impact, at which point flow may be allowed to overspill into larger attenuation components without initial treatment.

The SuDS Manual sets out different methods to assess water quality performance of SuDS, and when each method is required dependent on the hazard level associated with runoff.

Calculating runoff rates and volumes

Determining drained areas

Before runoff rates, volumes and associated site storage requirements can be calculated, the identification of areas drained by a site (or catchments) are required for both the existing and proposed development.

Existing catchments

For greenfield sites, the drained area is usually the redline boundary or works boundary of the proposed development. Where significant green areas exist within the boundary that are not altered through proposed landscaping or not intended to be served by the proposed drainage system, they may be excluded from the drained area.

On brownfield sites, different surface types will discharge different amounts of water into the drainage system. The surface water runoff from impermeable paving or steep landscaping is much higher than the runoff from a flat grass verge. Only a percentage of the total area of a more permeable surface can be considered to account for this, giving an effective impermeable area. Example values for common surfaces are provided in the following table:

Stakeholder	Effective Impermeable Area Percentage
Roofs	95%
Asphalt	95%
Stone or Brick Paving	80%
Gravel	30%
Grass	25%

These values must be agreed with the Lead Local Flood Authority before they are adopted. At an early stage, it is advisable to consider areas as 100% impermeable until more information is known about existing surfaces.

Proposed catchments

Proposed catchments should include all impermeable areas draining to the proposed drainage network. It is also important to consider potential runoff contributions from permeable areas as per the above table.

A common point of debate is whether the entire area occupied by vegetated SuDS features should be included in the drained area, rather than a smaller portion to account for interception. This is not explicitly addressed in existing guidance and, in the meantime, a conservative approach is to include the area occupied by SuDS components as 100% impermeable within the drained area. The estimated storage provided by the SuDS feature can instead be increased to account for interception.

Greenfield runoff rates

The most-commonly accepted procedures for calculating greenfield runoff rates are the IH124 methodology or the Flood Estimation Handbook (FEH) statistical equations. The selection of approach is dependent on whether Flood Studies Report (FSR) or FEH rainfall is used as input data. The drainage engineer and Lead Local Flood Authority should be consulted to ascertain which rainfall methodology and calculation method should be used.

Details of each method are provided in the SuDS Manual. However, as these are relatively thorough calculations, a freely available online tool provided by HR Wallingford is typically used which calculates greenfield runoff rates for a given location and site area using either approach.

Q_{bar}, the 100% AEP greenfield rate and the 1% AEP greenfield rate should be obtained in order to assess proposals.

Greenfield runoff volume

Greenfield runoff volume is assessed for the 1% AEP, 6 hour storm event and may be determined from design event runoff hydrographs or predictive equations. Details of both approaches are provided the SuDS Manual.

The approaches are often undertaken using drainage design software.

Brownfield runoff rates

Brownfield rates should be determined by a drainage engineer who will produce a simulation model of the existing drainage system and record the simulated flow rates from the site in the relevant storm events.

However, where information on the existing drainage system is unavailable or insufficient, or a quick estimate is required, the Modified Rational Method outlined in the Wallingford Procedure Volume 4, 1981 may be used.

This determines the peak flow rate using the following formula:

Q = $2.78 * C_v * Cr * I * A$

C_v = The runoff coefficient, which should be conservatively set to 1.

Cr = The routing coefficient, typically set to 1.3.

I = Rainfall intensity during the 'time of concentration' for the design return period (mm/hr).

A = Drained area (ha).

Greater Manchester's rainfall is complex, and intensities can change dramatically across relatively short distances. For a conservative estimate (i.e. the lowest rainfall intensity), and assuming a time of concentration of 5 minutes, the following rainfall intensities may be used when determining peak flow rates:

Storm Event	Rainfall Intensity (mm/hr)
100% AEP	**40**
3.33% AEP	**93**
1% AEP	**117**

The above values are for initial estimations only and must be checked by a drainage engineer once the concept design of the SuDS proposals commences.

Assessing infiltration Potential

The infiltration potential of the site should also be considered in the early stage of a project, as it may influence storage requirements.

At the early stages of design, approximate rates may have to be assumed from the anticipated ground conditions obtained from desk-based information. The SuDS Manual provides typical rates of infiltration for various soil types.

A rate of 1×10^{-6} m/s is the generally accepted minimum rate where infiltration is deemed to be feasible.

On-site testing must be carried out as the design moves from the concept to the outline design stage.

The approximate infiltration rate of the soil can be estimated by dividing the depth of water (in metres or millimetres) by the time taken to drain down (seconds or hours). The test should be repeated 3 times to account for the effects of saturated ground on the infiltration rate. Successive tests will often return a lower rate than the initial test and the worst-case rate should be used rather than an average.

In any case, where rates are estimated from desk-based information or approximated through rudimentary testing, they must be confirmed through more accurate testing.

This is generally scoped as part of intrusive ground investigations and will be ideally undertaken in trial pits using the methodology detailed in BRE Digest 365 (2016). Alternatively, a falling head test may be undertaken in boreholes as per the procedure presented in BS EN ISO 22282-2:2012.

Calculating storage volumes

Determining the storage to be provided in a SuDS design can be approached in many ways. In retrofit situations, it may be more practical to first look at how SuDS can be maximised within proposals. The storage provided by the proposed features can be estimated and discharge rates and volumes back calculated with the assistance of the drainage engineer.

Where a specific discharge rates/volumes are required as part of planning conditions or by the design brief, these rates and volumes are used to determine required storage.

Storage in individual SuDS features

Storage provided by different SuDS features can be quickly estimated. The following text outlines the methods, as well as how storage requirements may be determined for a target discharge rate or volume.

Rain garden

The storage provided by a rain garden may be estimated by adding the volume of water attenuated above ground in the rain garden's freeboard and the volume attenuated below ground in mulches, soils and drainage layers. The different layers have differing porosities, and each layer's volume is multiplied by a different factor to give the volume occupied by stored water.

For example, a $20m^2$ rain garden with a build-up consisting of:

- 50mm freeboard (100% porosity).
- 50mm mulch with a typical porosity of 30%.
- 300mm top-/subsoil with a typical porosity of 20%.
- 150mm drainage layer with a typical porosity of 30%

Would have an attenuation volume of $3.4\ m^3$.

It is important that layers are correctly specified to achieve the required porosities, and that testing of selected materials is undertaken to confirm this.

Storage volumes will also be reduced where rain gardens are sited on slopes, and the calculated storage volume should be treated with caution where the longitudinal slope of the rain garden is greater than 3%.

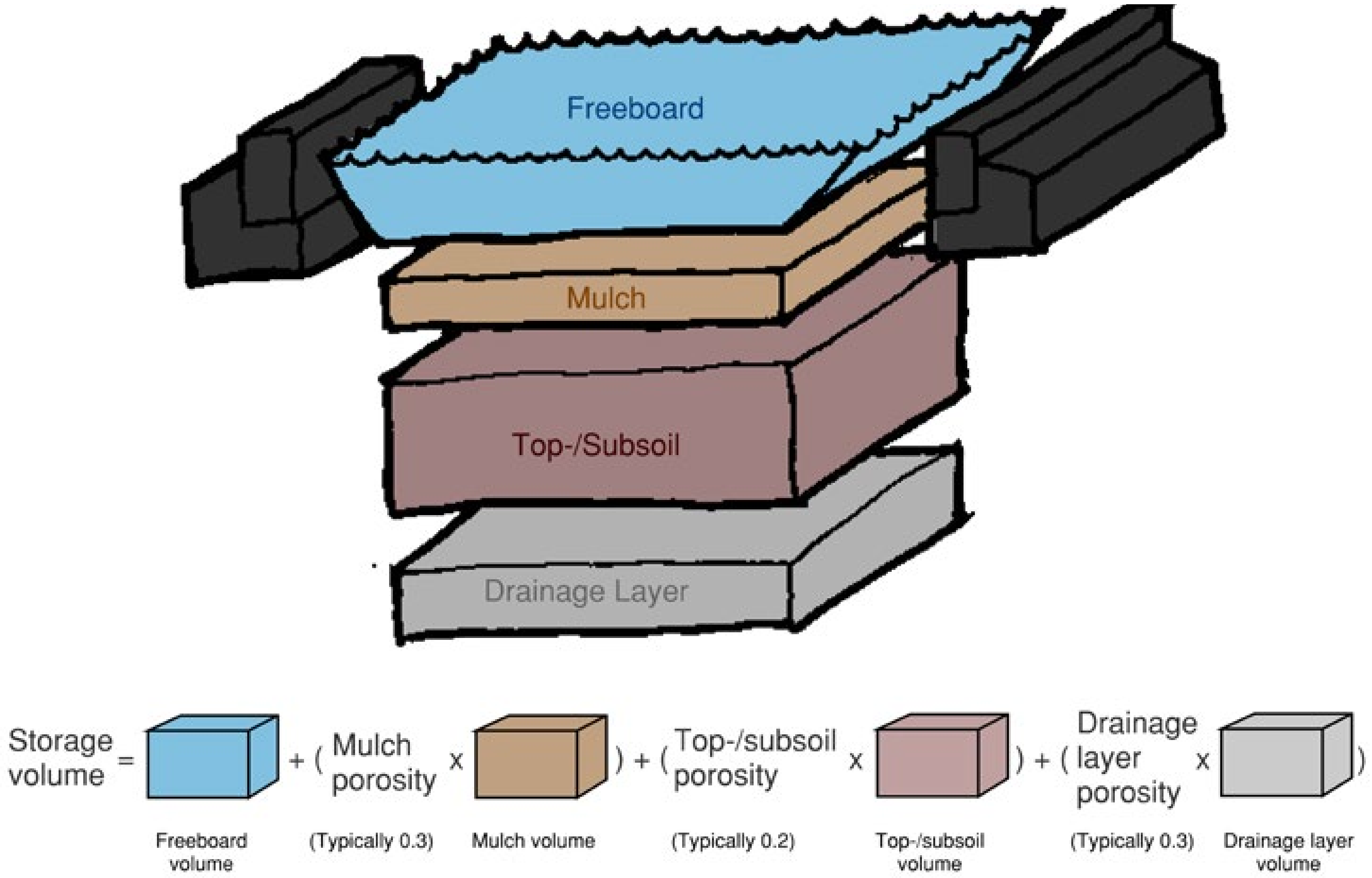


Figure 2.1

SuDS-enabled tree pit

Tree pits can come in a number of forms, however, the general principle for determining their storage volume is the same and follows a similar approach to rain gardens. The contribution of freeboard storage may sometimes be neglected as this is not always provided in tree pit designs.

As with rain gardens, it is important to select appropriate porosities and ensure this is achieved via correct specification and testing.

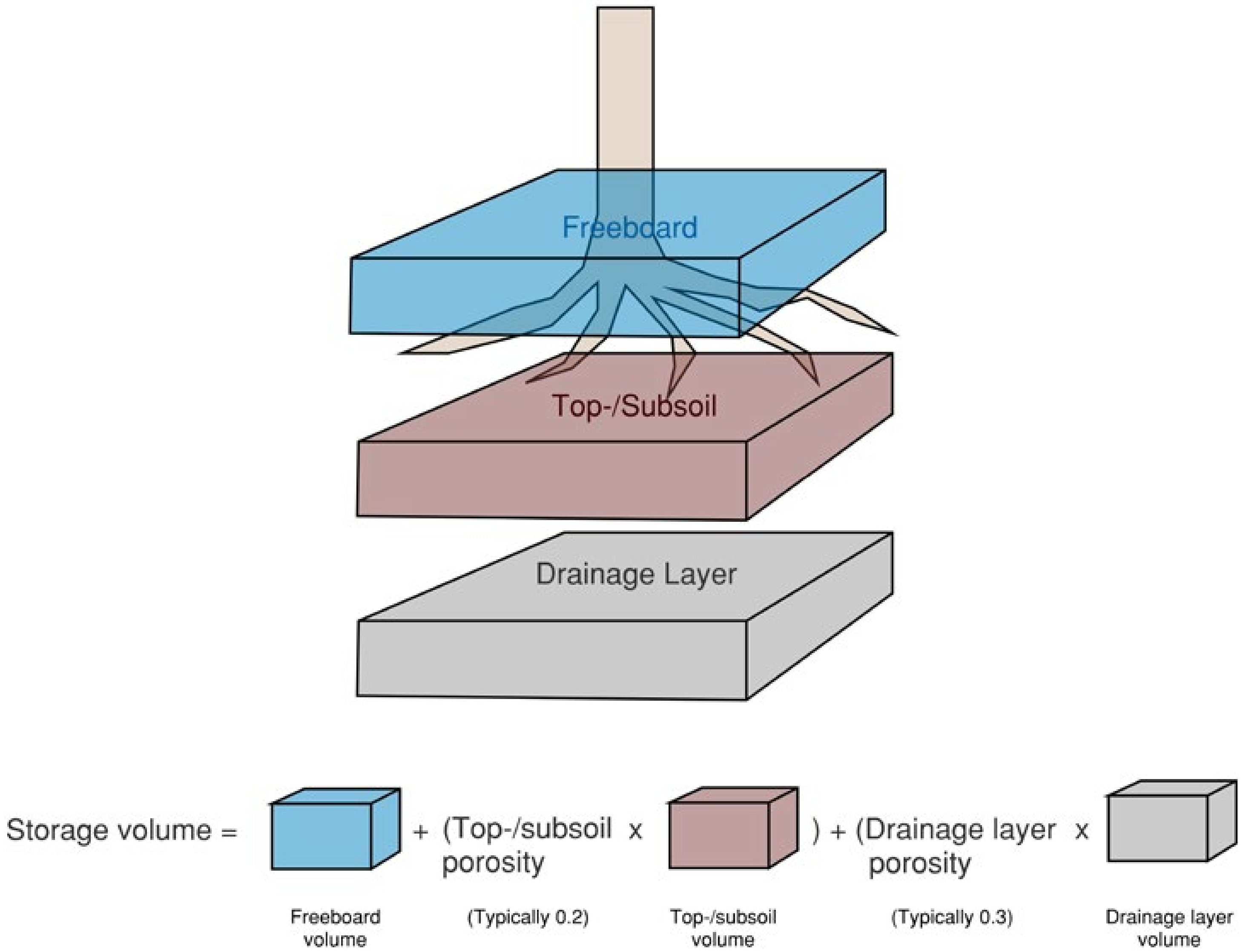


Figure 2.2

Swales and detention basins

Swales and detention basins derive most of their storage volume from above-ground storage of water, and estimates can therefore only consider the freeboard element of storage.

In these often larger features, the above-ground profile can be deeper and have a more complex shape. They can require a more accurate estimation, as per the procedure below:

Where a drainage layer is specified as part of an under drained swale or basin, the volume of this layer may also be added to the storage volume, multiplied by a porosity matching this of the proposed sub-base material, typically 30%.

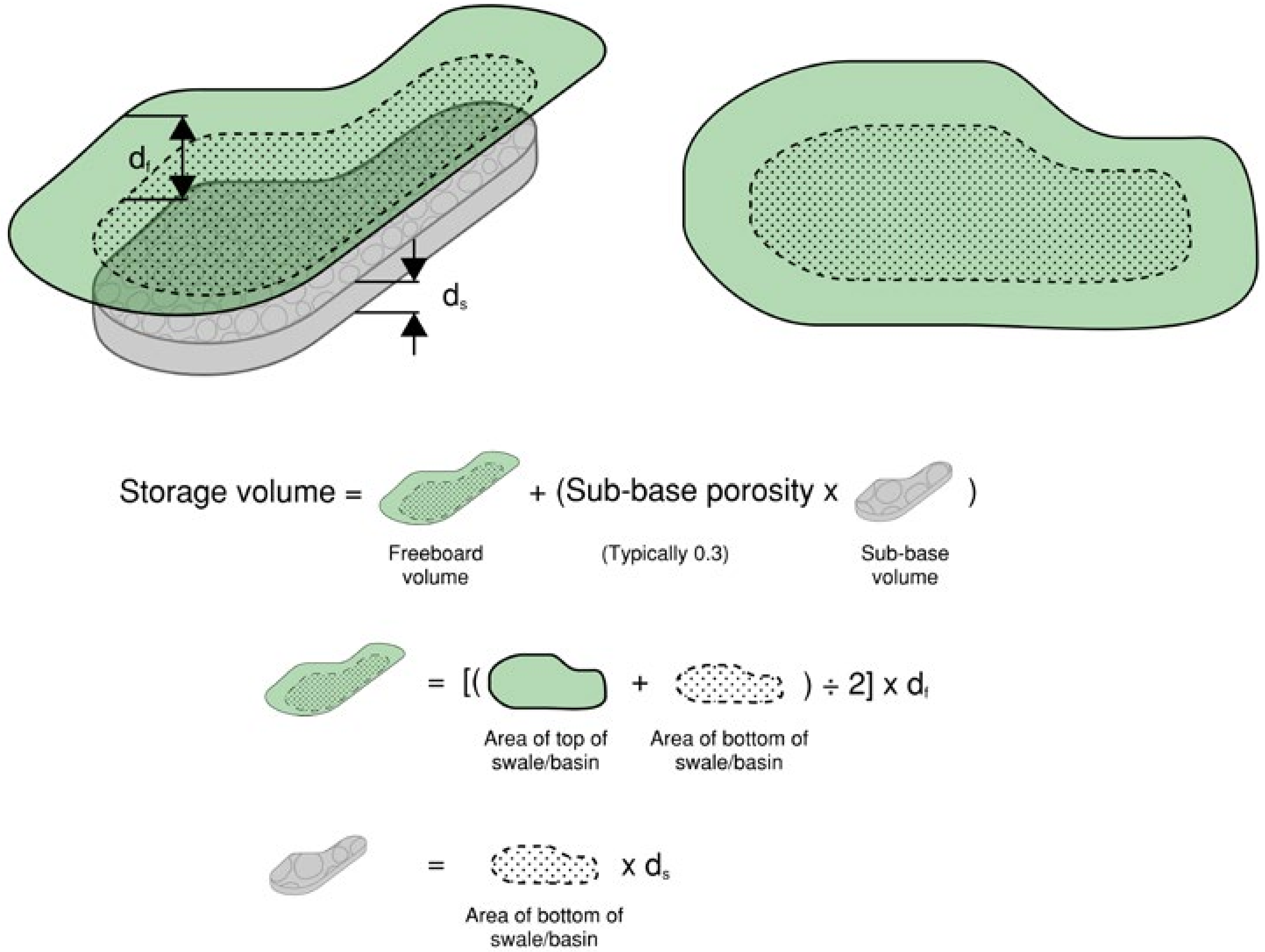


Figure 2.3

Permeable paving

The contribution to attenuation provided by permeable paving systems considers only the storage provided within the pavement sub-base.

This is the same calculation used for below ground layers in rain gardens, with a typical porosity of 30% applied to the sub-base, representing the porosity of the specified sub-base material.

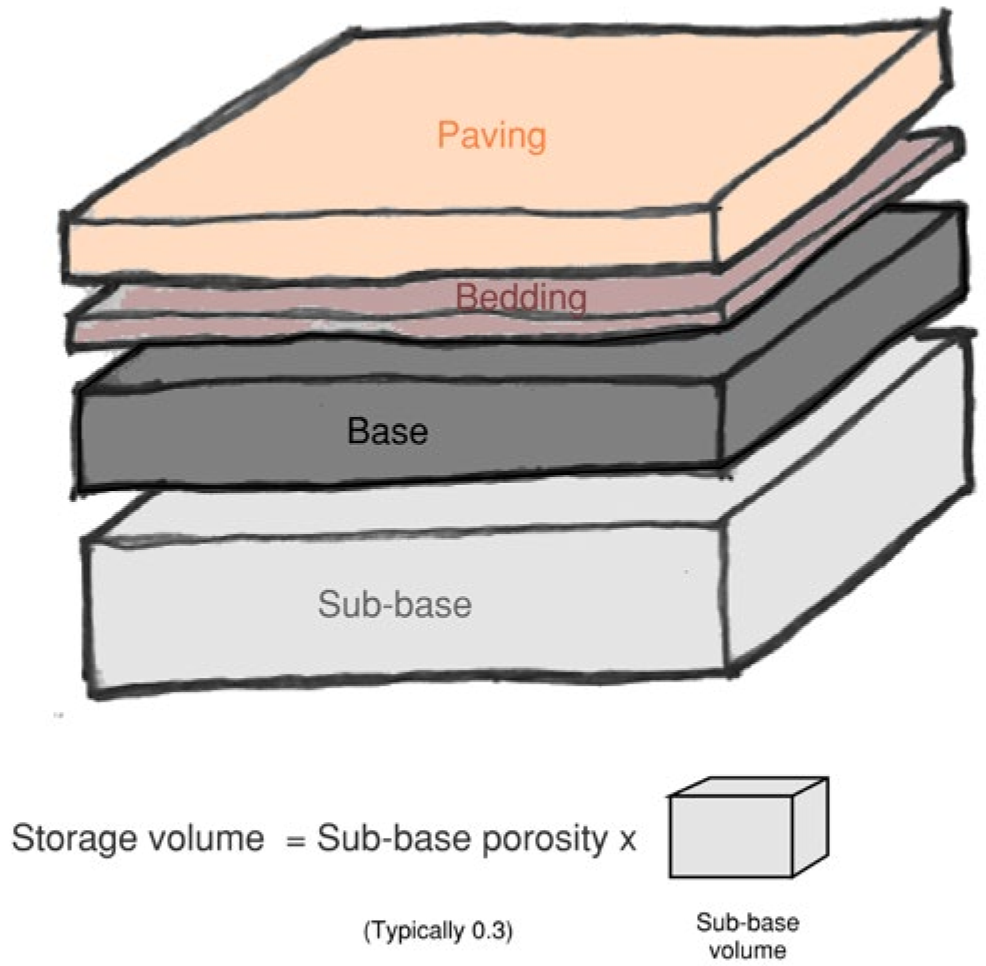


Figure 2.4

Where permeable paving is situated on a slope, it is necessary to account for a reduced storage volume as water will pond at the low end of the system. The calculated storage volume should be treated with caution where the slope of the paving is greater than 3%. A series of check dams can be used to maximise the storage potential.

The Strand, Liverpool

Accounting for interception

Additional storage may be available in SuDS because of interception.

For SuDS features with the following criteria, an additional 5mm/m2 of storage may be preliminarily added to the calculated storage:

Rain gardens

- Unlined rain gardens, where area drained by the rain garden is less than 5 times the planting area.

SuDS-enabled tree pit

- SuDS-enabled tree pits formed in vegetated areas where the area drained by the tree pit is less than 5 times the vegetated area.
- As younger trees have small canopies and mature canopy extents vary for different tree types, interception provided by tree canopies is typically ignored.

Swales

- Swales with a longitudinal gradient less than 1% where area drained by swale is less than 5 times the base of the swale and enters swale >5m away from swale outlet.
- Where the swale also infiltrates, this can be increased to 25 times.

Detention basins

- Unlined detention basins with flat base where area drained by swale is less than 5 times the base of the detention basin.
- Where the basin also infiltrates, this can be increased to 25 times.

Permeable paving

- All permeable paving where drained area equal to area of permeable paving.
- Unlined permeable paving draining adjacent impermeable areas, where adjacent impermeable area not greater than area of permeable paving.
- Where permeable paving infiltrates, this can be increased to 5 times the permeable paving area

These requirements are high-level considerations and should be checked by the drainage engineer.

2.5. Planting

This section sets out proposed suitable planting for rain gardens, conveyance swales and SuDS-enabled tree pits. The planting options have been chosen to maximise delivery of the four pillars of SuDS.

In SuDS planting it is important to take a context-specific approach to design, taking into consideration site conditions and environmental factors, such as:

- The land use, character and activity on the street.
- Microclimate e.g. full sun or shade.
- Visibility splays e.g. junctions, crossings.
- Salt/grit tolerance when planted adjacent to the carriageway.
- Adopt a 'right-tree-right-place' approach - a variety of tree species can give visual interest all year round, with different leaf colours, blossom and canopy shape, carefully selected to enhance the street scene.
- If the street is a bus route and trees are proposed adjacent to the carriageway, it is recommended to provide a suitable offset and choose upright species so when fully mature the tree canopy does not overhang the carriageway.

The following tables provide suggested planting options for a rain garden, conveyance swale and SuDS-enabled tree pit. Please note the list is not exhaustive and before deciding on appropriate planting for a scheme, advice should be sought from the relevant local authority and technical experts.

Rain garden

Potential planting for rain gardens		
Herbaceous plants and grasses (medium height)	Miscanthus sinesnsis 'Gracillimus' Miscanthus sinesnsis 'Variegatus'	Miscanthus grass
	Luzula sylvatica	Greater woodrush
	Aster amellus 'King George'	Italian aster 'King George'
	Betonica officinalis	Betony
	Calamintha nepeta subsp. nepeta 'Blue Cloud'	Lesser calamint 'Blue Cloud'
	Iris x robusta 'Gerald Darby'	Iris 'Gerald Darby'
	Molinia caerulea 'Poul Petersen'	Purple moor-grass 'Poul Petersen'
	Verbena bonariensis	Purple top
Herbaceous plants and grasses (low height to 60cm where required for visibility splays)	Carex morowii 'variegata'	Japanese sedge
	Rudbeckia fulgida var. deamii	Deam's coneflower
	Rudbeckia hirta	Black-eyed Susan
	Salvia x sylvestris 'Mainacht'	Wood sage 'Mainacht'
	Pulmonaria sp.	Lungwort
	Prunella vulgaris	Self heal
Shrubs	Aronia arbutifolia 'Brilliant'	Purple chokeberry
	Euonymus alatus 'Compactus'	Compact winged spindle tree
	Rosmarinus officinalis	Miss Jessopp's Upright
	Sarcococca hookeriana var.digyna	Sweet box
	Viburnum x bodnantense 'Dawn'	Arrowwood
	Yucca flaccida 'Ivory'	Needle palm 'ivory'
Bulbs (low height to 60cm where required for visibility splays)	Allium cernuum	White Dwarf
	Crocus tommasinianus	Early crocus
	Narcissus 'February Gold'	Daffodil 'February Gold'
Bulbs (medium height)	Allium hollandicum (aflatunse)	Allium
	Camassia leichtlinii 'Alba'	Indian Hyacinth
	Eremurus bungei	Foxtail lily
	Galtonia viridiflora	Green-flowered galtonia
	Crocosmia x crocosmiflora 'Venus'	Montbretia 'Venus'
Trees	Alnus glutinosa	Alder
	Betula pubescens	Downy Birch
	Prunus padus	Bird Cherry
	Sorbus aucuparia	Rowan
	Tilia cordata 'Streetwise'	Streetwise Small-Leaved Lime
	Acer campestre 'Elsrijk'	Field Maple

Kingsway, Stretford. Credit: United Utilities

Podium Park, Stockport. Credit: United Utilities

Conveyance swale

Potential planting for conveyance swales		
Herbaceous plants and grasses	Miscanthus sinesnsis 'Gracillimus' Miscanthus sinesnsis 'Variegatus'	Miscanthus grass
	Carex morowii 'variegata'	Japanese sedge
	Luzula sylvatica	Greater woodrush
Native wetland species	Acorus calamnus	Sweet flag
	Alisma lanceolata	Lanceleaf water plantain
	Baldellia ranunculoides	Lesser water plantain
	Caltha palustris	Marsh marigold
	Iris pseudacorus	Yellow iris
	Mentha pulegium	Pennyroyal
	Oenanthe fistulosa	Tubular water dropwort
	Thalictrum flavum	Common meadow rue
	Veronica beccabunga	Brooklime
Native grass/flower mix is recommended for sloping sides of the conveyance swale.		

Eddington, Cambridge. Credit: Planit-IE

Grangetown, Cardiff. Credit: Arup

SuDS enabled tree pit

Potential planting for SuDS-enabled tree pit		
Trees	Alnus glutinosa	Alder
	Betula pubescens	Downy Birch
	Prunus padus	Bird Cherry
	Sorbus aucuparia	Rowan
	Liquidambar styraciflua 'Worplesdon'	Sweet gum 'Worplesdon'
	Tilia cordata 'Streetwise'	Streetwise Small-Leaved Lime
	Acer campestre 'Elsrijk'	Field Maple

Sauchiehall Street, Glasgow. Credit: GreenBlue Urban

Oldfield Road, Salford. Credit: GreenBlue Urban

Rain garden and conveyance swale planting maintenance considerations

- For 'high-impact' rain gardens the preference is to use pot-grown plants. These offer the widest range of supply, availability and assurance of establishment.
- Where pot grown plants are not available, the preference in the first instance would be to use pre-grown turf with ornamental perennials.
- Should pre-grown turf not be available or suitable, perennial ornamental seed mixes would be the preferred options.
- The use of weed-suppressing stone mulch aids maintenance and reduces the risk of weed growth.
- Seed mixes create the greatest risks in terms of establishment and the quality or acceptability to residents and stakeholders. Poor management of seed-grown mixes will lead to growth of weeds. The eventual result may be rank grass, which then needs to be regularly mown and has limited biodiversity value.

Establishment

Best practice SuDS design would include the development of a Five Year Softworks Maintenance Plan, which details general establishment actions for all soft landscaping, including the soft SuDS areas.

To optimise establishment of vegetation within areas where water will flow over/through, turf can be used to minimise scour and avoid seed being washed away. Similarly, gravel mulches can be used as an alternative to bark, as bark could wash away. Gravel will also help to anchor planting and soils in place.

Once the initial establishment phase is complete, maintenance and management of the soft SuDS features can move on to longer-term ongoing actions, as detailed in Section 2.6.

2.6 Maintenance

The design of SuDS should be undertaken with maintenance in mind to ensure activities are cost-effective and can easily be integrated into existing site care through employment of standard maintenance techniques and actions. Example high-level maintenance programmes and activities are set out below. Full maintenance programmes for rain gardens, detention basins, conveyance swales, SuDS-enabled tree pits and permeable paving are detailed in Section 4.2.

Maintenance programme

Maintenance tasks will vary depending on the SuDS installed but also in frequency. Regular tasks such as litter collections, grass cutting and inspection of inlets, outlets and control structures are needed frequently to ensure the effective day-to-day running of the SuDS. These activities are normally carried out to coincide with regular maintenance visits.

Activities such as removing accumulation of silt, debris and vegetation only need to be carried out occasionally when noticed during site inspections or to specifications, with repair to unforeseen defects, damage or vandalism being undertaken as and when required. These tasks can be minimised with good design and ongoing maintenance.

Maintenance activities

Litter removal

Removal of litter is a critical aspect of SuDS maintenance to control pollution, prevent blockages and ensure the amenity of the location.

Litter should be removed at least monthly with debris naturally collecting in basins and swales allowing for easy collection.

Grass cutting

It is necessary to keep a dense cover of vegetation for the effective performance of SuDS to both filter and slow the rate of water and for the protection and control of sediment and soils. The ideal height of grass depends on the location within the SuDS feature.

In SuDS features doubling as amenity space, it may be preferable to mow grass to a shorter height to allow the area to be used for recreation purposes. However, to maximise the filtering of sediments and pollutants, grass within SuDS should ideally be kept within a range of 75-150mm. At this height, there is a reduced risk of grass falling over and blocking flow paths whilst water is still allowed to move through the vegetation. Over time, grass within swales and basins can be allowed to grow longer to support biodiversity and make the feature visually interesting.

Grass around inlets, outlets, control structures and any overflow or access routes should also be kept shorter to prevent blockages, allow the flow of water and access, if required.

Weed and invasive plant control

Normal routine maintenance of SuDS should be adequate for weed control. Invasive non-native species should be removed quickly to avoid establishment.

Tree and shrub management

Overhanging branches or self-seeded trees and shrubs should be cut back or removed from vegetated SuDS to ensure soil stability and flow paths are protected and maintained. This work should be undertaken outside of bird nesting season.

Maintenance costs

Maintenance costs will vary depending on the size and type of SuDS installed. Good SuDS design can help minimise both the frequency and cost of maintenance activities.

The following table gives an indication of typical annual cost estimates for maintenance of a 10m^2 rain garden feature. The costs are derived from six SuDS schemes across Greater Manchester.

Rain garden maintenance costs (at 2024 prices)

Maintenance activity	Number of visits (per annum)	Cost (per 10m^2)
Divide/replant	1	£92.80
Cut stem	1	£116.13
De-head	2	£15.54
Mulch	1	£7.25
Weed/ litter pick	4	£28.05
Total cost (per annum)		£259.77

Market Street, Altrincham. Credit: United Utilities

3. Delivering SuDS in Greater Manchester

3.1 Taking a Streets for All approach

Streets for All recognises the important role streets play in daily lives. Streets are used in different ways, not only for travelling along or parking on, but as spaces for living, learning, working, relaxing, playing, socialising and exercising. Trees and greenery can be what turns a 'road' into a 'street' to create an attractive and welcoming a place of connection and community. Greener streets have enormous potential to better connect people to nature and at the same time create more wildlife-friendly corridors for nature across the city region.

The legacy of street design decisions can have implications that last for generations. This highlights the importance of getting street design right from the outset, and the choices made when making changes to streets. To enable delivery of streets that work for everyone and contribute to create a more climate-resilient and greener Greater Manchester, designers should take a Streets for All approach to changing how streets and public spaces look, feel and function. At the heart of this approach are the principles of people-centred and context-sensitive design. Streets for All essentials are Greater Manchester's priorities and promises when changes are made to streets, at the heart of which are that streets are green, vibrant, welcoming and safe places to spend time in. Streets can be transformed by multifunctional green and blue infrastructure into more attractive and climate resilient places

Figure 3.1

People-centred design

People-centred design asks designers to consider and understand the needs and perspectives of different users of streets, and how a street might work, not work, or could work better for them. As well as striking a better balance between people driving, parking, cycling, walking, wheeling or taking public transport, there is also a need to consider space for the other functions a street can provide, related to the type of place the street is. This means space for things which make streets better places to both pass through and spend time in. Streets need to be more welcoming places for everybody, for example by greening streets, providing space for people to sit, relax and play.

Exposure to natural settings through greening our streets can help:

Figure 3.2 Adapted from Roe, J. and McCay, L. (2021) Restorative cities. Urban design for mental health and wellbeing. Bloomsbury.

Designers of SuDS should adopt the principle of inclusive design which seeks to minimise barriers or issues different people may face in using streets. The objective of inclusive design is to create universally accessible streets, where, to the fullest extent possible, no one is excluded from using our streets. Inclusive design looks to consider all forms of human diversity, and differing perspectives, to create streets which work for everyone, including younger people, older people, people with mobility impairments, neurodivergent people and people with neurodegenerative conditions such as dementia and Alzheimer's disease.

Green and blue spaces of any size can have a restorative effect on people. Increasing visual access to nature has important implications for health outcomes. Green space across the urban environment can provide a place for people to retreat to recover from sensory overload. In developing the Greater Manchester Streets for All Design Guide, a wide range of stakeholders and representative groups have been engaged, who have shared their lived experiences and powerful testimonies. Rachel told us:

"People with ADHD focus better and feel calmer if they have trees and greenery on their doorstep. Everyone experiences these benefits, but the effect is stronger and longer lasting for people with ADHD. It helps calm my anxiety too."

Street trees can transform how people experience and perceive streets, whether they are driving, walking, wheeling, cycling along, spending time in, or living on a street. Particularly on busier streets, they counter impacts of traffic and parking, reduce visual dominance of hard surfaces, and support biodiversity.

Grangetown, Cardiff. Credit: Mott Macdonald

Green features minimise and mitigate the impact of air and noise pollution from motorised vehicles for people who live on and use these streets. Children can particularly benefit from low-level planting that acts as a buffer zone between pedestrians on the footway and motor vehicles on the carriageway, captures pollutants and reduces noise levels.

Market Street, Altrincham. Credit: United Utilities

Incorporating playable features within SuDS can create engaging and playful spaces for people of all ages and abilities. In particular, they provide valuable space for children and adolescents to play, explore and interact.

Kingsway, Stretford. Credit: United Utilities

Context-sensitive design

The concept of context-sensitive design provides a flexible way of approaching SuDS design and delivery. It is an approach that recognises the complexities of scheme development and delivery in a space-constrained and complex urban environment. Understanding the particular context of a street can help inform design decisions, including balancing the competing demands on scarce street space. The first principle is to look to reallocate kerbside space to deliver SuDS. Key benefits of reallocating kerbside space are:

- It does not impact available footway width.
- There are usually less utilities in kerbside space than on the footway.
- SuDS features create new, or link up existing, green and blue spaces for people and nature.

Retrofit SuDS can provide small, incremental, opportunistic improvements that deliver blue green infrastructure in urban environments. These smaller scale, lower cost interventions could be rolled out more widely and more quickly. They could be delivered independently or as a stepped approach to longer-term delivery of a 'transformational' scheme.

Taking a context-sensitive approach to design supports:

- Taking every opportunity to deliver SuDS on streets – from small to large scale projects.
- Using standard materials and components.
- Using materials that should be easily maintained, with types and cost suited to location - do not always need to 'gold-plate' designs.
- Considering whole life costs from outset to inform SuDS design.

Stanley Square, Sale

3.2 SuDS features

Introduction

This section sets out technical details of SuDS features, chosen as those that could be delivered most widely in different contexts across Greater Manchester when making changes to existing streets or public realm, including:

- Rain garden
- Detention basin
- Conveyance swale
- SuDS-enabled tree pit
- Permeable paving

The diagrams are accompanied by supporting information about each SuDS feature, including guidance on inlets, outlets, working around existing underground services, and integration into the streetscape.

The diagrams are intended to be illustrative only and the exact details of each SuDS design will differ depending on the nature of the site and project drivers.

For detailed technical drawings for each SuDS feature, please refer to Appendix 1.

Guidance notes

The following guidance notes are applicable:

- Required components are represented by green annotations. 1
- Optional components, or alternatives, that can be added to adapt the design to the street context are shown in yellow. 1
- Light blue pipes represent flow under normal conditions, with dark blue pipes representing exceedance.
- Utilities are shown in green or white.
- 'Off the shelf' products and materials are used unless otherwise specified.
- SuDS features have been designed to drain through a positive drainage connection. Rain garden designed for infiltration.
- Visuals are not to scale.

Further information

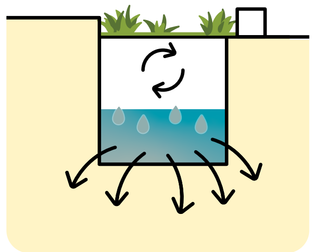
The designs have been created to represent as many different design variations as possible, which have been shown as optional components. The need for these should be analysed on a site-specific basis by a competent drainage engineer. It is essential for the design and implementation of any SuDS project be carried out with input from competent engineers, ecologists, and landscape architects, as set out by the CIRIA SuDS Manual. Reference should always be made to best practice guidance documents, which take priority over the designs shown within this guide.

Whilst the SuDS have been designed to mitigate design risks where possible, residual risks to all users of the street should be considered.

The purpose of this section is to provide an overview of key design parameters for each of the individual SuDS features. Whilst these are generally optimum values, to be used as a starting point, site specific constraints may dictate the use of values lower than those recommended, in which case the key considerations should be used as a reference point throughout the design process.

Designers should take into account the requirements for walking, wheeling, cycling, bus and motor vehicles as set out in Chapter 3 of the Greater Manchester Streets for All Design Guide. These requirements are central to delivering universally accessible streets.

Devonshire Street, Carlisle.
Credit: United Utilities



3.2.1 Rain garden

Rain gardens are planting cells consisting of multiple engineered layers below a landscaped depression designed to manage overland flows, optimising the storage both above and below ground. The layers and the planting provide filtration, sorption, and biological uptake of dissolved and suspended pollutants.

There are several elements that are essential to the normal function of a rain garden:

- Shape and size
- Infiltration potential
- Storage size and type
- Highway aspects – kerb design, white lining, and signage etc.
- Retaining details
- Inspection chamber, rodding eye and outlet piping layout
- Exceedance flow routes and overflow gullies

Rain gardens are flexible, scalable features suited to challenging and constrained environments. Ideally, they will have a minimum width of 2.0m to ensure a functioning root mass, however site specific constraints may dictate the use of values lower than this. The maximum dimension is determined in accordance with the available space within the cross-section, and maintenance regime.

If the inflow from the carriageway is only viable through a positive point inlet, the surface storage invert will have to be lowered to accommodate this. If outflow is via a positive drainage system, the perforated pipe should extend a minimum of 1m into the storage layer of any feature it is required in. The actual length of the perforated pipe, or surface area of the fin drain, should be determined such that it does not restrict discharge from the storage layer. If the system is discharging wholly under infiltration, the underlying infiltration rates should allow for the whole system to drain down 50% of the storage within 24 hours.

Exceedance gullies should be constructed at a level to allow a minimum of 50mm freeboard to the carriageway. To provide sufficient resilience for exceedance events, it is recommended that at least one overflow gully is provided for the greater of either every 500m^2 of contributing area or 50m^2 of rain garden surface area. Analysis of catchment areas and low spots should be undertaken to inform gully locations and numbers based on site specific factors such as hydrology, risk of blockage, exceedance flow routes and downstream receptors. Gullies are to be trapped and designed and installed as per the highway design guidance.

If rain gardens are adjacent to the highway, they may be subject to significant traffic loading. A 45° angle of repose from any surface with the potential for traffic loading to any non-structural layer should be observed, noting that granular fill may be compacted such that it is considered suitable for loading, at the expense of void ratio. Alternative solutions, where there are constraints to space, include gravity retaining structures.

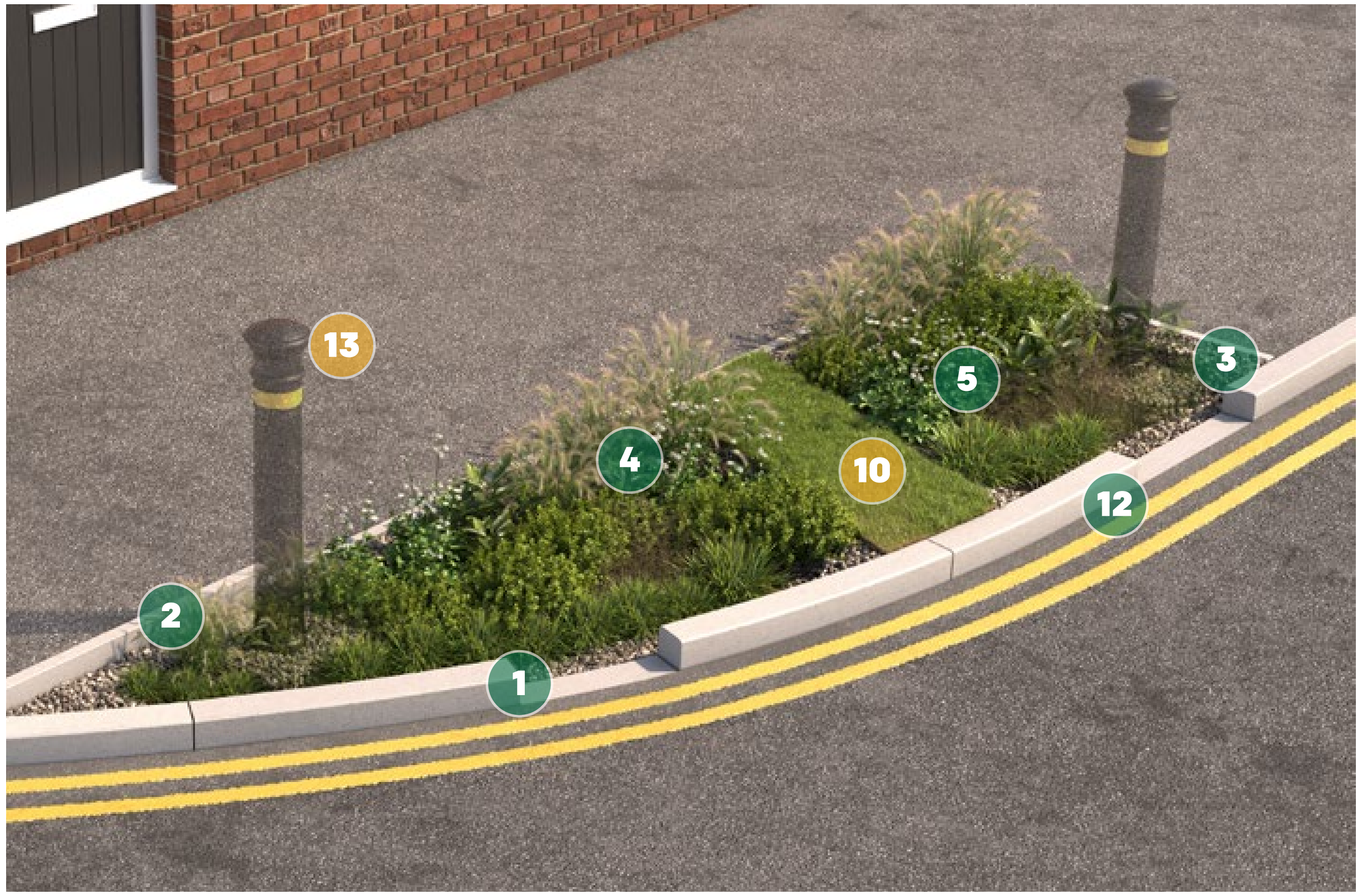
Access to the underdrain should be proportional to its length. It is not always pragmatic to provide upstream access to short lengths of pipe, however progressively longer lengths should utilise rodding eyes, inspection chambers and eventually catchpits, spaced no less than 45m as per the sewerage sector guidance.

It should be considered whether a non-return valve is required on the outfall into the existing drainage network, particularly if this is a combined system. This shall be dependent on several factors such as historic flooding, relative levels of the outfall and susceptibility to flooding and should be specified at detailed design stage. If a non-return valve is required, this shall be installed downstream of the flow control device. Wherever possible existing chambers should be utilised.

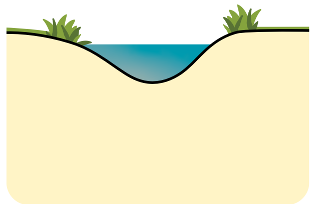
For rain gardens, in general, the contributing catchment area should not exceed 9 times the surface area of the rain garden to prevent surface storage inundating and exceeding in the critical duration storm. The design should ensure, in addition to this, the maximum catchment area for adequate treatment is observed, as highlighted in The SuDS Manual.

Regent Road, Altrincham. Credit: United Utilities

Rain garden



Inlets	
1	**Carriageway Inlet:** Alternating full height and flush kerbing to allow for point inflow into the rain garden, at a spacing to be agreed with the local highway authority. Alternatives include combined kerb drainage units, kerb weirs and chute gullies.
2	**Footway Inlet:** Flush edging to allow for sheet inflow into the rain garden. Note that should an upstand be required, this should be implemented as an alternating full height and flush edging to allow for point inflow from the footway.
SuDS components	
3	**Scour protection** is to be located immediately downstream of an inflow point and consist of aggregate embedded into concrete, set at least 50mm below the inlet level to limit flow velocity.
4	**Surface storage** can be included to increase the storage and treatment capacity of the rain garden in the shorter duration, more intense rainfall. In more complex features, the water level can be controlled by an overflow.
5	**Planting** options can range from trees, grasses, flowers, or shrubs, it should ensure coverage through as much of the year as possible and consider site specific environmental and ecological receptors.
6	A **mulch layer** will act to reduce both weeding requirements and help retain moisture. It can consist of up to 75mm clean aggregate; organic mulch should generally be avoided where the rain garden contains an overflow due to the risk of floatation and blockage.
7	A **growing medium** is required to support planting and aid in water quality improvements. It should be a site-specific mix of, informed by the planting, generally consisting of aggregate with a reasonable sand content, recycled organic matter and sandy silty loam. The growing medium should not hinder infiltration.
8	The **filter layer** protects the storage from clogging. Best practice would be to form it from a 100mm depth of crushed, no fines aggregate, wrapped in dense weave hessian however, if the rain garden has depth constraints, it could be substituted with a permeable geotextile liner.
9	The **drainage layer** should be sized via hydraulic modelling however generally be no less than 300mm in depth. It can consist of coarse open no fines graded aggregate or a proprietary product.
10	A **utility corridor** may be utilised to avoid the diversion of utilities. This should be agreed with each utility provider, however as a starting point would consist of a granular bed, sand cover wrapped in an impermeable membrane, warning tiles and grassed growing medium or topsoil up to the required cover level.
Outlets	
11	**Outlet** from the rain garden should follow the hierarchy of discharge. Where infiltration is deemed appropriate, the designer should ensure the rain garden sits a minimum of 5m away from any structure. Where there's a positive drainage connection, the designer should consider the need for associated maintenance, i.e., rodding eyes, flow control, flow control chamber, and a non-return valve.
12	**Exceedance:** It should be ensured that the design minimises the risk of flooding during the occurrence of a blockage or exceedance event. Where a positive drainage outfall exists, an overflow may be introduced, tying in downstream of any flow controls. Where there is no option for a positive drainage connection for an overflow, the proposed overland flow path should replicate the existing as far as possible, which will generally be via the highway.
Street Environment	
13	In certain contexts, the designer may wish to further mitigate against vehicular access over the rain garden. This can be achieved through the installation of a bollard. In this example, the bollard has a reflective strip to provide tonal contrast, which is particularly important for people with a visual impairment. A more natural approach of higher-level shrubs, boulders, benching, or street furniture. The location and type of planting must have regard to visibility to ensure that sight lines at junctions, crossing points and accesses and sight lines to signs and along the street are not compromised.



3.2.2 Detention basin

Detention basins are landscaped depressions which are generally designed to be dry in most conditions, and then fill up to provide temporary storage during and after a storm event.

Optional wetland or permanent water areas can be included for additional water quality, amenity, and biodiversity benefits.

Basins can be designed as on-line or off-line structures, however providing online structures allows for pollution control and water quality improvement.

There are a number of elements that are essential to the normal function of detention basins:

- Shape, size, and depth of basin, including benching
- Location, number and type of inlets and outlets, including fencing, screens, and other safety / security specifics
- Upstream inlet chamber
- Pipe layout
- Maintenance track layout and construction
- Exceedance flow routes, including weir overflows and spillways

Detention basins are often located away from the highway due to their spatial requirements and are recommended to be offset a minimum of 0.5m from any surface used by pedestrians.

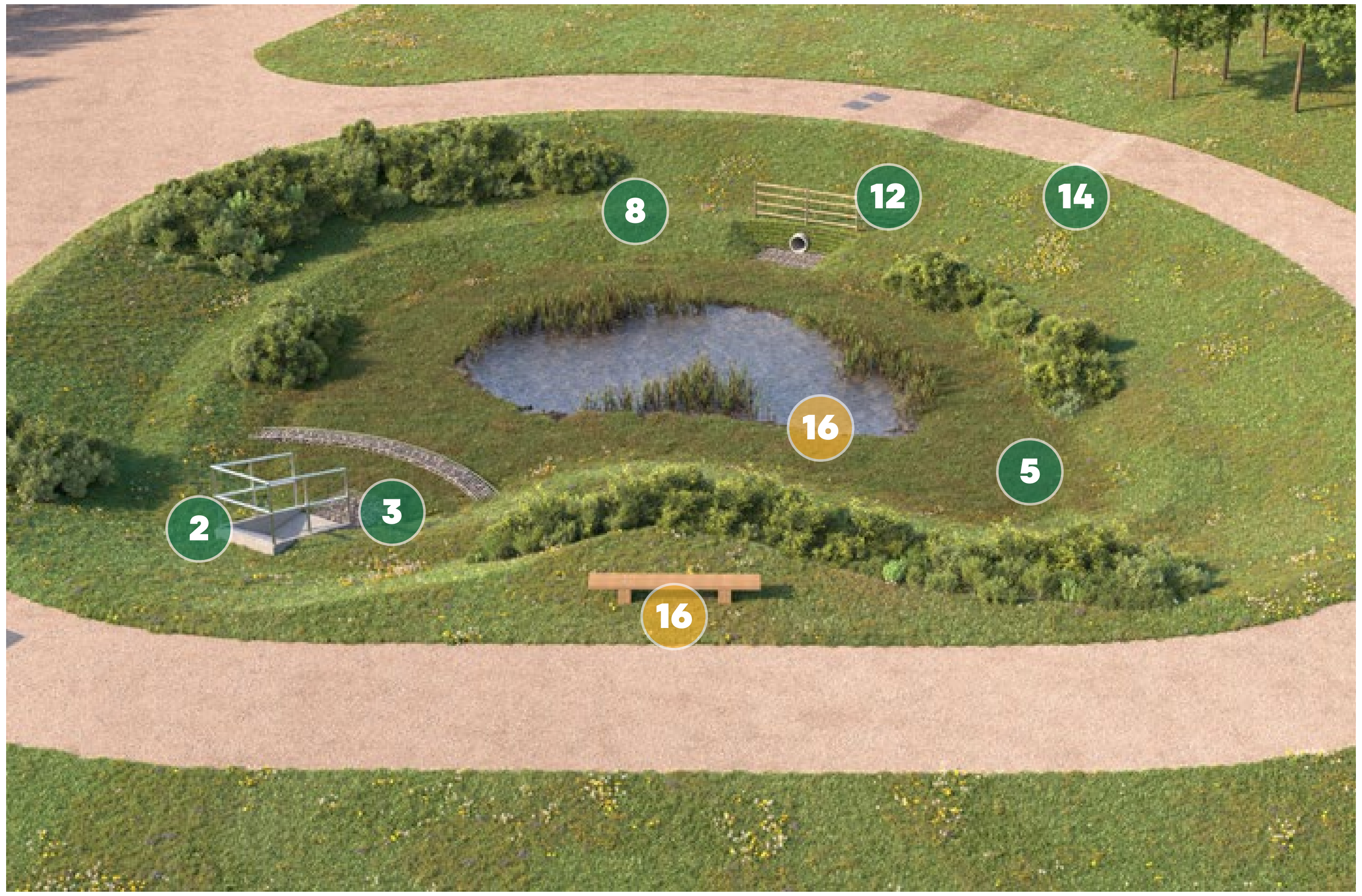
Where possible, the design should limit the number of inlets to prevent short circuiting of flow and the disturbance of sediment, including pre-treatment in the form of inlet chambers or sediment forebays which can be used to limit inflow or concentrate pollutants. In certain circumstances, additional underground auxiliary storage may be incorporated into the design.

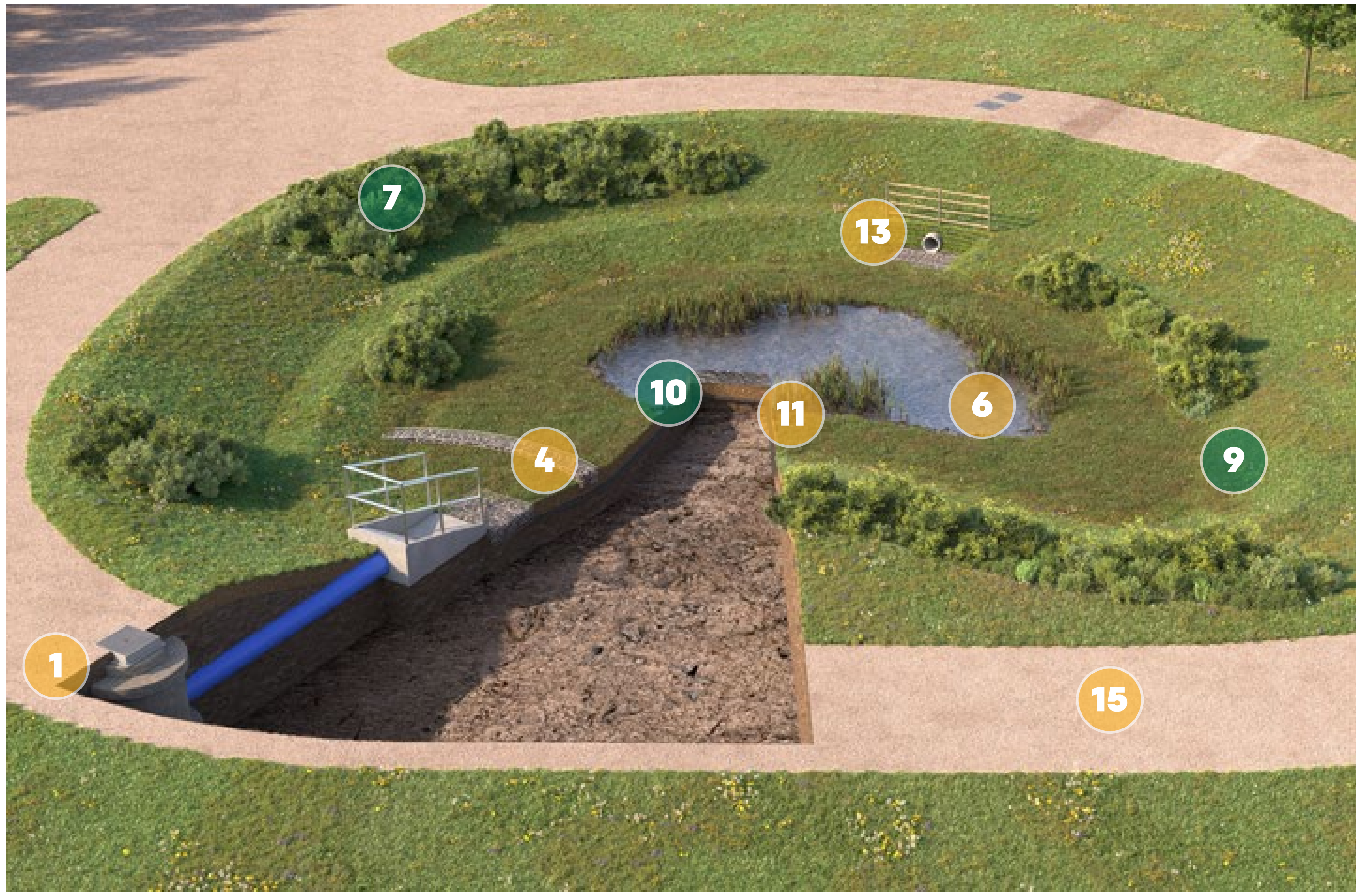
Under low flow conditions, the length to width ratio of the basin should be between 3:1 and 5:1, with a longitudinal gradient no greater than 1 in 100 towards the outlet, with a preference for a completely flat base.

Thought should be given to infiltrating within proximity to existing structures or property boundaries. In general, a 5m buffer should be applied for infiltration to be considered feasible. The designer should be confident that no flow paths exist that would connect the infiltrating system to adjacent subsurface structures, such as basements. If infiltration is not deemed allowable, it may be necessary to impermeably line the whole basin. If such a case occurs, the designer should undertake flotation calculations where groundwater levels may rise in line with the impermeable liner.

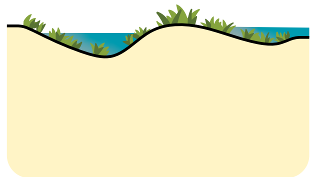
Dales Brow. Credit: Salford City Council

Detention basin





Inlets	
1	**Highway inlet:** When retrofitting a detention basin, it is likely that the diversion of an existing sewer or highway drain will be required. An inlet chamber may be necessary for the diversion or bifurcation of flows, in addition to any necessary pre-treatment and maintenance access.
2	The **inlet headwall** will be required for retaining purposes, however, could also include a non-return valve, to prevent surcharge, along with a safety grille or trash screen. Handrailing is advised for public safety. Natural designs, such as vegetated walls or gabion units, are preferable over hard engineering solutions.
SuDS components	
3	**Scour protection** is to be located immediately downstream of an inflow point to reduce the velocity of flows and can be formed from large loose aggregate, gabion mattresses, pre-cast concrete products or even vegetation, where flows allow.
4	A **sediment forebay** utilises a check dam to create a small, easily maintainable area around the inlet where sediment will concentrate in smaller events, such as a 'first flush'. A sediment forebay should be between 200 to 300mm in depth, with an area proportional to the expected sediment load. Pre-treatment alternatives to a sediment forebay include silt traps or inlet swales.
5	**Temporary storage** is the functional storage of the basin, dictated by the level difference between the invert of the outlet and top water level, often dictated by an overflow. The depth of temporary storage can be up to 2m but is often capped to 0.5m in public spaces. There should be a minimum freeboard of 300mm between the top water level and top of bank level for public safety.
6	**Permanent storage** refers to any storage capacity below the invert of the outlet. Whilst the water level may reduce via evapotranspiration, the storage element is often excluded from calculations. It does, however, provide benefits to water quality and biodiversity.
7	**Planting** options can range from trees to flowers to aquatic planting and should be included across all aspects of the basin from slopes to benching, it should ensure coverage through as much of the year as possible and consider site specific environmental and ecological receptors. The design should be undertaken by a landscape architect.
8	**Benching**, flat offsets between slopes, provides safety and biodiversity benefits. Wet and dry benching, a minimum of 500mm wide, should be included with every 500mm of water depth, in addition to the top of slope. Benching between permanent and temporary storage should be increased to a minimum of 1500mm.
9	An optimal **slope** of 1 in 7 should be used for the basins side slopes, dictated by both safety and maintenance. This can be increased to 1 in 3 where constraints are in place. The longitudinal slope should be as flat as possible to maximise the length of flow path and subsequent retention time within the basin, not exceeding 1 in 100.
10	**Ground:** where a basin is free to infiltrate, the ground should consist of a low nutrient topsoil of a sufficient depth to maintain the planting.
11	**Lining:** where the design seeks to restrict infiltration, or utilise permanent bodies of water, an impermeable membrane is required up to the top water level of said feature. This should consist of a suitable depth of topsoil overlying either: 1m of cohesive fill or, an impermeable membrane, sandwiched between anti slip membranes with a 300mm layer of cohesive fill to protect the liner.
Outlets	
12	An **outlet headwall** is required for retaining purposes where the basin is discharging via a positive drainage network. The design of which is similar to the inlet headwall, however a detailed assessment of a trash screen requirement should be undertaken.
13	**Outlet** from the basin should follow the hierarchy of discharge. Where infiltration is deemed appropriate, the designer should ensure a minimum offset of 5m from any structure. Where there's a positive drainage connection, the designer should consider the need for associated maintenance, i.e., rodding eyes, flow control, overflow mechanism, flow control chamber, and a non-return valve.
14	**Exceedance** overland flow routes are crucial to maintain a suitable top water in the event of a blockage or exceedance event. It may be necessary to include multiple redundancies, i.e., a weir overflow to bypass any flow control mechanism in place, in addition to a high-level overflow channel directing flood flows towards the lowest risk receptor such as a highway. The risk of flooding after the installation of a detention basin should always be lower than it was previously.
Street Environment	
15	Several features may require maintenance in line with that of a standard drainage network. If this isn't achievable from a public access point, the designer should consider a maintenance track, which can offer amenity benefits. Given the infrequent use, they should be naturalised as much as possible, with unbound aggregate or grasscrete preferred over a tarmac surface. A vehicle tracking exercise should be undertaken to ensure it is fit for purpose.
16	**Amenity** value of the space can be enhanced by providing seating. Optional wetland or permanent water areas can be included for additional water quality, amenity, and biodiversity benefits.



3.2.3 Conveyance swale

There are numerous types of swales, however this guide will focus on dry swales for the purpose of conveyance, although it should be noted that any swale will aid in providing attenuation. Swales are shallow, continuous, vegetated channels designed to manage overland flows from adjacent surfaces. They store runoff within the ponding on their surface.

In addition to being a sustainable method of drainage that provide attenuation of flows, swales improve water quality, enhance the natural landscape, and provide amenity and biodiversity enhancements.

Verges can be converted to conveyance swales and are an especially appropriate solution alongside highways due to their ability to drain long, linear stretches of hardstanding.

There are a number of elements that are essential to the normal function of swales:

- Shape and size
- Infiltration potential
- Storage size and type
- Inspection chamber, rodding eye and outlet piping layout
- Exceedance flow routes and overflow gullies

Swales should ideally have a base width between 0.3 and 2.0m. In more remote locations, it may be necessary to provide a maintenance track to enable vehicular access to the inflow and outflow chambers and headwalls. Where possible, the design should limit the number of inlets to maximise hydraulic retention and subsequent treatment whilst limiting the disturbance of sediment. As with detention basins, swales may benefit from pre-treatment in the form of inlet chambers if a high sediment load is expected.

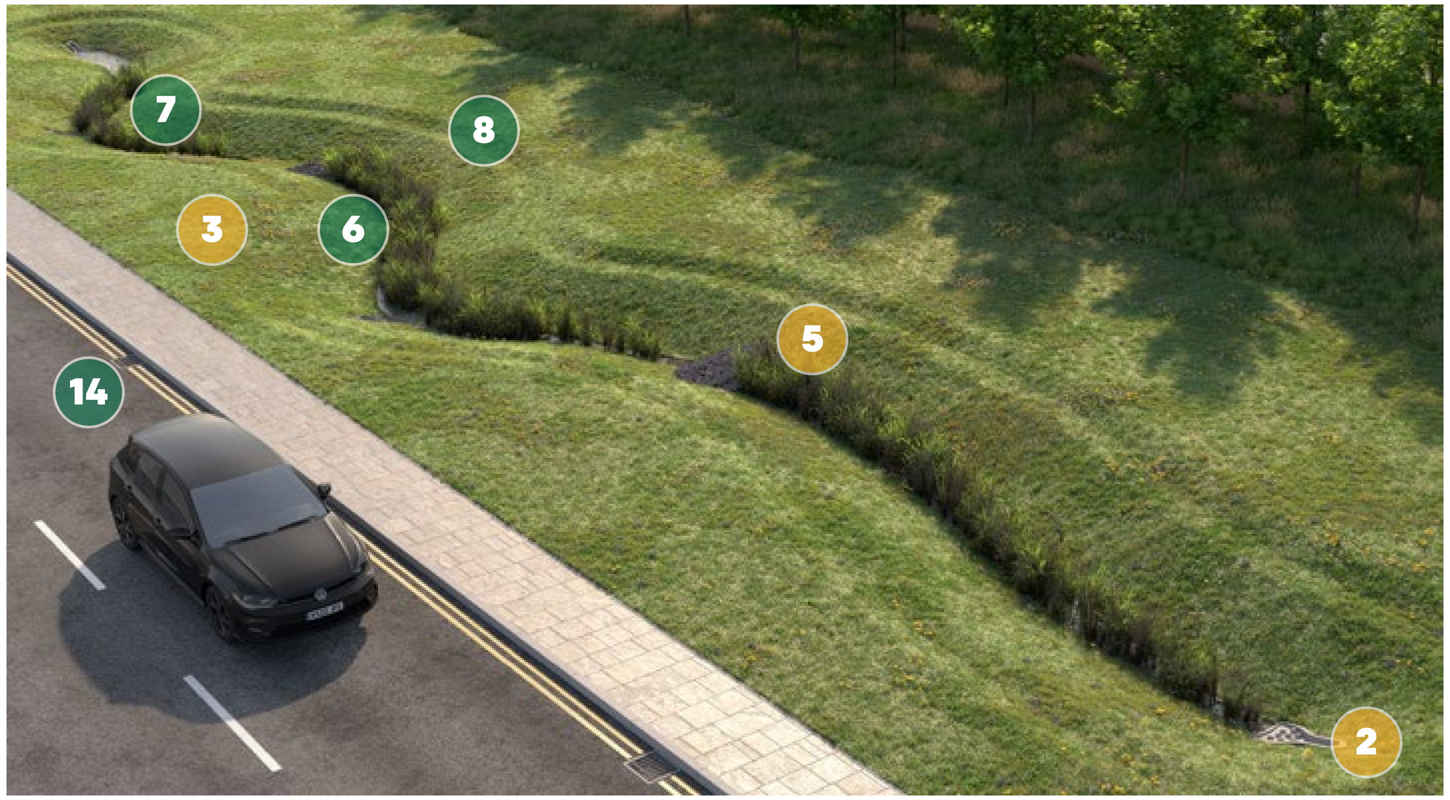
Assuming the minimum side slopes of 1 in 3 and base widths between 0.5 – 2.0m, a swale can accommodate an upstream contributing area of between 25 and 50m^2 per metre length, depending on the design storm return period. The design should ensure, in addition to this, the maximum catchment area for adequate treatment is observed.

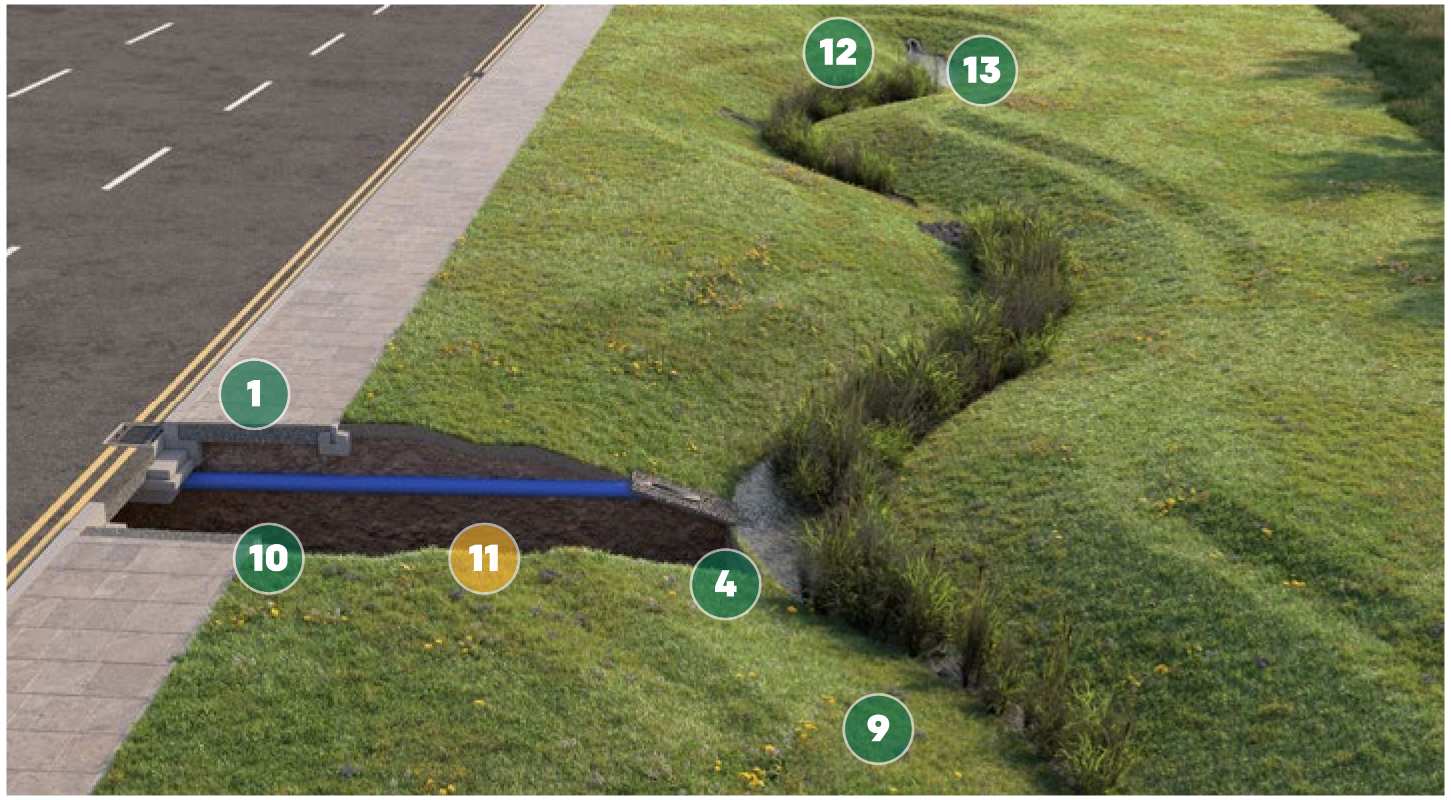
Positive inlets such as gullies can be incorporated at the top water level to provide sufficient resilience for exceedance events, it is recommended that at least one overflow gully is provided for the greater of either every 500m^2 of contributing areas or 40m of length. The catchment areas and low spots should be analysed, and gully locations and numbers confirmed based on site specific factors such as hydrology, risk of blockage, exceedance flow routes and downstream receptors. Except for meeting the minimum gully intensity per area of contributing catchment, gullies are to be trapped and designed and installed as per the highway design guidance.

For public safety, headwalls should be as small as possible whilst meeting the hydraulic requirements of the design. Proprietary swale inlets are recommended for any 150mm diameter inlets to the swale. The removal and relocation of existing highway drainage features may be necessary to maximise the contributing catchment area to the feature.

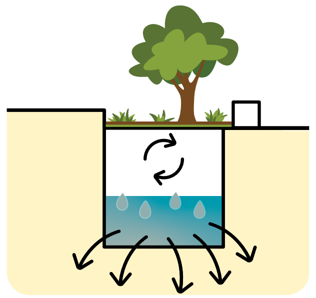
Eddington, Cambridge. Credit: Planit-IE

Conveyance swale





Inlets	
1	**Highway inlet:** When retrofitting a swale, it is likely that the diversion of an existing sewer or highway drain will be required. An inlet chamber may be necessary for the diversion or bifurcation of flows, in addition to any necessary pre-treatment and maintenance access. As a longitudinal feature, it is expected that swales will receive multiple inlets from the adjacent carriageway, via standard surface water collection features such as gullies or combined kerb drainage units. These should outfall into the swale at a minimum of 150mm above the invert to prevent blockages.
2	The **inlet headwall** will be required for retaining purposes, however, could also include a non-return valve, to prevent surcharge, along with a safety grille. Handrailing is advised for public safety. Natural designs, such as vegetated walls or gabion units, are preferable over hard engineering solutions.
3	The swale may be positioned to collect **overland flows** from adjacent public spaces or footways. Vegetation is generally sufficient to disperse sheet flows, however, scour protection should be considered where point inflow is likely. Overland flows from impermeable surface should include pretreatment before entering the swale, such as a filter strip.
SuDS components	
4	**Scour protection** is to be located immediately downstream of an inflow point to reduce velocities and can be formed from a number of options: aggregate embedded into concrete, proprietary products, i.e., an integrated headwall and scour protection apron, a gabion mattress, and in some cases loose aggregate or vegetation.
5	**Check dams** can be utilised to reduce flow velocities on steeper sites, in turn increasing retention time and improving water quality, whilst also maximising the storage capabilities of the swale. Check dams can be formed from loose stone, gabion baskets, concrete weir walls or logs, largely consisting of low-level orifices or general permeability with a weir overflow. Gradients can increase from a recommended 1 in 30 without check dams, to 1 in 7 with check dams.
6	**Storage** is the functional storage of the swale, dictated by the level difference between the invert of the outlet and top water level, often dictated by an overflow. As swales are often located in public areas, the depth of water should be limited to between 400 and 600mm, with the inclusion of freeboard between the top water level and top of bank level for public safety.
7	**Planting** in the swale is often dictated by its purpose and surrounding ground conditions. A swale used primarily for conveyance may have a grassed base with vegetation kept to between 75 and 150mm, where as a swale design for water quality located in impermeable soils may opt for aquatic planting in its base. The design should be undertaken by a landscape architect.
8	**Benching**, flat offsets between slopes, provides safety and biodiversity benefits. It is sensible to include 500mm of dry benching at the top of the swale, which will double up as a filter strip for overland lows.
9	An **optimal slope** of 1 in 4 should be used for the swales side slopes, dictated by both safety and maintenance. This can be increased to 1 in 3 where constraints are in place. The longitudinal slope should be as flat as possible to maximise retention time within the swale, with check dams in place for steeper sites.
10	**Ground:** where a swale is free to infiltrate, the ground should consist of a low nutrient topsoil of a sufficient depth to maintain the planting.
11	**Lining:** where the design seeks to restrict infiltration, an impermeable membrane is required up to the top water level. This should consist of a suitable depth of topsoil overlying either: 1m of cohesive fill or, an impermeable membrane, sandwiched between anti slip membranes with a 150mm layer of cohesive fill to protect the liner.
Outlets	
12	**Outlet:** outlet from the swale should follow the hierarchy of discharge. Where infiltration is deemed appropriate, the designer should ensure a minimum offset of 5m from any structure. Where there's a positive drainage connection, the designer should consider the need for associated maintenance, i.e., rodding eyes, flow control, overflow mechanism, flow control chamber, and a non-return valve.
13	An **outlet headwall** is required for retaining purposes where the swale is discharging via a positive drainage network. The design of which is similar to the inlet headwall, however a detailed assessment of a trash screen requirement should be undertaken in line with the CIRIA Culvert, screen and outfall manual. An outlet chamber should be considered as an option where a flow control device and overflow mechanism, i.e., a weir overflow with an orifice plate, are required prior to discharge via a positive drainage network to protect features and allow for maintenance access.
14	**Exceedance:** overland flow routes are crucial to maintain a suitable top water in the event of a blockage or exceedance event. It may be necessary to include multiple redundancies, i.e., a weir overflow to bypass any flow control mechanism in place, in addition to a high-level overflow channel directing flood flows towards the lowest risk receptor such as a highway. The risk of flooding after the installation of a swale should always be lower than it was previously.



3.2.4 SuDS-enabled tree pit

Both the use and benefits of trees in SuDS features are extensive, they can be included in near enough any green features such as basins, swales and rain gardens, in addition to being standalone features. They provide water quantity benefits through transpiration, interception, increased infiltration and phytoremediation in addition to significant water quality, amenity and biodiversity benefits. They can attenuate significantly more rainwater than conventionally planted trees and roots are contained to avoid disturbing the pavement construction.

The inclusion of trees as standalone tree pits mitigates against spatial constraints. Tree pits are favourable for retrofitting; the subsurface construction can be made from structural soils or a geocellular unit with root barriers included to integrate utilities, and there are a range of viable inlet mechanisms, including trapped gullies, pervious surfaces, or any other positive drainage collection system.

There are a number of elements that are essential to the normal function of SuDS-enabled tree pits:

- Choice of species
- Growing medium size and structural requirements
- Inlet type and arrangement
- Infiltration potential
- Storage size and type
- Highway aspects - kerb design, white lining, and signage etc.
- Inspection chamber, rodding eye and outlet piping layout
- Exceedance flow routes and overflow gullies

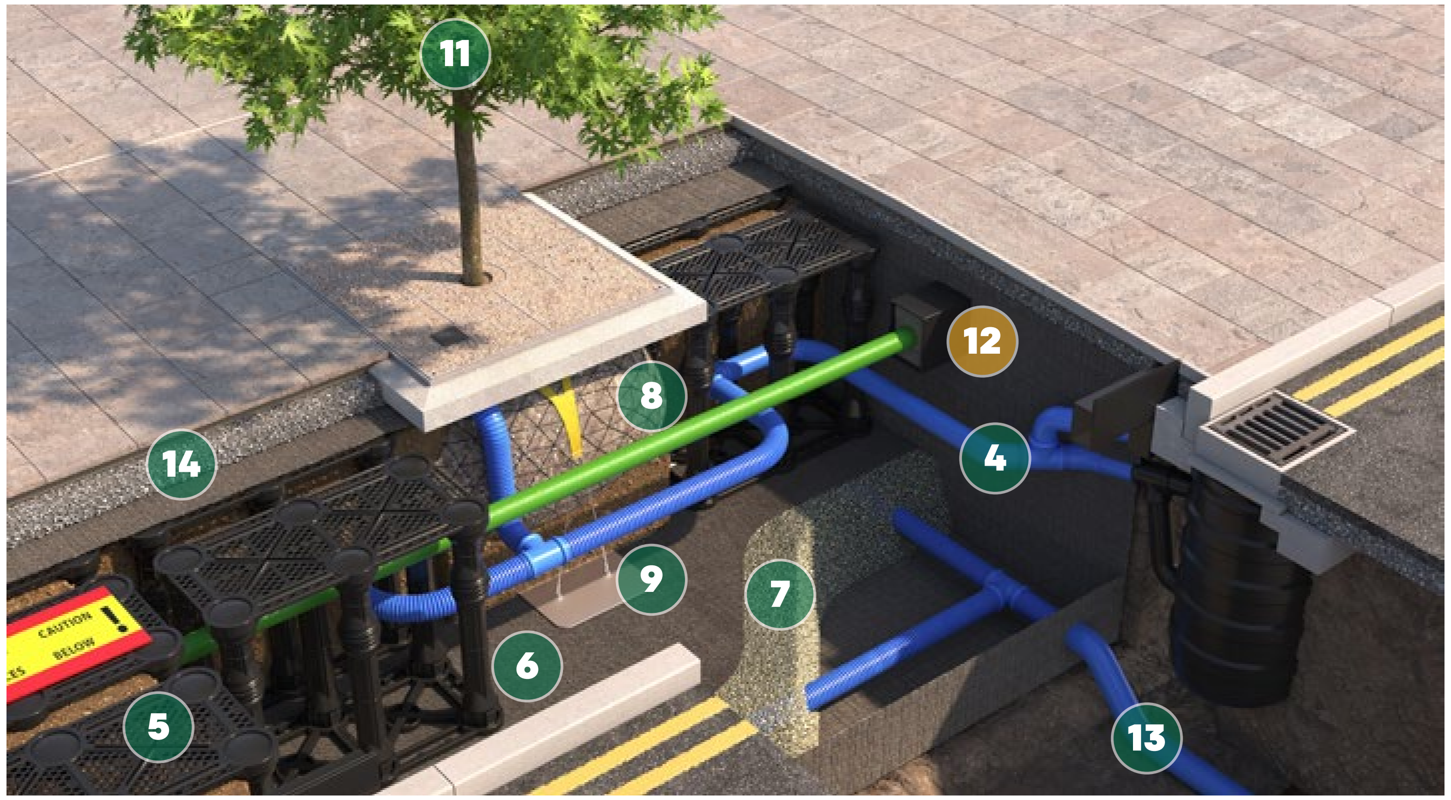
As a tree matures, it may require over 40m^3 of soil volume to flourish, as such it is essential the tree pit is designed around the mature tree, with consideration for the requirements of a specific species. Where tree pits are located to manage highway runoff, inflow is likely to be via subsurface point inflows from a positive drainage network (i.e., gullies or a combined kerb drainage unit).

Thought should be given to the build-up of sediment within the inlet and subsequent maintenance access, which may result in a downstream inspection chamber. Mature trees require a substantial amount of water, ranging from 30m^3 to 240m^{3}per year; if the contributing catchment area is insufficient to deliver this then an additional watering system should be implemented and integrated into the maintenance programme. Trees also require gaseous exchange to thrive and, whilst this is provided through aerated soil under normal circumstances, can be replicated within the growing medium or via the structure of a positive drainage network. Where systems are to be wrapped in impermeable liners to prevent infiltration, care should be taken to provide a breathable membrane on the surface.

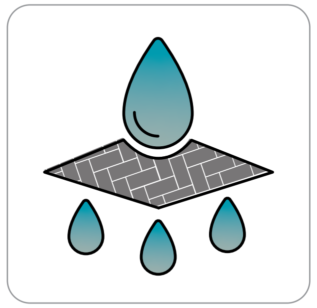
It should be considered whether a non-return valve is required on the outfall into the existing drainage network, particularly if this is a combined system. This shall be dependent on several factors such as historic flooding, relative levels of the outfall and susceptibility to flooding and should be specified at detailed design stage. If a non-return valve is required, this shall be installed downstream of the flow control device. Wherever possible existing chambers should be utilised.

West Street, Oldham.
Credit: United Utilities

SuDS-enabled tree pit



Inlets	
1	**Carriageway inlet:** Flow from the carriageway should be collected via standard surface water collection methods, i.e., a gully or combined kerb drainage network, and discharged into a high-level perforated pipe. Pre-treatment, such as a catchpit, is recommended where sediment loads are anticipated to be high.
2	**Footway inlet:** flow from the footway is likely to be collected as sheet flow and can be collected via a linear drainage feature or permeable paving, the latter of which will provide pre-treatment, although footways generally have much lower sediment loads than carriageways.
3	**Irrigation** is required to sustain the tree through periods of extended drought. This can be achieved by using proprietary products or something as simple as a pipe upstand covered with a grille or grate, to allow for the flow of oxygen within the system.
4	**Diffuser:** Point flow discharging into a subsurface layer should do so via a diffuser to reduce velocities and the risk of blockages. A high-level perforated pipe accomplishes this, whilst allowing maintenance access. Pre-treatment should always be considered alongside the use of a diffuser.
SuDS components	
5	The **structural layer** can be comprised of a modular system backfilled with bioretention soil, or structural soil, and should generally be a minimum of 1000mm in depth.
6	The **filter layer** protects the storage from clogging. Best practice would be to form it from a 100mm depth of crushed, no fines aggregate, wrapped in dense weave hessian however, if the rain garden has depth constraints, it could be substituted with a permeable geotextile liner.
7	The **drainage layer** should be sized via hydraulic modelling however generally be no less than 300mm in depth. It can consist of coarse open no fines graded aggregate or a proprietary product. Please note that minimum pipe cover levels should be observed when sizing layers.
8	**Root ball:** Mature trees can be installed providing there is sufficient rooting volume to sustain the tree.
9	The **anchor system** should ensure stability until the roots have time to fully establish.
10	There are various products available that maximise both the longevity of the tree and amenity value provided by the SuDS feature. These range from grilles, which allow both aeration and expansion of the trunk, frames and guards, which mitigate any potential damage to the trunk, to bench surrounds.
11	**Tree species:** there are many considerations for the selection of tree species, including: water requirements, the future canopy area, maintenance requirements and local environmental receptors. The design should be undertaken by a landscape architect.
12	A **utility corridor** may be utilised to avoid the diversion of utilities. This should be agreed with each utility provider, however as a starting point would consist of a granular bed, sand cover wrapped in an impermeable membrane overlain by warning tiles. Surface identification, i.e., footway edging or alternate pavement design, should be considered if access requirements are anticipated.
Outlets	
13	**Outlet:** outlet from the feature should follow the hierarchy of discharge. Where infiltration is deemed appropriate, the designer should ensure a minimum offset of 5m from any structure. Where there's a positive drainage connection, the designer should consider the need for associated maintenance, i.e., rodding eyes, flow control, overflow mechanism, flow control chamber, and a non-return valve. It should be ensured that the design minimises the risk of flooding during the occurrence of a blockage or exceedance event. As tree pits drain overland flows from the footway, the flood flow route is likely to be via the carriageway.
Street environment	
14	**Pavement construction** over the tree pit should be standard as per the local highway authority, overlaying coarse open no fines graded aggregate to allow for aeration.
15	**Perimeter edging** for future maintenance purposes, the designer could consider marking out the perimeter of the SuDS feature, either by alternating the pavement type or with footway edging.



3.2.5 Permeable paving

Permeable paving provides a surface suitable for vehicle and pedestrian traffic whilst allowing water to infiltrate through the surface into the foundation layers. The pavement can also be designed to accommodate additional runoff from adjacent surfaces and buildings. The foundation layers are generally formed of coarse graded aggregates which allow for storage of rainwater. These layers and additional geotextile layers provide filtration, absorption, biodegradation, and sedimentation. Ultimately, flows are either infiltrated into the ground or discharged into the existing drainage system via a flow control. Gullies are situated at low points in the pavements to carry exceedance flows away from the pavement and into the existing drainage system should an extreme rainfall event occur.

There are a number of elements that are essential to the normal function

- Pavement construction, either block paving or porous asphalt. Including:
  - Structural design
  - Hydraulic design
  - Infiltration design
  - Block pattern (if block paving)
- Kerb and interface design
- Chambers and outlet piping layout
- Exceedance flow routes and overflow gullies

This guide focuses on the design of permeable concrete block paving, however surfacing options include grasscrete, asphalt and resin, amongst others. The SuDS Design Guide alludes to a maximum contributing catchment area to surface area ratio of 2:1, however subsequent studies have shown that to be the extreme for areas of high sediment loading and may be relaxed on a site-specific basis. The depth of granular fill is likely to be determined by structural requirements, as opposed to hydraulic, however it's important to ensure, where outflow is via a positive drainage system such as a perforated pipe or fin drain, that this system does not hinder the hydraulic capacity. Where inlets to the permeable paving are via point inflows, they should include a diffuser to distribute the sediment load and reduce clogging. Subsurface inlets should have a sediment trap for easy maintenance access.

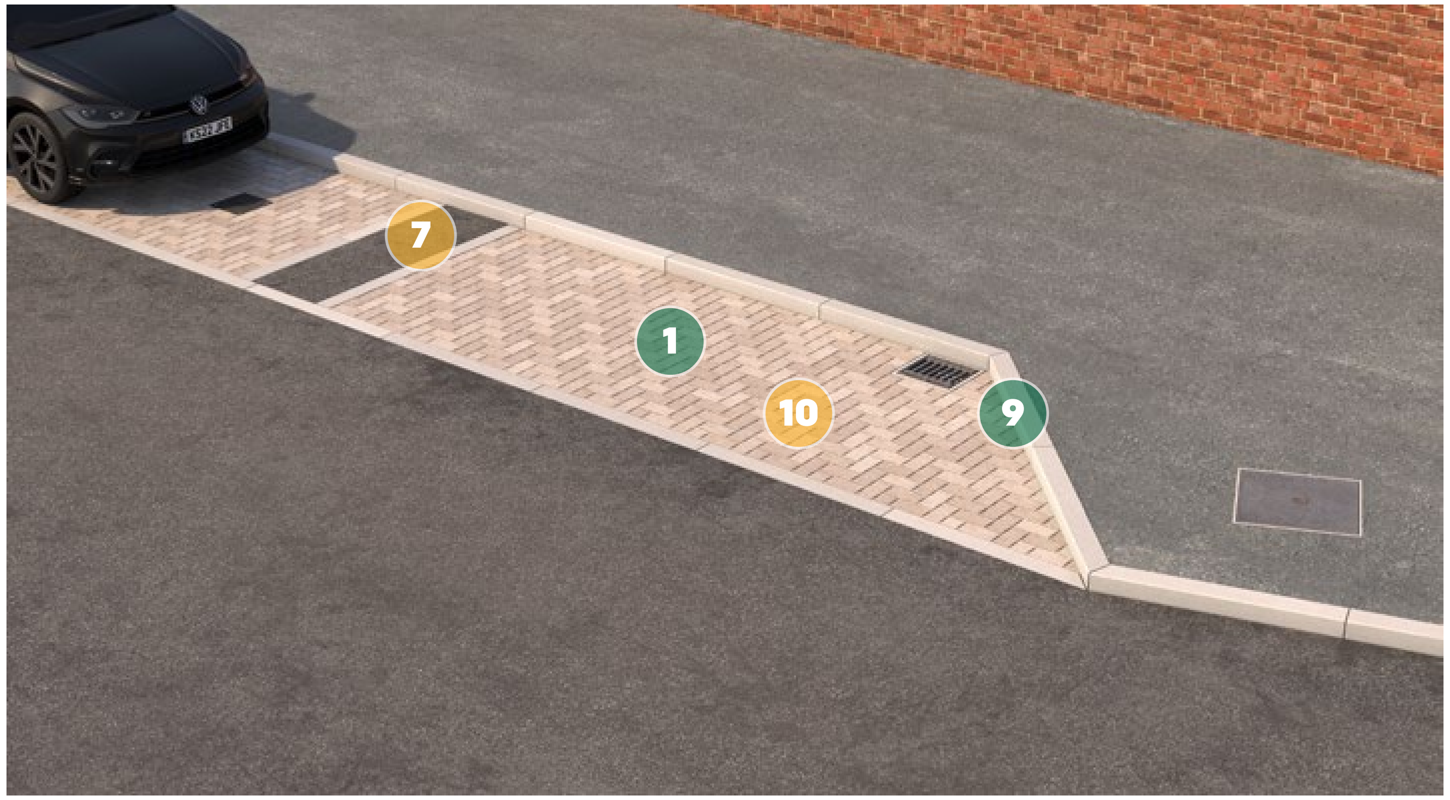
Analysis of existing CBR values should be undertaken. Where existing pavement construction is present, excavation to the necessary depth should be carried out before testing is done on the existing sub-base. The designer should also allow for the occasional loading from higher load categories. If existing CBR values are less than 5%, infiltration is often discounted to allow for subgrade improvement or a capping layer. If infiltration is feasible, any existing pavement construction materials that are present, such as Type 1, would have to be excavated to their full depth if not considered permeable. If CBR values are unknown, guidance should be sought.

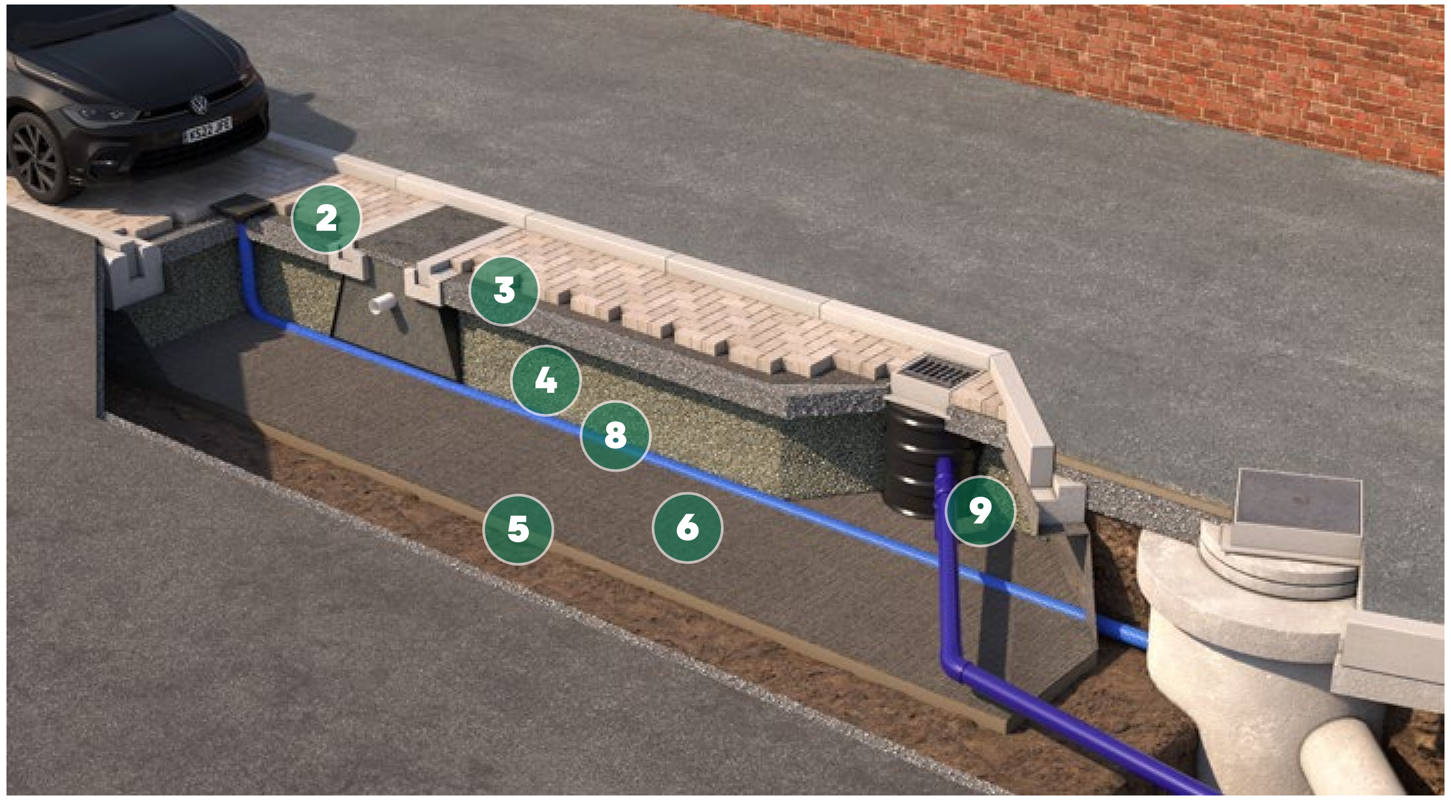
If check dams are to be included, they should cross the pavement, edge to edge, against the slope of the surface. In Type C systems, they will have orifices to control the flow between sections. These openings should be offset as to maximise retention time within the pavement. In this system the check dam and orifice should be wrapped in a permeable geotextile. Type A systems will not require openings as all the water will infiltrate. The check dams will extend from just below the base of the surfacing/laying course to below the final engineered layer. In the event of severe rainfall or a blocked orifice (Type C only), this will allow excess water to overtop the check dam and enter the next section without causing surface flooding. A structural design exercise should be undertaken at detailed design to determine the requirement for concrete strength and reinforcement, depending on the site-specific loading values.

It should be considered whether a non-return valve is required on the outfall into the existing drainage network, particularly if this is a combined system. This shall be dependent on several factors such as historic flooding, relative levels of the outfall and permeable paving and susceptibility to flooding and should be specified at detailed design stage. If a non-return valve is required, this shall be installed downstream of the flow control device. Wherever possible existing chambers should be utilised.

Podium Park, Stockport.
Credit: United Utilities

Permeable paving





	Inlets
1	**Highway inlet: The surface layer** acts as the pavements' inlet, collecting overland flows from the highway. It is commonly formed of either pervious asphalt or permeable block paving, however, can be any permeable surface, such as grasscrete. The depth of the surface layer will depend on the material and loading requirements, however, is generally between 80 and 180mm.
	SuDS components
2	A standard geotextile liner should be utilised as a **filter layer** to prevent siltation of the storage layer. Where sediment loads are higher, the engineer should consider the introduction of a filter layer between each unbound layer.
3	The **structural layer** will vary depending on the type of surface layer, however, is commonly formed from a hydraulically bound course graded aggregate. The thickness is determined by the loading requirement (traffic category) but is likely to be no more than 300mm in depth.
4	The **drainage layer** should be sized via hydraulic modelling however generally be no less than 100mm in depth. It can consist of coarse open no fines graded aggregate or a proprietary product.
5	**Capping:** A minimum CBR value of 5% is required, any value below this will require subgrade improvement or capping.
6	**Liner:** permeable paving should generally be lined to prevent the ingress of fines into the storage layer. For type C paving, this should be an impermeable liner, whereas a standard permeable geotextile is suitable for types A and B.
7	A **utility corridor** may be utilised to avoid the diversion of utilities. This should be agreed with each utility provider, however where cover levels would situate utilities above the storage layer, this could be formed from standard impermeable carriageway construction, in effect making a check dam to maximise flows. The utility corridor surfacing has been depicted as asphalt to stand out, however any non-permeable surfacing is allowable, i.e., block paving to match the style and colour of the surrounding permeable paving.
	Outlets
8	**Outlet:** outlet from the feature should follow the hierarchy of discharge. Where infiltration is deemed appropriate, the designer should ensure a minimum offset of 5m from any structure. Where there's a positive drainage connection, the designer should consider the need for associated maintenance, i.e., rodding eyes, flow control, overflow mechanism, flow control chamber, and a non-return valve.
9	**Exceedance:** It should be ensured that the design minimises the risk of flooding during the occurrence of a blockage or exceedance event. Where a positive drainage outfall exists, an overflow gully may be introduced, tying in downstream of any flow controls. Where there is no option for a positive drainage connection for an overflow, the proposed overland flow path should replicate the existing as far as possible, which will generally be via the highway.
	Street environment
10	Permeable paving can be used across a number of different urban context e.g. parking bay, footway, public square, etc. Designing a universally accessible street requires dropped kerbs (flush) at crossing points to give access between the carriageway and footway, provided as appropriate.

3.3 SuDS in urban spaces

Introduction

Through worked examples, this section uses existing streets in Greater Manchester to demonstrate how individual SuDS features can be delivered together as part of a multifunctional system. The illustrations, both in plan and section, show how different types of SuDS can be delivered in an existing and complex street environment by taking account of the context, uses of the street, and the existing drainage system. They illustrate the sub-surface detail as well as the above-ground features that contribute to creating more attractive and welcoming spaces for everyone.

The example locations are closely linked to the Greater Manchester Street Types and are used to demonstrate options for designers to consider across different contexts, including:

- Neighbourhoods (Terrace Street)
- Neighbourhoods (Outer Suburbs)
- Local Connector Street
- Multi-lane Connector Street
- Destination Places and Gateways
- Off-street Car Park

Fundamentally, there is no one single "right answer" for any street or context. The visuals are presented with the aim to inspire and set out options for designers to consider. They are not templates for design. Existing features of the street have been compressed into a short section for illustration purposes with additional features and issues introduced. As such, the representations are not to scale, and distances between features along the streets must not be inferred as advice, or suggestion. Where applicable a Road Safety Audit should be undertaken for highways schemes.

For detailed technical drawings for each example location, please refer to Appendix 2.

Designers should take into account the requirements for walking, wheeling, cycling, bus and motor vehicles as set out in Chapter 3 of the Greater Manchester Streets for All Design Guide. These requirements are central to delivering universally accessible streets.

Guidance notes

The following guidance notes are applicable:

- Required components are represented by green annotations. 1
- Optional components, or alternatives, that can be added to adapt the design to the street context are shown in yellow. 1
- Light blue pipes represent flow under normal conditions, with dark blue pipes representing exceedance.
- Utilities are shown in green or white.
- 'Off the shelf' products and materials are used unless otherwise specified.
- SuDS features have been designed to drain through a positive drainage connection.
- Visuals are not to scale.

Oval, Lambeth. Credit: Sustrans

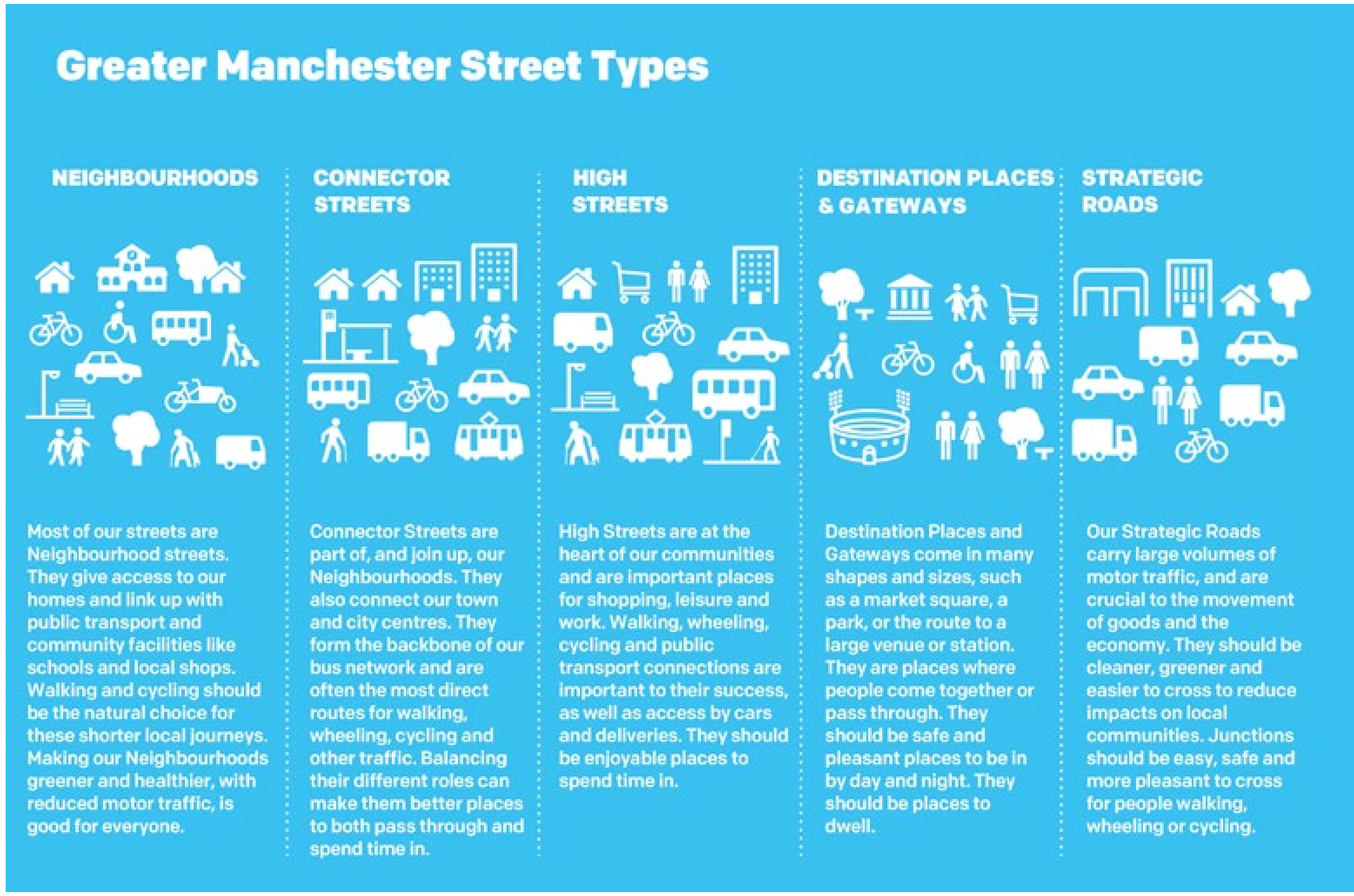


Figure 3.3 Greater Manchester Street Types

3.3.1. Neighbourhoods (Terrace Street)

This is a typical Victorian terraced street within a Neighbourhood in Greater Manchester. There are a mix of both residential and commercial uses along the street. Some of the local streets within the neighbourhood are heavily used by through traffic. Motor vehicles often travel above the 20mph posted speed limit. There is no off-street parking and on-street parking is uncontrolled. There is no formal provision for loading. On some narrow streets, vehicles park on the footway. Surface water ponding on both the carriageway and footway is common in heavy rain and storms, creating a hazard for pedestrians and vehicles.

Existing street context

Transform the street

Inlets	
1	**Overland flow inlet:** Both rain gardens and permeable paving will primarily receive overland flows from both the footway and the carriageway, via flush kerbed inlets in the case of the rain garden, with the addition of exceedance flows from upstream features where there are consecutive SuDS features.
SuDS features	
2	**Consecutive features:** Rain garden build outs may run consecutively, sharing a single underdrain. Whilst this limits the contributing catchment area for the downstream features, it can maximise storage through a shared outfall, and better manage exceedance flows.
Outlets	
3	**Outlet:** Outlet flows should follow the drainage hierarchy with regards to discharge location, however where infiltration isn't viable, multiple SuDS features should outfall via a single connection to maximise storage and benefits to the sewer. Where consecutive features outfall via a single connection, thought should be given to the inclusion of an outfall chamber with flow control and non-return valve.
4	**Exceedance flows:** Exceedance flows from consecutive features may drain directly into a downstream component, however exceedance flows from individual features should, where possible, be managed via a positive drainage feature (i.e., overflow gully bypassing flow controls) in such a way that provides freeboard to the carriageway. Exceedance onto the carriageway should only be used as a last resort, where flows will enter downstream gullies with a flow width no greater than that agreed with the local authority.
Street environment	
5	**Streetscape:** Rain gardens form traffic calming features and create physical and visual localised narrowing of the carriageway to keep motor traffic speeds low. Rain gardens at junctions act as a gateway feature to the Neighbourhood. Optional bollards can be used to deter vehicle overrun.
6	**Formalised parking:** Where rain gardens or permeable paving is utilised to formalise existing on-street parking, charging points for electric vehicles may be constructed on build outs within the SuDS features to maintain footway widths. Providing formalised parking can deter footway parking.
7	**Planting:** Planting should be such that visibility splays are not impacted. Low-level planting provides a buffer for people walking and wheeling between the footway and carriageway and increases people’s everyday contact with nature.

Spotlight on Greener Grangetown

The Greener Grangetown project has transformed 12 streets across the Cardiff neighbourhood. 108 rain gardens, 127 SuDS-enable tree pits and permeable paving have improved the water quality (both physical and biological treatment) of surface runoff before being discharged into the nearby River Taff via a new pipe network. The scheme has also transformed the public realm across the neighbourhood, with the creation of new public spaces, street furniture and re-designed streets and junctions.

Credit: Mott Macdonald

Credit: Arup

Credit: Mott Macdonald

Credit: Mott Macdonald

3.3.2. Neighbourhoods (Outer Suburbs)

This is a typical street in an inter-war estate. All residential properties have driveways or access to off-street parking. Many properties have paved over their front gardens to provide off-street parking, which contributes to localised surface water ponding on the footway. A large, grassed verge provides a buffer between homes and the carriageway but is of low amenity and biodiversity value. It is regularly maintained by the local authority. Historically grass verges between driveway access points provided some greenery however they would often be churned up by parking so have since been converted to hardstanding.

Existing street context

Transform the street

Inlets	
1	**Overland flow inlet:** Rain gardens will primarily receive overland flows from both the footway and the carriageway, via flush kerbed inlets, with the addition of exceedance flows from upstream features where there are consecutive SuDS features. Tree pits, via a permeable surface layer, and swales may receive a portion of their inflow from overland flows, however it will generally be smaller.
SuDS features	
2	**Conveyance features:** Swales can be used for the conveyance as flows, in addition to providing storage and water quality improvements. In this case, upstream features should outfall into the swale whilst exceedance flows are directed there. Thought should be given to the inclusion of suitable freeboard and exceedance flows from the swale itself, ensuring it minimises flood risk. Check dams may be used to maximise storage on sites with a steeper longitudinal gradient.
3	**Consecutive features:** Rain gardens and tree pits may run consecutively, sharing a single underdrain to maximise storage and better manage exceedance flows.
4	**Individual component:** Where the distance to a nearby component is too great to justify a shared underdrain, or other connecting drainage infrastructure, rain gardens and tree pits can be used as individual features.
Outlets	
5	**Outlet:** Outlet flows should follow the drainage hierarchy with regards to discharge location, however where infiltration isn't viable, multiple SuDS features should outfall via a single connection to maximise storage and benefits to the sewer. Where consecutive features outfall via a single connection, thought should be given to the inclusion of an outfall chamber with flow control and non-return valve.
6	**Exceedance flows:** Exceedance flows from consecutive features may drain directly into a downstream component, however exceedance flows from individual features should, where possible, be managed via a positive drainage feature (i.e., overflow gully bypassing flow controls) in such a way that provides freeboard to the carriageway. Exceedance onto the carriageway should only be used as a last resort, where flows will enter downstream gullies with a flow width no greater than that agreed with the local authority.
Street environment	
7	**Streetscape:** Trees and low-level planting break up the uniform linear street. The swale creates a focal point on the street. Opportunity to integrate play features into the swale. Permeable paving used to delineate pocket park zone with seating and SuDS-enabled tree pits creating canopy cover for shade.
8	**Property access:** An exclusion zone inclusive of a suitable buffer should be applied to all existing access points (i.e. car parks or driveways) to ensure SuDS features do not impact pedestrian or vehicular access. On narrow carriageways, thought should be given to the location of features on the opposite side of the road. Vehicle tracking is recommended during detailed design.
9	**Planting:** Where SuDS features are located in front of properties, junctions or crossing points, planting should be such that visibility splays are not impacted.
10	**Verges:** Where verges have been turned into areas of hardstanding to reduce maintenance or to provide parking motor vehicles this exacerbates surface water flooding and should be the first area looked at for the retrofitting of SuDS. Re-greening these areas could be delivered opportunistically, or as part of a larger scheme.
11	Where there is a possibility of introducing conveyance swales, care should be given to **integrating them into the existing street environment as safely as possible,** including freeboard and fencing where necessary whilst ensuring they are universally accessible. It can be beneficial to discuss larger features with the impacted residents at an early stage to maximise public amenity.

Spotlight on Eddington, Cambridge

Eddington is a new district northwest of Cambridge city centre, comprising 3,000 dwellings, 2,000 student bed spaces and community facilities including indoor sports provision, primary health care centre and a primary school. A large scale linked SuDS scheme has been implemented featuring landscaping with varying depths to provide additional storage during high intensity rainfall events, a bridged watercourse running through the site to promote amenity and a large attenuation basin. Swales have been included to transport surface water to the attenuation basin at a controlled rate. This also provides a level of surface water treatment, filtering and trapping debris before it enters the attenuation basin. The site then discharges surface water into Washpit Brook from 8 different outfalls using complex flow controls. This limits discharge to varying Greenfield runoff rates depending on the size of the storm event.

Credit: Planit-IE

Credit: Cambridgeshire County Council

Credit: Planit-IE

Credit: Planit-IE

3.3.3. Local Connector Street

This is a typical tree-lined Local Connector Street which is an important link between surrounding neighbourhoods and the local district centre. It is served by buses every 15 minutes. The bus lay-by and positioning of the bus stop and shelter creates a pinch point on the footway which makes it difficult for people to pass by. Buses experience severe delays when leaving the lay-by to rejoin traffic. There is no formal provision for cycling along the street. Sunken and overloaded gullies create surface water ponding issues on the carriageway and people waiting for the bus can be splashed by buses pulling up to the boarding point.

Existing street context

Transform the street

Inlets

1 **Overland flow inlet:** Rain gardens will receive overland flows from both the footway and cycle track, however alternating full height and flush kerbs are generally advised against on the approach to bus stops so inlet flows should be achieved with a shallow positive connection (i.e., combined kerb drainage unit). Flush kerb spacing facing the cycle track should be minimised for safety. Tree pits may receive a portion of their inflow from overland flows via a permeable surface layer, however it will generally be smaller.

SuDS features

2 **Consecutive features:** Rain gardens and tree pits may run consecutively, sharing a single underdrain to maximise storage and better manage exceedance flows.

3 **Individual component:** Where the distance to a nearby component is too great to justify a shared underdrain, or other connecting drainage infrastructure, or the topography does not allow, rain gardens and tree pits can be used as individual features.

Outlets

4 **Outlet:** Outlet flows should follow the drainage hierarchy with regards to discharge location, however where infiltration isn't viable, multiple SuDS features should outfall via a single connection to maximise storage and benefits to the sewer. Where consecutive features outfall via a single connection, thought should be given to the inclusion of an outfall chamber with flow control and non-return valve.

5 **Exceedance flows:** Exceedance flows from consecutive features may drain directly into a downstream component, however exceedance flows from individual features should, where possible, be managed via a positive drainage feature (i.e., overflow gully bypassing flow controls) in such a way that provides freeboard to the carriageway. Exceedance onto the carriageway should only be used as a last resort, where flows will enter downstream gullies with a flow width no greater than that agreed with the local authority.

Street environment

6 **Bus stop:** The bus lay-by has been 'filled in' so buses are not delayed when leaving the stop. This stop is not a timing point but note that bus timing points require a lay-by or sufficient carriageway width to allow other vehicles to pass. Space freed up by filling in bus lay-by is used to provide a bus shelter and waiting area which doesn't compromise footway widths.

7 **Planting:** Where tree pits are introduced in the vicinity of bus stops, planting should be such that visibility splays are not impacted for pedestrians, cycles and motor vehicles. Apply the principle of 'right tree right place' to ensure appropriate tree species are chosen to avoid damage to buses by the mature tree canopy.

8 **Cyclists:** Hazards should be assessed on their risk to cyclists. This includes, but is not limited to cycle safe gullies, low level planting that doesn't overhang the cycle track, organic debris and leaf litter.

Spotlight on Oldfield Road

As part of the planning permission for the adjacent residential development, a sustainable drainage system flanking a new cycle path and bus stop was constructed on Oldfield Road, including rain gardens and SuDS-enabled tree pits. Carefully chosen plant and tree palette means that the planting continues to thrive whilst attenuating and cleaning storm water running from adjacent hard surfacing.

Credit: GreenBlue Urban

Credit: Buttress

3.3.5. Connector Street

This is a typical post-war Connector Street fronted by residential properties. The street is lined with monofunctional grass verges that perform no drainage role. Built as a wide single-carriageway road, the nature of the street has changed over time. The current street layout does not respond to its residential context. The painted central hatching has been added as a speed mitigation measure area but has little impact on reducing motor traffic speeds and is an inefficient use of limited space. There is no formal provision for cycling on this key route within the neighbourhood. Parking for motor vehicles is provided both on and off-street.

Existing street context

Transform the street

Inlets	
1	**Overland flow inlet:** Both rain gardens and permeable paving will primarily receive overland flows from both the footway and the carriageway, via flush kerbed inlets in the case of the rain garden, with the addition of exceedance flows from upstream features where there are consecutive SuDS features. Flush kerb spacing facing the cycle track should be minimised for safety.
SuDS features	
2	**Consecutive features:** Rain gardens build outs around formalised permeably paved parking may run consecutively, sharing a single underdrain. Whilst this limits the contributing catchment area for the downstream features, it can maximise storage through a shared outfall, and better manage exceedance flows.
Outlets	
3	**Outlet:** Outlet flows should follow the drainage hierarchy with regards to discharge location, however where infiltration isn't viable, multiple SuDS features should outfall via a single connection to maximise storage and benefits to the sewer. Where consecutive features outfall via a single connection, thought should be given to the inclusion of an outfall chamber with flow control and non-return valve.
4	**Exceedance flows:** Exceedance flows from consecutive features may drain directly into a downstream feature, however exceedance flow via a positive drainage feature (i.e., overflow gully bypassing flow controls) in such a way that provides freeboard to the carriageway, should be utilised at regular intervals to prevent an excessive flow width where all features share an outfall. Exceedance onto the carriageway should only be used as a last resort, where flows will enter downstream gullies with a flow width no greater than that agreed with the local authority.
Street environment	
5	**Streetscape:** To enhance the streetscape in response to the frontage context, reallocate carriageway space to provide SuDS and additional space for walking and wheeling, cycling, and formalised parking within the existing cross section. Removal of railings de-clutter. Rain gardens provide buffer between cycle track and carriageway.
6	**Planting:** Where SuDS features are located in front of properties, junctions or crossing points, planting should be such that visibility splays are not impacted. Biodiverse planting chosen to enhance visual attractiveness and provide amenity.
7	**Continuity:** The design should allow for regular breaks in consecutive SuDS features to allow for maintenance access and utility corridors.
8	**Cyclists:** Hazards should be assessed on their risk to cyclists. This includes, but is not limited to cycle safe gullies, low level planting that doesn't overhang the cycle lane and organic debris and leaf litter.

Spotlight on Kingsway, Stretford

As part of a package of improvements to Stretford Town Centre, Kingsway was identified as a major barrier to pedestrian connectivity, with footways currently enclosed by guard railing and fast-moving dual-carriageway traffic generating significant noise and pollution.

In addition to creating a more pleasant environment for pedestrians and cyclists by reducing Kingsway to a single carriageway, reclaiming space for footways, providing segregated cycle lanes, improving crossing points and enhancing public transport provision; SuDS was implemented within the highway and public realm in the form of rain gardens, bioretention tree planting and filter drains.

Credit: United Utilities

Credit: Civic Engineers

Credit: United Utilities

3.3.6. Destination Place

This Destination Place is a public square animated by shops, offices, bars and restaurants alongside residential dwellings. It is a key transport node and is a place to both pass through and spend time in. The large open space lacks drainage infrastructure which leads to excessive surface water ponding, which is particularly hazardous to people walking and wheeling, and impacts the usability of the space as a place for events and socialising. Planters provide some amenity value but do not provide cooling and shade.

Existing street context

Transform the street

Inlets	
1	**Overland flow inlet:** Rain gardens will primarily receive overland flows from both the footway and the carriageway, via flush kerbed inlets, with the addition of exceedance flows from upstream features where there are consecutive SuDS features. Tree pits may receive a portion of their inflow from overland flows via a permeable surface, however it will generally be smaller.
2	**Positive drainage inlet:** Tree pits may receive inflow via a positive drainage connection, either from carriageway runoff or as an outfall or exceedance from an upstream component. Thought should be given to the maintenance and collection of sediment within such networks, which are at a higher risk of blockages.
SuDS features	
3	**Consecutive features:** Rain gardens and tree pits may run consecutively, sharing a single underdrain to maximise storage and better manage exceedance flows. Large areas of open space may have minimal gradients, so all features could be hydraulically linked via linear drains.
Outlets	
4	**Outlet:** Outlet flows should follow the drainage hierarchy with regards to discharge location, however where infiltration isn't viable, multiple SuDS features should outfall via a single connection to maximise storage and benefits to the sewer. Where consecutive features outfall via a single connection, thought should be given to the inclusion of an outfall chamber with flow control and non-return valve.
5	**Exceedance flows:** Exceedance flows from consecutive features may drain directly into a downstream component. Exceedance flows from individual features should, where possible, be managed via a positive drainage feature (i.e., overflow gully bypassing flow controls) in such a way that provides freeboard to the surrounding highway. Exceedance onto the public open space should only be used as a last resort, as it is unlikely they will have the drainage infrastructure in place to adequately deal with ponding.
Street environment	
6	**Streetscape:** Public spaces may already have raised planters and seating. Any design should look to enhance the attractiveness and usability of the space whilst tying the area into the water environment. Good design using nature-based drainage solutions can create interesting and active places that are attractive places to spend time in and pass through, including providing opportunities to incorporate urban play, spaces to socialise and artwork.
7	**Ponding:** Large open spaces often lack drainage infrastructure, which can lead to excessive surface water ponding, impacting the areas functionality. The implementation of SuDS should target the natural low points to enhance the usability and accessibility of the space free from ponding.
8	**An inclusive environment:** Rain gardens with detectable kerb edges are located to maintain clear through routes on pedestrian desire lines. Landscape design must accommodate large numbers of people congregating or pass through the space. Kerb upstands can deter pedestrians from encroaching on to the rain garden. Rain garden design should minimise opportunities for concealment.

Spotlight on Altrincham town centre

Since 2015, public realm improvements to Altrincham marketplace and surrounding streets have been delivered to regenerate the town centre, including:

- 300m² of SuDS installed across the town centre.
- Improved streetscape to redress the balance between vehicles and pedestrians.
- New cycling facilities and cycle storage.
- Carefully considered design to reduce traffic speeds through surface treatments, tree planting, furniture, lighting and removal of kerbs, traffic lights and barriers.

Credit: Planit-IE

Credit: Planit-IE

3.3.7. Multi-lane Connector Street

This street is an example of an inner urban connector street. The allocation of space in the carriageway cross section, particularly the asphalt central reservation, does not make best use of the available width. It is heavily trafficked and there is no formal provision for cycling. It is a busy pedestrian route but is unpleasant to walk and wheel along. Although the footways are not narrow, they feel narrow given proximity to motor traffic. There are major surface defects, e.g. sunken gullies, that present a safety issue to all users. Surface water flooding in heavy rain is a hazard to all users, and pedestrians can be splashed by passing motor traffic.

Existing street context

Transform the street

Inlets	
1	**Overland flow inlet:** Rain gardens will primarily receive overland flows from both the footway and the carriageway, via flush kerbed inlets, with the addition of exceedance flows from upstream features where there are consecutive SuDS features. Tree pits, via a permeable surface layer, and swales may receive a portion of their inflow from overland flows, however it will generally be smaller.
2	**Positive drainage inlet:** Tree pits and swales will primarily receive inflow via a positive drainage connection, either from carriageway runoff via trapped gullies or combined kerb drainage units (into a high level "diffusion" pipe in the case of tree pits), or as an outfall or exceedance from an upstream component. Thought should be given to the maintenance and collection of sediment within such networks, which are at a higher risk of blockages. Where rain gardens are set back from the carriageway, shallow / surface level point inflow connections may be required (i.e., via a linear drain or combined kerb drainage unit).
SuDS features	
3	**Conveyance features:** Swales can be used for the conveyance as flows, in addition to providing storage and water quality improvements. In this case, upstream features should outfall into the swale whilst exceedance flows are directed there. Thought should be given to the inclusion of suitable freeboard and exceedance flows from the swale itself, ensuring it minimises flood risk. Check dams may be used to maximise storage on sites with a steeper longitudinal gradient.
4	**Consecutive features:** Rain gardens and tree pits may run consecutively, sharing a single underdrain to maximise storage and better manage exceedance flows.
5	**Individual component:** Where the distance to a nearby component is too great to justify a shared underdrain, or other connecting drainage infrastructure, rain gardens and tree pits can be used as individual features.
Outlets	
6	**Outlet:** Outlet flows should follow the drainage hierarchy with regards to discharge location, however where infiltration isn't viable, multiple SuDS features should outfall via a single connection to maximise storage and benefits to the sewer. Where consecutive features outfall via a single connection, thought should be given to the inclusion of an outfall chamber with flow control and non-return valve.
7	**Exceedance flows:** Exceedance flows from consecutive features may drain directly into a downstream component, however exceedance flows from individual features should, where possible, be managed via a positive drainage feature (i.e., overflow gully bypassing flow controls) in such a way that provides freeboard to the carriageway. Exceedance onto the carriageway should only be used as a last resort, where flows will enter downstream gullies with a flow width no greater than that agreed with the local authority.
Street environment	
8	**Streetscape:** In this context, delivering SuDS requires a reallocation of space across the full width of the existing cross section. This should first be achieved via the direct conversion of a verge or central reservation to SuDS features, followed by the removal of any additional width within the carriageway and finally by either reducing footway space or by removal of any offside verges to maintain a buffer between motor vehicles and pedestrians as far as practicable.
9	**An inclusive environment:** Tree pits installed where footways are wide. Designers should look for opportunities to increase green and blue infrastructure to support people feeling comfortable using the street. SuDS rain gardens and street trees have a transformational effect on the way all users experience and use the street.

Spotlight on Trafford Road

Flagship landscape-led scheme along a busy highway integrating junction improvements, bus improvements and active travel. Introducing green and blue infrastructure allowed both the mitigation of surface water runoff whilst providing extensive ecological and visual benefits to Trafford Road.

Credit: Salford City Council

Credit: Salford City Council

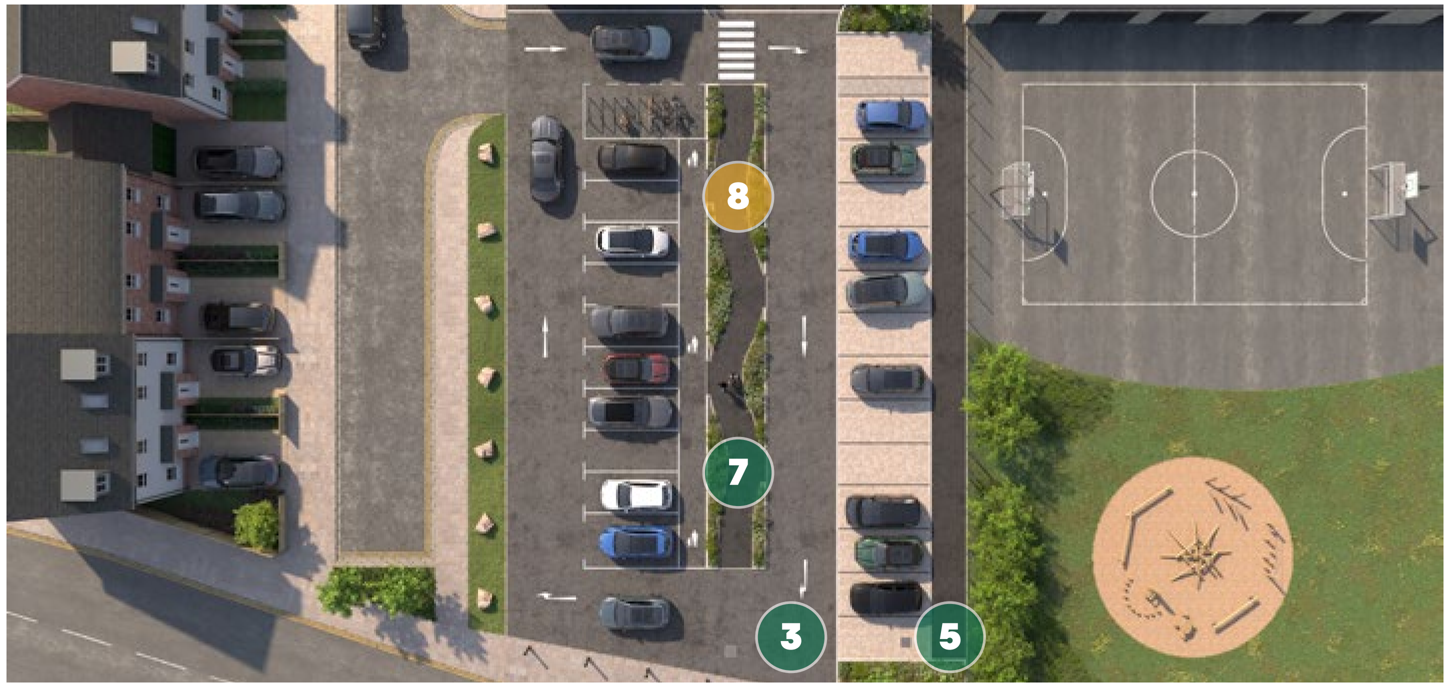
Credit: Salford City Council

3.3.8. Off-street car park

This is an example of an off-street car park. The asphalt surfaced car park lacks drainage infrastructure which becomes overloaded and leads to excessive surface water ponding in light rainfall. The verges have no drainage, biodiversity or amenity role.

Existing street context

Transform the street



Inlets	
1	**Overland flow inlet:** Both rain gardens and permeable paving will primarily receive overland flows, via flush kerbed inlets in the case of the rain garden, with the addition of exceedance flows from upstream features where there are consecutive SuDS features. Flush kerb spacing should be minimised for safety.
2	**Positive drainage inlet:** Tree pits may receive inflow via a positive drainage connection, either from carriageway runoff or as an outfall or exceedance from an upstream component. Thought should be given to the maintenance and collection of sediment within such networks, which are at a higher risk of blockages.
SuDS features	
3	**Consecutive features:** Rain gardens build outs around formalised permeably paved parking may run consecutively, sharing a single underdrain. Whilst this limits the contributing catchment area for the downstream features, it can maximise storage through a shared outfall, and better manage exceedance flows.
Outlets	
4	**Outlet:** Outlet flows should follow the drainage hierarchy with regards to discharge location, however where infiltration isn't viable, multiple SuDS features should outfall via a single connection to maximise storage and benefits to the sewer. Where consecutive features outfall via a single connection, thought should be given to the inclusion of an outfall chamber with flow control and non-return valve.
5	**Exceedance flows:** Exceedance flows from consecutive features may drain directly into a downstream component. Exceedance flows from individual features should, where possible, be managed via a positive drainage feature (i.e., overflow gully bypassing flow controls) in such a way that provides freeboard to the surrounding highway. Exceedance onto the car park should only be used as a last resort, as ponding may impact user safety.
Street environment	
6	**Planting:** Planting should be such that visibility splays are not impacted; vegetation will not overhang areas where motor vehicles will drive, or the footway, and organic matter will not create unnecessary maintenance liabilities on other SuDS features.
7	**Continuity:** The design should allow for regular breaks in consecutive SuDS features to allow for access and utility corridors.
8	**Reallocation of space:** The conversion of parking spaces to SuDS is minimal, balanced with maximising benefits to water quality, amenity and biodiversity

Spotlight on RHS Bridgewater

The design for the surface water drainage system across the site is entirely SuDS based. The site's car parks have permeable surfaces to collect water run-off, swales for storm water attenuation and a bio-retention pond before discharging to the local watercourse at greenfield runoff rates. The bio-retention pond can hold up to 24 hours of constant rainfall.

4. Sharing good practice

4.1 Case study library

Neighbourhoods

Greener Grangetown

Neighbourhood-wide SuDS and street improvement scheme.

Location

Grangetown, Cardiff, CF11 7, Wales

Timeframe

January 2017 to July 2018.

Scheme description

SuDS and street improvements delivered across 12 streets in the Grangetown neighbourhood. The concept for Greener Grangetown was developed from the original aim of removing surface water that entered Dŵr Cymru Welsh Water's combined sewer network. Rain gardens, SuDS-enabled tree pits and permeable paving have improved the water quality (both physical and biological treatment) of surface runoff before being discharged into the nearby River Taff via a new pipe network. Alongside the SuDS features, the scheme has also delivered:

- 1,700m^2 of new green space
- 14 re-designed road junctions for safer walking and wheeling
- New Bicycle Street (priority for cyclists) along the Taff Trail
- 550m new footway for pedestrians along Taff Trail
- Improved public realm with new street furniture & surfacing

SuDS features

- Permeable paving
- 127 SuDS-enabled trees
- 108 rain gardens
- Combined kerb drainage and channel drainage

People involved

Client and funders

- Cardiff Council
- Dŵr Cymru Welsh Water
- Natural Resources Wales
- Landfill Communities Fund

Designers

- Arup
- Input from various teams within Cardiff Council. This included drainage, parks, highways, and waste management.

Contractors

- ERH Communications and Civil Engineering – Principal Contractor
- Gerald Davies Landscape and Maintenance Services – Landscape
- Other third parties were also engaged during the design process, including South Wales Police and Sustrans.

Design process

Geotechnical investigations found that infiltration into the ground was not feasible due to the presence of contaminated made ground and impermeable material. All the SuDS features are therefore lined with an impermeable liner, which also protects nearby buildings from the impacts of tree roots. Drainage is kept shallow wherever possible using recycled plastic composite kerb drainage and channel drainage units to convey flows from the busy Corporation Road into rain gardens located at 7 stopped-up streets.

Community involvement throughout design and construction including school visits, weekly drop-in sessions, planting events and updates through leaflets and social media.

Costs

Total scheme cost: £3m

Evaluation

Greener Grangetown removes an average of 40,000m^3 of surface runoff from the combined sewer system annually.

Before

Credit: Cyngor Caerdydd/Cardiff Council and Arup

After

Credit: Cyngor Caerdydd/Cardiff Council and Arup

Before

Credit: Cyngor Caerdydd/Cardiff Council and Arup

After

Credit: Cyngor Caerdydd/Cardiff Council and Arup

Information adapted from Sudsdrain case study

Dales Brow

Grassed corner adjacent to junction converted to swales and wetland area to divert rainwater run-off from highway.

Location

Land adjacent to the junction of Folly Lane and Dales Brow, Swinton, Salford, M27 0YN

Timeframe

November 2019 to August 2020

Scheme description

The green space on the corner of the junction has been transformed from a monofunctional grassed area to a multi-functional green space. Rainwater running off the road is now diverted away from the sewers into the swales. In heavy rainfall events the rainwater will travel along the swales and into a temporary wetland area.

When the swales and wetland area are full, the water will overflow back into the local water course via a pipe connection in a clean and safe condition.

This new wetland site enhances biodiversity and provides a high-quality recreation space. The site provides climate change adaptation benefits at a low cost; something that could be easily replicated.

SuDS features

- 2 swales
- Creation of a new 64m2 wetland area
- 40m long beech hedge
- New plants and trees

People involved

- Environment Agency
- Salford City Council
- United Utilities
- University of Salford
- City of Trees

Design process

The project has been delivered in partnership with City of Trees, Salford Council, Environment Agency, United Utilities and the University of Salford.

Landscape designers: Wardell Armstrong

Contractor: Landscape Engineering.

Costs

Total scheme cost: £127,000

Evaluation

The project helps to reduce surface water flooding at a local level, eases pressure on the sewer infrastructure as well as providing cost savings with respect to water treatment and reducing the likelihood of pollution incidents in watercourses from overflowing sewers.

Before

Credit: Salford City Council

After

Credit: Salford City Council

After

Credit: Salford City Council

After

Credit: City of Trees

Information adapted from Salford City Council

Kenmont Gardens

Scheme to ease pressure on the sewer system and create an accessible high-quality public space.

Location

Kenmont Gardens, Harlesden, London Borough of Hammersmith and Fulham, NW10 6BU

Timeframe

6 months construction, completed summer 2015.

Scheme description

Kensal Green is at the start of the storm water sewer catchment draining towards the Thames. The borough suffers from downstream issues. This scheme was developed to ease pressure on the system and provide more capacity by slowing the flow rate into the sewer. The site is on London clay soil and is not permeable. Therefore, the solution was to attenuate using SuDS-enabled tree pits and permeable paving.

SuDS features

- Total area covered: 300-350m^2
- Rain gardens
- SuDS-enabled tree pits
- Permeable paving
- Flow control chambers
- Connection to sewer

People involved

Client: London Borough of Hammersmith and Fulham
Designer: Project Centre
Contractor: FM Conway
Stakeholders: Kenmont Gardens Residents Group, Kenmont Primary School

Design process

The overall design principles of wanting an accessible public space with seating, trees and other vegetation were established early with the residents' group and client.

The methodology for control of the surface runoff was established after trial pits showed that infiltration on the site was almost non-existent. The Project Centre team consulted a SuDS expert, Bob Bray, to investigate appropriate alternatives. The team then worked with SuDS materials suppliers Green Blue Urban and Controflow to design and specify the underground SuDS elements.

It was important that the planting beds should retain their permeability for the effective functioning of the scheme. As the beds were flush with the resin-bound gravel surface they were vulnerable to trampling and compaction. Therefore, the soils were covered in coarse resin-bound materials with pockets of soil for the planting contained by short lengths of large diameter perforated pipe sections (as shown below before the resin-bound material being applied).

Costs

Total scheme cost: approximately £330,000

Evaluation

A closed-off street corner has been transformed into a vibrant public open space with seating, lighting and planting was created.

Engaging the local school children was positive. As well as helping with the final planting, children had the opportunity to create tiles that were incorporated into the scheme, giving them a legacy in their local area.

Before

Credit: Mott Macdonald

After

Credit: Mott Macdonald

After

Credit: Mott Macdonald

After

Credit: Mott Macdonald

Information adapted from Salford City Council

Oval, Lambeth

Part of the Oval to Stockwell Low Traffic Neighbourhood.

Location

Oval, Lambeth, London

Timeframe

Per site:

Design – 6weeks

Construction – 8 weeks

Completion date: March 2023

Scheme description

Oval LTN was one of the five original Low Traffic Neighbourhoods in Lambeth consisting of five filters in total and eight wider improvements.

Claylands Road features a diagonal filter that permits cycles, and pedestrians. The concept behind the scheme was to frame the entire junction beyond the diagonal closure to create a residential public square, introduce a series of rain gardens, and provide seating to allow local cafés to spill out, creating a street that looks less like a carriageway and offers numerous opportunities to cross and stay.

SuDS features

- Approx 150m^2 of rain gardens
- SuDS-enabled tree pits
- Permeable paving

People involved

- Design: Sustrans, Capital Studios & Ringway Jacobs
- Engagement: London Borough of Lambeth & Sustrans
- Contractor: Ringway Jacobs
- Landscape: Meristem Design

Design process

The design encourages a low speed environment for cycles and motor vehicles. through the narrow geometry, encouraging an informal give-way system between people.

Sustrans visited the site, temporarily activated the street with coloured surfacing, and left engagement boards for two weeks to gain a better understanding of local needs. These insights were transformed into designs that went out for consultation. In 2022, construction began and was completed in early 2023. The street has now transformed into a green, people-friendly space, where quiet conversations fill the street instead of vehicle noise.

Costs

- Claylands diagonal filter £200k
- £330 per m^2 for rain gardens

Evaluation

No specific evaluation of SuDS features, but the area has seen approx. 92% increase in cycling.

Credit: Mott Macdonald

Credit: Sustrans

Information adapted from Sustrans

Connector Streets

Kingsway

Installation of rain gardens, bioretention tree planting and filter drains as part of highway and public realm improvements.

Location

Kingsway (A5145), Stretford, Trafford, M32 8AP

Timeframe

Concept design commenced August 2021

Construction commenced May 2023

Complete October 2024

Scheme description

As part of a package of improvements to Stretford Town Centre, Kingsway was identified as a major barrier to pedestrian connectivity, with footways currently enclosed by guard railing and fast-moving dual-carriageway traffic generating significant noise and pollution.

In addition to creating a more pleasant environment for pedestrians and cyclists by reducing Kingsway to a single carriageway, reclaiming space for footways, providing segregated cycle lanes, improving crossing points and enhancing public transport provision; 2104m^2 of SuDS were delivered within the highway and public realm in the form of rain gardens, bioretention tree planting and filter drains.

SuDS features

- Rain gardens installed in existing carriageway, taking advantage of existing falls within the highway to drain runoff. Due to low potential for infiltration, rain garden sub-bases were wrapped with an impermeable liner to reduce the risk of sub-surface flows of water undermining the adjacent existing carriageway construction.
- Where constraints such as existing trees or costs precluded the excavation of full-depth rain gardens, filter drains were installed at the perimeter of soft landscaping to provide additional attenuation and filtration of pollution.
- These SuDS features cover a total plan area of 2104 m^2, equating to 13% of the 1.58 hectare site.

People involved

- Client: Trafford Borough Council
- Civic Engineers (Civil Engineer)
- Exterior Architecture (Landscape Architect)
- A E Yates (Main Contractor)
- Simon Fenton Partnership (Cost Consultant)
- Landfill Communities Fund
- LK Group (Project Manager)

Design process

In the conceptual design, general siting of SuDS was based on interrogation of existing topography, however, it was also cognisant of the proposed character areas across the site. The southern footway adjacent Stretford Mall has a 'Civic' character, with less soft landscaping to maximise retail frontage and enable spill out of retail onto the improved public realm. In contrast, the northern footway forms a green corridor that acts as a green buffer between existing residential estates and the Kingsway, and therefore features a much greater proportion of SuDS.

'Dutch-style' kerbs were utilised within rain garden edgings, as well as across the wider development. These kerbs are more forgiving to cyclists and help prevent cycle wheels and pedals from catching on the edge of the cycle lane.

New pedestrian crossings and facilities to encourage pedestrian priority.

Costs

Total scheme construction value: £7.75m

Evaluation

The Kingsway four-lane vehicle-dominated road previously severed the communities to the north from Stretford Mall and has now been redeveloped to reintroduce a fine-grained town centre and local focus.

Rate and volume of runoff into sewers reduced through interception storage provided in rain gardens and filter drains as well as treatment of total suspended solids, hydrocarbons and metals.

Information adapted from Civic Engineers

Before

Credit: Civic Engineers

After

Credit: United Utilities

Before

Credit: Civic Engineers

After

Credit: United Utilities

Liverpool Street corridor

Remodel of existing route to prioritise cyclist safety whilst providing green and blue infrastructure.

Location

Liverpool Street, Salford, M5 4LT

Timeframe

Design Stages: 2018 – 2019

Construction: 2020 – 2023

Scheme description

Previously dominated by vehicular traffic, the need to create opportunities for active travel along the Liverpool Street corridor was ever increasing in response to the extensive regeneration taking place in surrounding neighbourhoods.

The scheme improved footways, creating segregated cycle tracks and provided a significant opportunity to provide green and blue infrastructure, which in turn improved the visual appeal of the corridor.

SuDS features

Liverpool Street underwent significant design and construction to introduce continuous stretches of rain gardens running the entirety of the route (approx. 700m). Buffer zones between the cycle track and the carriageway in the form of planting margins ensure further/ safer segregation from motor vehicles.

Rain gardens formed the basis of the landscape element of the scheme – with a mixture of perennials, ferns and grasses.

People involved

- Salford City Council
- Landscape Architecture Design Team
- Drainage Engineer Team
- Highway Engineer Design Team
- Transport for Greater Manchester, including the Urban Traffic Control unit.

Design process

- Liaison and discussions at an early stage to advise and educate utility providers what SuDS are and how their assets would be integrated within SuDS and developing mitigation where required.
- Design around SuDS in the first instance to further maximise extent of Blue and Green Infrastructure into a scheme.
- Planting specification – adapting to location and plants specified for year-round interest.
- RIBA Work Stages 1-7
- Regular design team meetings and design workshops both with internal and external partners.

Costs

Total project cost = £2.5m

Evaluation

This is a route that is heavily used by HGV's, which in turn produces extensive pollution. The soft landscape aspect will go some way to alleviate the impact of this – physically and visually whilst the SuDS elements continually work to alleviate the pressure on the drainage network.

Before

Credit: Google maps

After

Credit: Salford City Council

Before

Credit: Google maps

After

Credit: Salford City Council

Information adapted from Salford City Council

Trafford Road Corridor

Remodel of existing route to increase capacity for all modes.

Location

A5063 Trafford Road, Salford, M5 3AW

Timeframe

Design Stages: 2018 – 2020

Construction: 2020 – 2023

Scheme description

The scheme improved capacity and efficiency for all modes along the corridor by enhancing junctions and links through the integration of green and blue infrastructure. The scheme aims were to improve safety and connectivity, segregated cycleway and footway and the inclusion of 'cyclops' junctions to provide increased opportunities for active travel.

SuDS features

Rain Gardens formed the basis of the landscape element of the scheme – the central reservations saw a mixture of SuDS-enabled tree pits and rain gardens with a mixture of perennials and grasses and large expanses of wildflower.

People involved

- Salford City Council
- Landscape Architecture Design Team
- Drainage Engineer Team
- Highway Engineer Design Team
- Transport for Greater Manchester, including the Urban Traffic Control unit.

Design process

- Working collaboratively with the Highway engineers, the rain garden details with respect to kerb types and layout were able to be agreed that would satisfy both highways standards and to enable rain gardens to be introduced to the full extent of the scheme. This collaborative approach also allowed for the integration of the SuDS enabled tree trenches whilst needing to be designed to withstand carriageway loads.
- Working with the engineers allowed a mutual understanding of both landscape and highway requirements and standards.
- RIBA Work Stages 1-7
- Regular design team meetings and design workshops both with internal and external partners.

Costs

Total project cost = £8.7m

Evaluation

Introducing green and blue infrastructure allowed both the mitigation of surface water runoff whilst providing extensive ecological and visual benefits to Trafford Road.

Before

Credit: Google maps

After

Credit: Salford City Council

After

Credit: Salford City Council

Information adapted from Salford City Council

URBAN GreenUP Sustainable Drainage Tree System

Retrofit SuDS-enabled street trees into a wider city highways and regeneration scheme.

Location

The Strand, Liverpool, L2 0RG

Timeframe

SuDS trees completed February 2020

Planting and connections/landscape completed September 2020

Scheme description

URBAN GreenUP was an EU funded Horizon 2020 project that ran between 2017 – 2023, which retrofitted nature-based solutions into urban areas and monitored them for environmental, social, and economic benefits.

Integration of 20 SuDS-enabled street trees into the central reservation as part of a wider regeneration and highways connectivity scheme.

SuDS features

- 20 Dawn Redwood Metasequoia glytostroboides trees planted in silva cells
- Length of SuDS 174.9m
- Area of permeable paving 579.25m^2
- Total catchment area 765m^2
- Average volume of soil/tree 18.5m^3

Tree root barriers and tree root deflectors were used to protect utility infrastructure passing through the framework structure and root void area.

People involved

- Liverpool City Council as Local Authority (various service areas)
- Local residents
- Contractors: Amey, Graham, BCA Landscaping
- Project partner consortium: Liverpool City Council, Mersey Forest, The University of Liverpool.

Information adapted from Liverpool City Council

Design process

The trees had to be lifted 20cm after planting to accommodate an unexpected and critical structure in the wider highways works. Reworked hydraulic calculations were needed to ensure there was still sufficient fall and runoff volume for the trees to be effective.

Issues arose over the specified pH of topsoil for the tree SuD pits which could not be sourced in time and compromises on soil pH had to be made in conjunction with the Councils Tree Officer. Covid also restricted on site interaction between different organisations meaning that some desired aspects of the project were compromised, and final data was limited or compromised.

Costs

A contribution of £300,000 was made towards the wider scheme.

Evaluation

Scheme resulted in

- Decrease in water flow and volume to drain
- Reduction in suspended solids of 74%
- Shade and cooling provision by the trees
- 13.4t carbon stored and 0.13tCO2e sequestered

Before

Credit: Juliet Staples

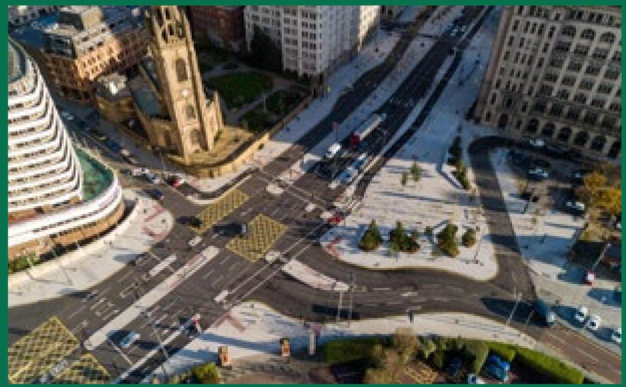
After

Credit: Juliet Staples

After

Credit: BCA Landscape

After



Credit: MatthewNicholPhotography

High Streets

Altrincham town centre

Town centre-wide SuDS and public realm improvements.

Location

Altrincham, Trafford

Timeframe

Construction completed: August 2023.

Scheme description

- SuDS and improved streetscape to redress the balance between vehicles and pedestrians.
- New cycling facilities and cycle storage.
- Carefully considered design to reduce traffic speeds through surface treatments, tree planting, furniture, lighting and removal of kerbs, traffic lights and barriers.

SuDS features

300m^2 of SuDS installed across the town centre, including:

- Rain gardens
- SuDS-enabled trees
- Permeable paving

People involved

Client and funders: Trafford Council and Altrincham BID

Designers: Planit-IE

Contractors: Alined and Wright Landscapes

Others involved in the design process include comprehensive consultation with stakeholders, including the Disability Group, was a pre-requisite to project success and extended to over 50 engagement sessions throughout the life of the project.

Costs

SuDS features (including excavation, all below drainage, kerbs to form beds, forming the bed, type 3 material, soil, planting, trees and prelims) was approx. £750 m^2. Cost excludes design fees.

Evaluation

- The public realm works have acted as a catalyst for wider regeneration and development proposals.
- Town centre property vacancy rates reduced by 2%
- Planning applications increased by 60%
- Increased property values and prosperity of the surrounding restaurant, bars, cafés and shops.

Information adapted from Planit-IE

Before

Credit: Google maps

After

Credit: Planit-IE

Before

Credit: Google maps

After

Grey to Green

Grey to Green has delivered a SuDS drainage system that reconnects Sheffield city centre with its waterways, flowing rainwater back to rivers in a way that mimics nature – cleanly, slowly, sustainably.

Location

West Bar, Bridge Street, Exchange Place, Castlegate, Angel Street and Snig Hill, Sheffield

Timeframe

Phase 1: Approved in 2014, complete 2016

Phase 2: Approved 2019, complete 2022

Scheme description

The location and scale of the new green landscape was influenced by numerous factors including provision for bus, pedestrian and cyclist movement and the need to create spaces for the working, living and visiting communities. This combined with the levels of the highway and known service locations created the spatial framework for how the SuDS would be designed and what it could deliver in terms of hydraulic benefits.

Throughout the scheme are a number of 4.2m totem-like structures filled with sculptures and carvings. The artworks are made from wood and are designed to create habitats for the wildlife that is returning to the area.

SuDS features

Phase 1: project area is 1.0Ha and the total length is 0.7km

Main SuDS features in both Phase 1 and 2:

- Flush kerbs allowing immediate flow from highway into receiving resin bounded gravel filter strip
- Subsequent receiving ornamental planted swale adapted with 25 run-off storage compartments (cells) provided by check dams for larger storm events with control structures ensuring the attenuation and subsequent drawdown of run-off
- Shallow connectivity between green areas through dished channel drains
- Attractive protected inlets providing connectivity to final river discharge

The scheme manages flows from the new paved pedestrian/cycle surfaces as well as half of the highway (service depths made it difficult to re-profile whole highway). Runoff is collected via simple over edge flush kerbs into a swale running the length of the scheme.

People involved

- Sheffield City Council
- European Regional Development Fund
- Yorkshire Water
- Canal and River Trust
- Amey consulting
- Robert Bray Associates
- McCloy Associates
- University of Sheffield
- Nigel Dunnett Contractors
- North Midland Construction
- Ashlea
- Green Estates
- Turner and Townsend

Design process

A central tenet of the approach to the site was to place SuDS at the heart of the scheme, celebrating the function and using it as an organising factor. By doing so the alignment, engineering and particular mixture of planting help to set the character and establish the identity of the area. The scheme is opportunistic in terms of SuDS rather than driven through surface water problems, it is a demonstration that SuDS can be achieved in an inner city urban environment.

It was not a case of setting standards, for example discharge rates, rather a case of working with the environment to see how it can maximise benefits whilst making a safe and attractive environment.

In a city of makers, substantial elements of the engineering such as the check dams, outfalls and grilles are celebrated as positive aspects of design rather than hidden or disguised.

Costs

Phase 1: Project cost around £3.6m

Phase 2: Project cost around £6.3m

Evaluation

The project has already had a significant impact on the area. From an economic perspective, new office and residential developments have taken place in West Bar and Castlegate. Visitors, residents and workers alike enjoy the new seating and the surrounding planting.

Besides these economic benefits, the project has significantly increased biodiversity and improved surface water management. A series of new habitats have been created. The species diversity and length of flowering times of the bulbs and perennials mean that insect pollinators have a good source of nectar throughout the year. The linear nature and degree of plant cover, including 40 semi-mature trees, provides a near continuous corridor which will connect with the river Don in future phases.

Infoworks (ICM) modelling showed the scheme could contain a 60 minute, 1 in 30 year event with discharge from the whole scheme to the river reduced from 47.3l/sec to 9l/sec.

Information adapted from Grey to Green – Sheffield, Sudsdrain and UK 100

Before

Credit: Grey to Green

After

Credit: Grey to Green

Before

Credit: Grey to Green

After

Credit: Grey to Green

Sauchiehall Street

The Sauchiehall Street Avenue project transformed a four-lane city highway into a linear public space with segregated cycle tracks, continuous wide footways, seats and trees.

Location

Sauchiehall Street, Glasgow, G2 3HQ

Timeframe

Design stage: January 2016 – December 2017

Construction started: January 2018

Construction completed: September 2019

Scheme description

The project transformed 600 metres of the street by:

- Removal of two traffic lanes to allow space for widened pavements and a central verge, increasing both pedestrian and cycle space.
- Planting 28 new trees on the street to form part of a SuDS solution, allowing water to runoff from the paving, over the SuDS-enabled tree pit and work its way at a controlled rate into the sewers.
- Raising side road crossings to footway level to run continuously along the street to prioritise east-west pedestrian and cycle movements.
- Creating segregated bi-directional cycle lanes.
- Installing new bus shelters, 30 new cycle stands, and 30 new three person benches with backs and arm rests.

SuDS features

- 28 SuDS- enabled deciduous semi-mature trees (8m+ height)
- Permeable paving with root-space storage capacity below ground

People involved

Client and funders

- Glasgow City Council

Designers

- Urban Movement
- Civic Engineers

Contractors

- Ideverde Ltd

A series of community engagement and design workshop events for BID members, disability groups, council officers, residents and businesses, held on or close to the street, aimed at both gaining support for the project as well as informing the design.

Design process

Geotechnical investigations found that infiltration into the ground was not feasible due to the presence of contaminated made ground and impermeable material. All the SuDS features are therefore lined with an impermeable liner, which also protects nearby buildings from the impacts of tree roots.

Drainage is kept shallow wherever possible using recycled plastic composite kerb drainage and channel drainage units to convey flows from the busy Corporation Road into rain gardens located at 7 stopped-up streets.

Community involvement throughout design and construction including school visits, weekly drop-in sessions, planting events and updates through leaflets and social media.

Costs

Total cost £6m

Evaluation

- Estimated value of the wider benefits of the project of over £8.4 million
- Trade on the street has increased, creating new retail and hospitality jobs following increases to footfall
- Cycling levels have increased by 80% eastbound and 600% westbound

Information adapted from Green Blue Urban case study, Sustainable Scotland Network case study and Urban Design Group case study

Before

Credit: Urban Movement

After

Credit: Sustainable Network Scotland

After

Credit: GreenBlue Urban

After

Credit: GreenBlue Urban

Swinton Square shopping centre

Rain gardens installed in a local shopping precinct.

Location

Swinton Square, Salford, M27 4BH

Timeframe

April 2022 – July 2022.

Scheme description

Located in the hard paved pedestrian shopping precinct of Swinton Square.

The rain garden was used to demonstrate the function of a rain garden and as an experiment to see if the softening of the hard built environment could attract more shoppers into the area along with birds and bees. A green roof was installed over some of the shop canopies and a small area of green/living wall was created at the same time as the rain garden was installed.

SuDS features

The Green Blue Urban HydroPlanter module system was used for the rain garden. With controlled out flow via a perforated pipe which included an overflow outlet. Bioretention soils and gravel base with geotextile membrane filtration and separation layer between the two. The out feed is linked to the existing drainage network.

The 17m^2 rain garden drains 160m^2 of hard surfacing.

People involved

- Avison Young. The management company for Swinton Square.
- Salford City Council
- Swinton Square users
- Groundwork Greater Manchester as Consultant / Designers and Contractor
- Structural Survey Engineers
- Green Blue Urban

Design process

An area of pavement was selected in a wide area of the pedestrian precinct, between two gullies and two tree pits and designed so as not to interfere with the tree pits or the curved decorative block paving. With the gully being so close it was relatively easy to link the rain gardens into the existing drains and it was also known that the pavement was designed to shed surface water to the rain garden's location.

The edging kerbs laid with 20mm gaps between them allow surface water to enter the rain garden but prevent most litter and other detritus entering the rain garden.

Information adapted from Groundwork Greater Manchester.

Before

Credit: Groundwork Greater Manchester

After

Credit: Groundwork Greater Manchester

Stockport Interchange

New public transport interchange with SuDS and public rooftop park.

Location

Stockport Interchange, Swaine Street, Stockport, SK3 0GJ

Timeframe

Design Period: Sept 2021 – Aug 2022

Park construction start: 1st March 2023

Completion date: 15th March 2024

Scheme description

The Stockport Interchange project comprises the delivery of a modern, multi-modal transport Interchange in conjunction with significant supporting residential development and associated infrastructure comprising the provision of a green space park above the Interchange with a 'blue roof'; a bridge link to the existing rail station; enhanced pedestrian and cycling routes along the Mersey frontage including the provision of a cycle ramp to connect with the park; and a new bridge across the River Mersey to facilitate bus movements in the town centre.

The attenuation was spread over a flat concrete podium deck. The development will manage the 100-year storm event with an additional 40% added to peak flows for climate change. The attenuation at the podium level is not to exceed discharge rate of 10.2l/s.

SuDS features

The blue roof has been designed using the Polypipe Permavoid blue roof system which collects, attenuates and discharges water within an 85mm blue roof layer. Runoff falling on the Podium Park will percolate through the pervious surfacing (both hard and soft landscaping) until it is within the Permavoid blue roof attenuation layer. Due to the number of movement joints, the system works as 8 independent blue roofs all sized to manage the design storm at the given flow rates. Each individual roof discharges vertically, via one outlet, to an underslung pipe system that will ultimately take the runoff to the River Mersey.

The development size is approximately 1ha (10,000 m^2).

People involved

Client: Transport for Greater Manchester

Designer: Environmental Protection Group (EPG) & Renaissance

Contractor: Willmott Dixon

Design process

For the blue roof, reuse and outfall to watercourse was established as the most sustainable outfall option.

Costs

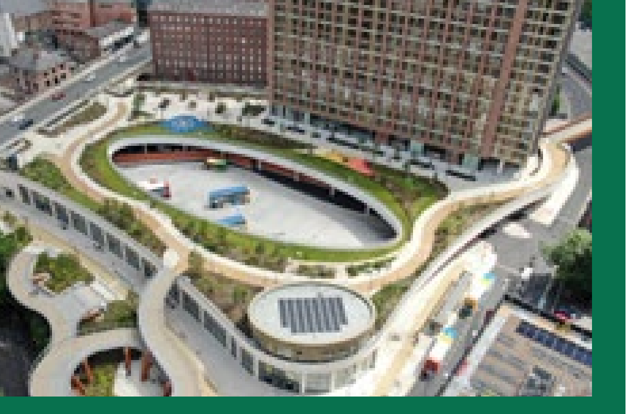
Total cost £6m

Evaluation

The SuDS system effectively treats the pollution contained within the runoff. Heavy metals, hydrocarbons and suspended soils are treated within the system. As the system is shallow and close to the surface, it is easy to maintain. If it clogs with silt localised ponding of water occurs on the surface to warn the owners of the site that maintenance is required. A regular maintenance regime will reduce the risk of blockage. The proposed surface water drainage system combines conventional drainage principles and components with the proprietary collection and attenuation systems.

Before

After



After

Credit: United Utilities

After

Credit: United Utilities

Information adapted from Transport for Greater Manchester

Stourton bus Park & Ride

A new bus park and ride facility integrating SuDS and landscaping.

Location

Stourton, Leeds, LS10 1FF

Timeframe

Scheme delivered between 2019 and September 2021.

Scheme description

Stourton Park and Ride is the UK's first solar bus park and ride facility.

The project demonstrated effective multidisciplinary coordination to manage complex interfaces between drainage attenuation, tree pits, solar canopy foundations, and utilities servicing the site. Such coordination maximised tree retention and enabled an earlier woodland planting phase, further enhancing local biodiversity and reducing the carbon footprint.

SuDS features

- Rain gardens
- SuDS-enabled tree pits
- Permeable surfaces
- Green roof

To mitigate flood risk and the impact on the existing drainage infrastructure, the full car park area incorporates permeable paving with integrated attenuation. SuDS-enabled tree pits were installed to increase tree canopy.

Material selection is both durable and sustainable, contributing to the project's overall lifespan and environmental footprint.

A comprehensive green strategy, involving a 54:1 tree replacement ratio, green corridors, and woodland reinstatement, has led to the addition of over 11,000 trees and 9,000 shrubs.

People involved

Delivery partners:

- Leeds City Council
- BAM Nuttall
- NPS Leeds
- West Yorkshire Combined Authority

Design process

Adverse weather conditions throughout two winters challenged delivery when bulk earthworks were at their most extensive. In response to the site's needs, soil modification was specified by the design team to improve the quality of the affected material the Contractor. Likewise, a granular drainage blanket was designed to manage rising ground water following initial earthworks. Despite these challenges the delivery team successfully met the opening date of September 2021.

Design rationalisation was undertaken on the outline design to integrate SuDS and remove a large storage tank, maximise the number of parking spaces, ensure new landscaping exceeded expectations, and achieve a cut fill balance to minimise the export of material.

Costs

Total scheme cost: £38.5m

Evaluation

Stourton Park and Ride Project received the Centenary Award Certificate of Excellence at the ICE Yorkshire and Humberside Awards 2022. It is the UK's first fully solar P&R facility. Rather than just being a car park, the whole scheme was designed with sustainability in mind.

Before

Credit: Mott Macdonald

Credit: Mott Macdonald

Credit: Mott Macdonald

Information adapted from West Yorkshire Combined Authority

4.2 SuDS features maintenance activities

This section sets out suggested maintenance activities for each SuDS feature.

Guidance notes

- Where possible, these should be incorporated into existing maintenance programmes.
- Only applicable tasks should be carried out.
- During the first few weeks following installation, more intense maintenance may be required, especially during establishment period for vegetation.
- The recommended maintenance activities may be reduced over time based on feedback from site observations, and that it's likely the recommended activities will only be required for heavily trafficked areas with high expected sediment loads.

Rain garden

Schedule	Action	Suggested Frequency
Regular Inspections	Inspect infiltration surfaces for silting and ponding, record de-watering time of the facility and assess standing water levels in underdrain (if appropriate)	Quarterly
	Check operation of underdrains by inspection of flows after rain	Annually
	Assess plants for disease infection, poor growth, etc. and replace as necessary	Quarterly
	Inspect inlets and outlets for blockage	Quarterly
Occasional maintenance	Infill any holes or scour in the mulch layer, improve erosion protection if required	As required
	Repair accumulations of silt by raking away surface mulch, scarifying surface of medium and replacing mulch	As required
	Check scour protection for any misalignments	As required
Remedial actions	Remove and replace mulch, growing medium and vegetation above	As required
	Repair any defects in pipe networks	As required
	Replace any malfunctioning parts or structures of trapped gullies	As required
	Replace any malfunctioning parts or structures of the check dam	As required

Schedule	Action	Suggested Frequency
Regular maintenance	Remove litter and surface debris and weeds	Quarterly
	Cut back and replace any plants, to maintain planting density, including: • December maintenance to remove dead and untidy plant material • February maintenance, to remove almost all remaining grass and seed heads/stems, although some species are not cut back. All cut material is removed off-site	Annually
	Weed removal (spot treatment and hand weeding)	Six times per year (monthly April to October inclusive) during Years 1 to 3
	Watering plants (herbaceous, grasses and shrubs)	Twice year 1; once year 2; additional watering during dry periods subject to client approval
	Watering semi-mature trees (50 litres per tree, per visit)	• Year 1: Fortnightly (Year 1) from beginning of April to end of September. • Year 2: monthly from April to September (5 visits) • Year 3: regular visual inspections with watering as advised.
	Remove sediment, litter, and debris build-up from around inlets	Quarterly to bi-annually
	Inspect pipework and clear blockages	Annually or after severe storms
	Inspect chambers and clear blockages	Annually or after severe storms
	Inspect trapped gully structure and remove any debris/litter	Annually or after severe storms
	Inspect check dam structure (if present) including weir and remove any debris	Annually or after severe storms

Detention basin

Schedule	Action	Suggested Frequency
Regular Inspections	Remove litter and debris	Monthly
	Cut grass – for spillways and access routes	Monthly (during growing season), or as required
	Cut grass – meadow grass in and around basin	Half yearly (spring – before nesting season, and autumn). Cutting may be annual (autumn only) if biodiversity or inclusion of ornamental plants is a priority.
	Manage other vegetation and remove nuisance plants including: • December maintenance to remove dead and untidy plant material • February maintenance, to remove almost all remaining grass and seed heads/stems, although some species (e.g. Carex secta) are not cut back. All cut material is removed off-site	As required
	Weed removal (spot treatment and hand weeding), including aquatic weeds	Quarterly
	Inspect inlets, outlets, and overflows for blockages, and clear if required	Monthly
	Inspect banksides, structures, pipework etc. for evidence of physical damage	Monthly
	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Monthly (for first year), then annually or as required
	Check any penstock and other mechanical devices	Annually
	Tidy all dead growth before start of growing season	Annually
	Remove sediments from inlets, outlet and forebay	Annually (or as required)
	Manage wetland plants in outlet pool – where provided	Annually
	Entire basin to be checked to make sure no liner is visible	Annually
	Inspect pipe work and clear blockages in all system	Annually or after severe storms

Schedule	Action	Suggested Frequency
Regular Inspections	Inspect structure and remove excessive silt build up in flow chamber	Annually or after severe storms
	Flow chamber - Inspect flow control, ensure operating freely and emergency drain down inlet and weir operating correctly	Annually or after severe storms
Occasional maintenance	Reseed areas of poor vegetation growth	As required
	Prune and trim any trees and remove cuttings	Every 2 years, or as required
	Remove sediments from inlets, outlets, forebay and main basin when required	Every 5 years, or as required (likely to be minimal requirements where effective upstream source control is provided)
	Check gabion for stability, corrosion of wiring and if basket replacement is needed	Every 2 years, or as required
Remedial actions	Repair erosion or other damage by returfing or reseeding	As required
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required
	Realignment and replacement if required of erosion control	As required
	Repair/rehabilitation of inlets, outlets, and overflows	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Repair any defects in pipe network	As required
	Replace malfunctioning parts or structures in flow chamber	Annually or after storms
Remedial actions	Inspect for evidence of poor operation in flow control chamber	Every 6 months
	Inspect sediment accumulation rates in flow control chamber and establish appropriate removal frequencies	Every 6 months
	In the flow chamber – test control structure to ensure operating as per original design	Every 5 years

Conveyance swale

Schedule	Action	Suggested Frequency
Regular maintenance	Remove litter and debris	Monthly, or as required
	Cut grass or wildflower/grass mixes – to retain grass height within specified design range	Monthly (during growing season), or as required. When cutting wildflower/grass mixes for biodiversity, annual cuts during later summer/early autumn many be required
	Manage other vegetation and remove nuisance plants including: • December maintenance to remove dead and untidy plant material • February maintenance, to remove almost all remaining grass and seed heads/stems, although some species (e.g., Carex secta) are not cut back. All cut material is removed off-site	As required
	Weed removal (spot treatment and hand weeding)	Six times per year (monthly April to October inclusive) during Years 1 to 3
	Watering plants	Twice year 1; once year 2; additional watering during dry periods subject to client approval
	Inspect inlets, outlets, and overflows for blockages, and clear if required	Quarterly
	Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for > 48 hours	Quarterly, or when required
	Inspect vegetation coverage	Monthly for 6 months, quarterly for 2 years, then half yearly
	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Half yearly
	Remove litter and debris	Monthly, or as required
	Inspect pipework and clear blockages	Annually or after severe storms
	Inspect manholes and clear blockages	Annually or after severe storms
	Inspect chute gully structure and remove any litter/debris	Annually or after severe storms
	Inspect headwall structure and remove any debris/litter on structure	Annually or after severe storms

Schedule	Action	Suggested Frequency
Occasional maintenance	Reseed areas of poor vegetation growth, alter plant types to better suit conditions, if required	As required or if bare soil is exposed
	Repair erosion or other damage by returfing or reseeding	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required
	Remove build-up of sediment on scour protection or at top of filter strip	As required
	Remove and dispose of oils or petrol residues using safe standing practices	As required
	Repair any defects in pipe network	As required
	Replace malfunctioning parts or structures in chute gully	As required
	Check scour protection for any misalignments	As required
	Replace malfunction parts or structure of headwall	As required

SuDS-enabled tree pit

Schedule	Action	Suggested Frequency
Regular inspections	Inspect filtration surfaces for silting and ponding, record de-watering time of the facility and assess standing water levels in underdrain to determine if maintenance is necessary	Quarterly
	Check operation of underdrains by inspection of inspection chamber/overflow pipe	Annually
	Assess tree for disease infection, poor growth, invasive species etc.	Quarterly
	Inspect inlets and outlets for blockage	Quarterly
Regular maintenance	Remove litter and debris	Monthly (or as required)
	Remove sediment, litter and debris build up from around inlets or from forebays	Quarterly to biannually
	Manage other vegetation and remove nuisance plants (do not use weedkiller)	Monthly (at start, then as required)
Occasional maintenance	Check tree health and manage tree appropriately	Annually
	Remove silt build-up from inlets and surface and replace mulch as necessary	Annually, or as required
	Water	As required (in periods of drought)
	Jetting of the perforated pipe	Annually, or as required
	Inspection of overflow pipe	Annually, or as required
Remedial actions	The trees should also be inspected post extreme heavy rainfall events (100-year event) or following storms which include high wind speeds. The inspection should include The trees should also be inspected post extreme heavy rainfall events (100-year event) or following storms which include high wind speeds. The inspection should include checking that the tree is not physically damaged, checking inlet and outlets and that there has been limited or no soil erosion.	As required

Permeable paving

Schedule	Action	Suggested Frequency
Regular maintenance	Brushing and suction cleaner (standard cosmetic sweep over whole surface) or lightweight rotating brush cleaners combined with power spraying using hot water. Care should be taken in adjusting vacuuming equipment to avoid removal of jointing material.	Once year, after autumn leaf fall, or reduced frequency as required, based on site specific observations of clogging or manufacturers recommendations
	Inspect pipe work and clear all blockages	Annually or after severe storms
	Inspect chambers and clear blockages	Annually or after severe storms
	Inspect the chute gullies for any debris or litter and remove	Annually or after severe storm
Occasional maintenance	Stabilise and mow contributing and adjacent areas	As required
	Removal of weeds or management using nature-friendly weed killer applied directly into the weeds by an applicator rather than spraying	As required – once per year on less frequently used pavements
Remedial actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50mm of the level of the pavement	As required
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and replace lost jointing material	As required
	Rehabilitation of surface and upper substrate by remedial sweeping	Every 10 years to 15 years or as required (if infiltration performance is reduced)
	Repair any defects in pipe network	As required
	Replace any malfunctioning parts or structures in the chute gullies	As required
Monitoring	Initial inspection	Monthly for three months after installation
	Inspect for evidence of poor operation and/or weed growth	Every 3 months, 48hr after large storms in first six months
	Inspect silt accumulation rates and establish appropriate brushing frequencies	Annually
	Monitor inspections	Annually

4.3 Resource library

Legislation and regulations

- Highways Act 1980
- Planning and Compulsory Purchase Act 2004
- Traffic Management Act 2004
- Flood and Water Management Act 2010
- Town and Country Planning Regulations 2012
- Traffic Signs Regulations and General Directions 2016
- Levelling-up and Regeneration Act 2023
- National Planning Policy Framework 2023
- Biodiversity Net Gain 2024
- Equality Act 2020

SuDS technical guidance

CIRIA (2015) SuDS Manual

Best practice guidance on the planning, design, construction, operation, and maintenance of SuDS.

CIRIA (2017) Guidance on the Construction of SuDS

Best practice guidance on the construction of SuDS to ensure effective delivery.

Bray et al. (2012) Rain Garden guide

Highlights benefits, design, construction, and maintenance of rain gardens. Information on planting schemes for rain gardens.

British Water (2017) How to Guide to Sustainable Drainage Products and Services

Guidance for engineering and construction professionals on applying the CIRIA SuDS Manual.

Defra (2015) Sustainable Drainage Systems: Non-statutory Technical Standards

Non-statutory technical standards for the design, maintenance, and operation of SuDS to drain surface water in England.

Design and Construction of Concrete Block Permeable Pavements (2018)

A guide for planners, urban designers, engineers, local authorities and other decision makers to assist them in the design, construction, approval and maintenance of Concrete Block Permeable Paving (CBPP) on developments.

ICE & ACO (2018) SuDS route maps CE & ACO Guide to Effective Surface Water Management

Outlines the processes and stages involved in SuDS delivery and provides useful links to resources on the design, delivery, adoption, and maintenance of SuDS.

Local Authority SuDS Officers Organisation (2015) Non-statutory SuDS Standards Practice Guidance

Guidance on meeting the (English) non-statutory SuDS standards.

South East Lead Local Flood Authorities (2013)

Guides what needs to be considered when designing SuDS at the initial and concept design stage of a masterplan.

Trees in Hard Landscapes a Guide for Delivery (2014)

Explores the practical challenges and solutions to integrating trees in 21st century streets, civic spaces and surface car parks, detailing process, design and technical options. Of particular interest to highway engineers, public realm professionals and tree specialists.

Tree Pits with Structural Soils Practice Note

An introduction to growing urban trees in structural soils.

Urban Design London (2018) Designing Rain Gardens: A Practical Guide

Practical guide to designing and installing rain gardens in an urban environment.

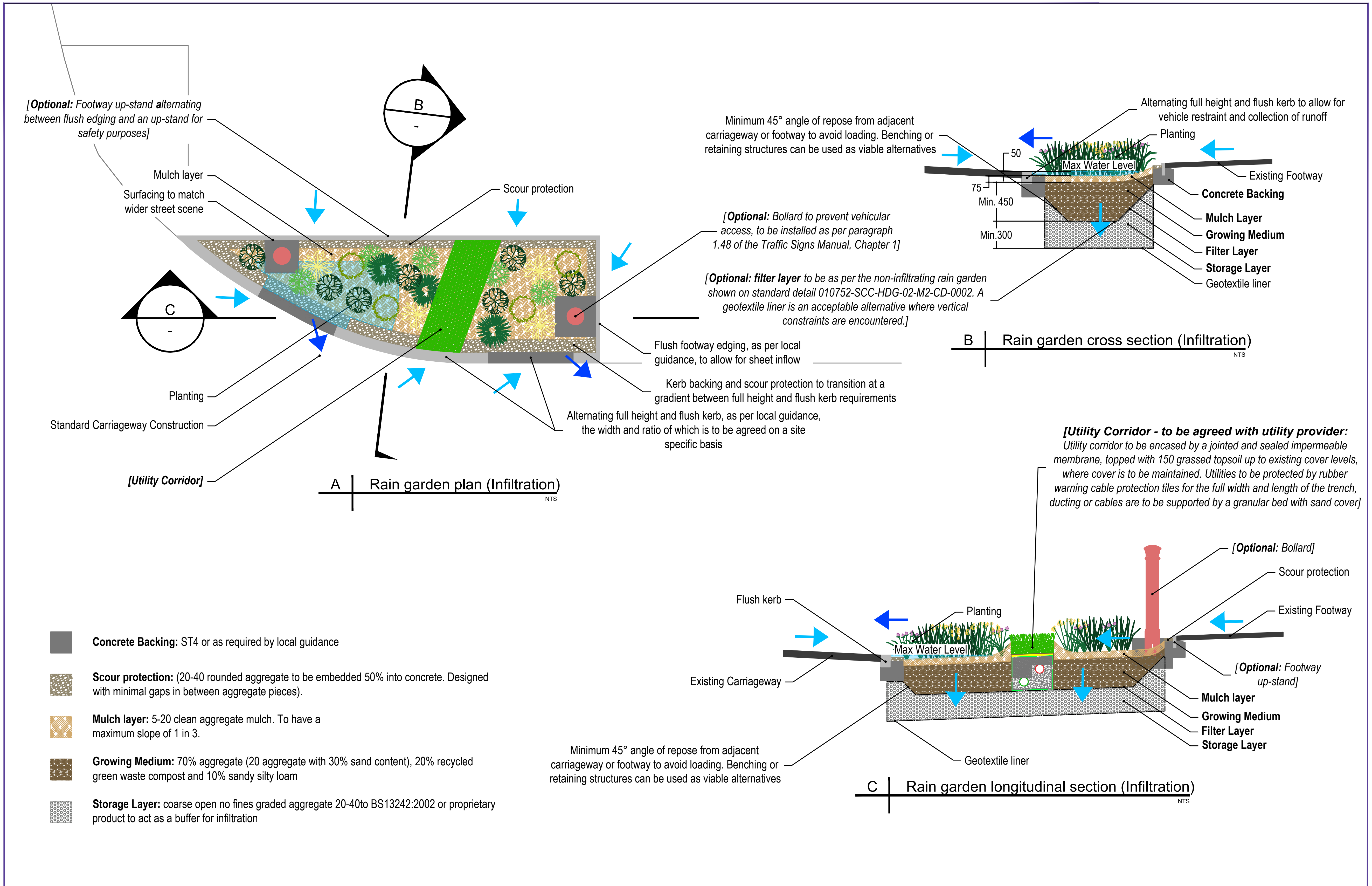
Appendix

Appendix content list

Appendix 1	SuDS features technical drawings
Appendix 2	SuDS in urban spaces technical drawings
Appendix 3	List of figures
Appendix 4	Glossary

Appendix 1: SuDS features technical drawings

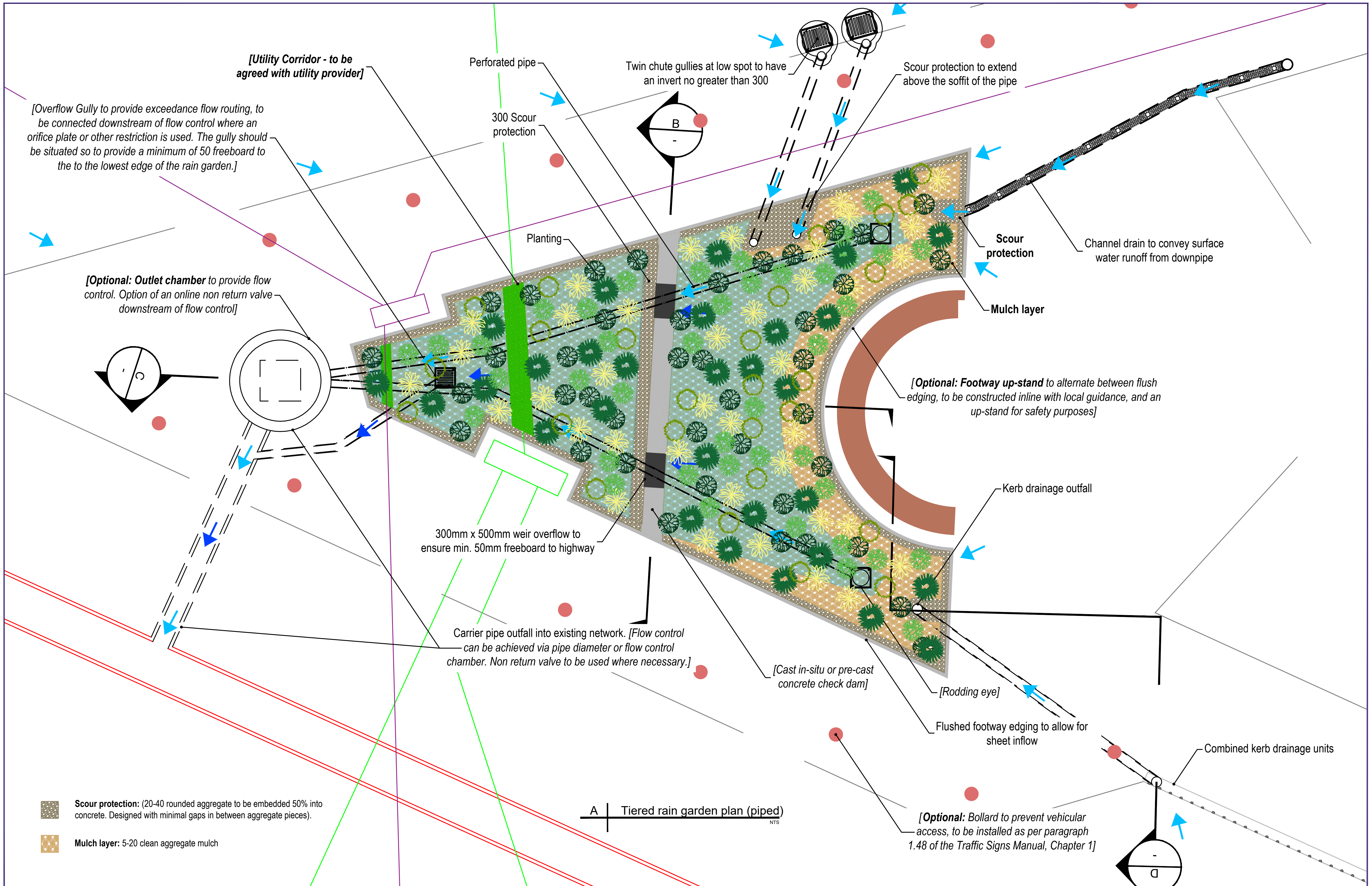
Rain garden (infiltrating)



Drawn By	Drawing	Scale	Drawing Reference	Notes
Salford City Council	Rain Garden Plan (Infiltration)	NTS	010752-SCC-HDG-01-M2-CD-0001	1. All dimensions in millimetres and all levels in metres unless shown otherwise.
Project	Sheet 1 of 1	**Date**		2. Do not scale from this drawing. use only printed dimensions.
Standard Details		22/05/2024		3. This drawing should be read in conjunction with the 'Greater Manchester Sustainable Drainage Design Guide for Streets', with component specific design considerations included in section 3.2.

GREATER MANCHESTER
Transport for Greater Manchester

Rain garden (non-infiltrating) 1 of 2



Drawn By	Drawing	Scale	Drawing Reference
Salford City Council	Rain Garden Plan (Non-infiltrating)	NTS	010752-SCC-HDG-01-M2-CD-0001
Project	Sheet 1 of 2	**Date**	
Standard Details		22/05/2024	

Notes

1. All dimensions in millimetres and all levels in metres unless shown otherwise.
2. Do not scale from this drawing. use only printed dimensions.
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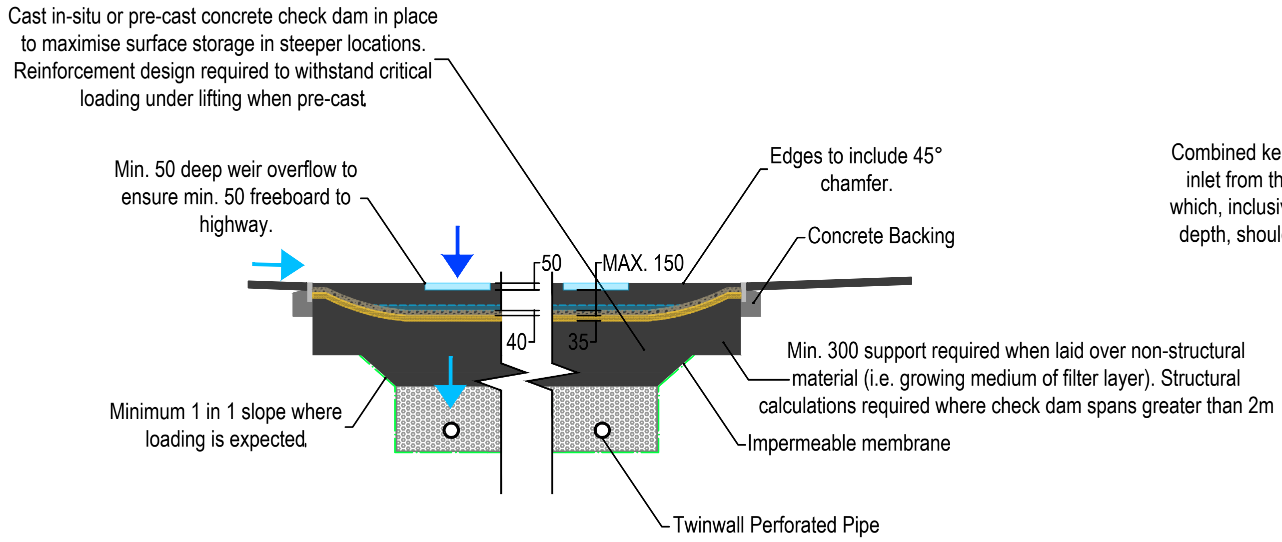
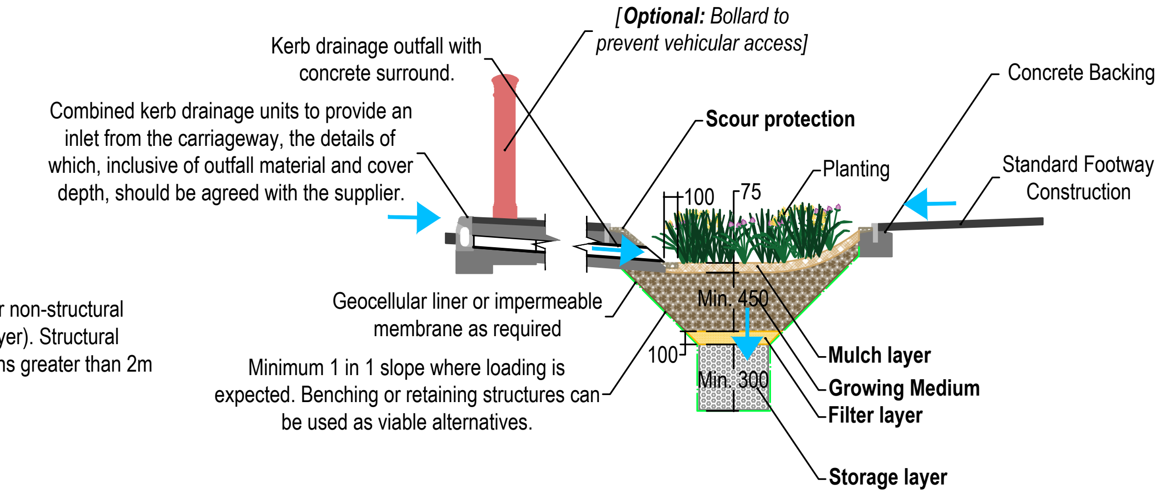
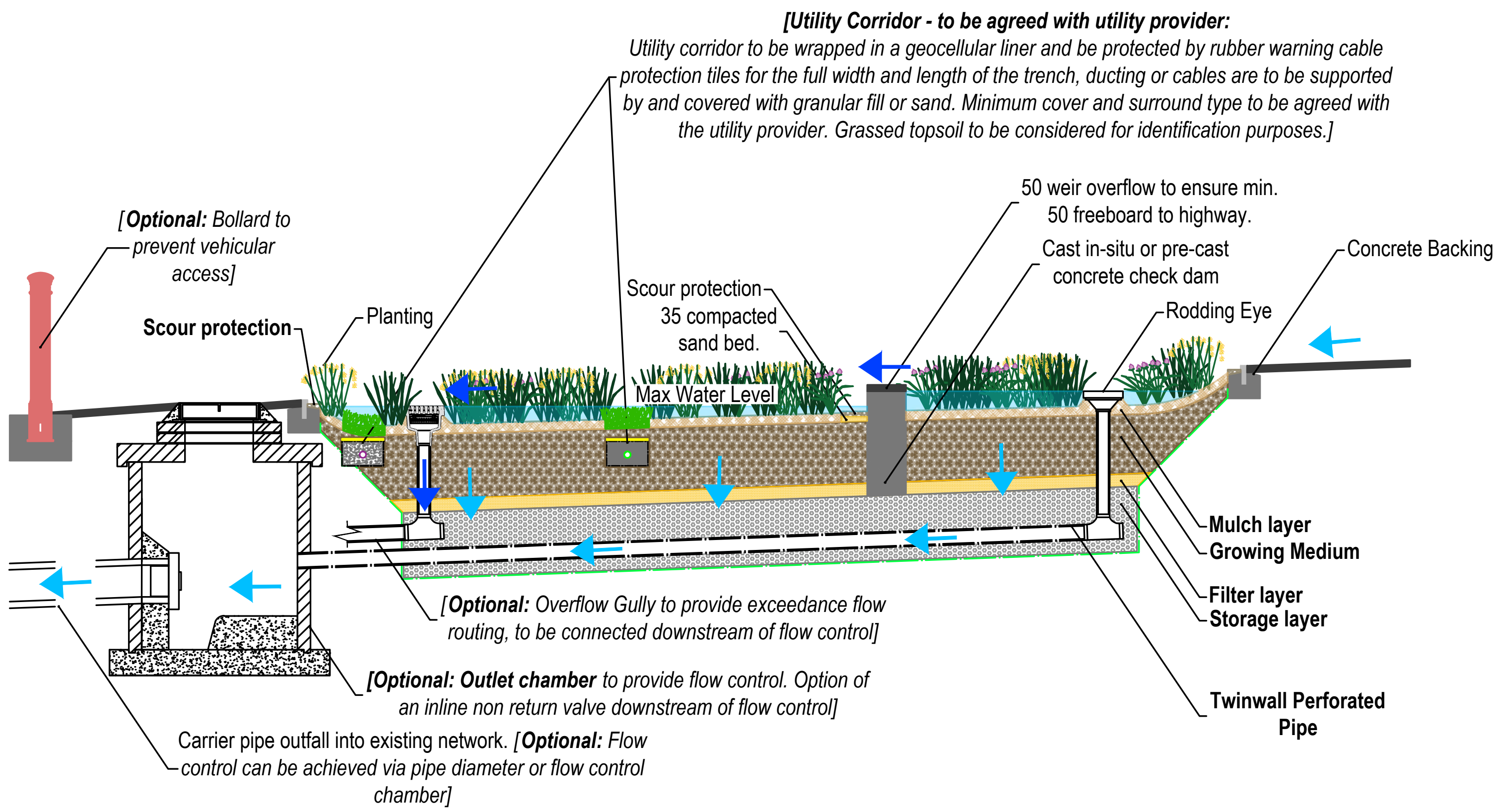
Rain garden (non-infiltrating) 2 of 2



B | Check dam cross section
NTS



D | Tiered rain garden cross section (piped)
NTS



C | Tiered rain garden longitudinal section (piped)
NTS

Concrete Backing: ST4 or as required by local guidance

Scour protection: (20-40 rounded aggregate to be embedded 50% into concrete. Designed with minimal gaps in between aggregate pieces).

Mulch layer: 5-20 clean aggregate mulch. To have a maximum slope of 1 in 3.

Growing Medium: 70% aggregate (20mm aggregate with 30% sand content), 20% recycled green waste compost and 10% sandy silty loam

Storage Layer: coarse open no fines graded aggregate 20-40 to BS13242:2002 or proprietary product to act as a buffer for infiltration

Drawn By	Drawing	Scale	Drawing Reference
Salford City Council	Rain Garden Plan (Non-infiltrating)	NTS	010752-SCC-HDG-02-M2-CD-0002
Project	Sheet 2 of 2	**Date**	
Standard Details		22/05/2024	

Notes
1. All dimensions in millimetres and all levels in metres unless shown otherwise.
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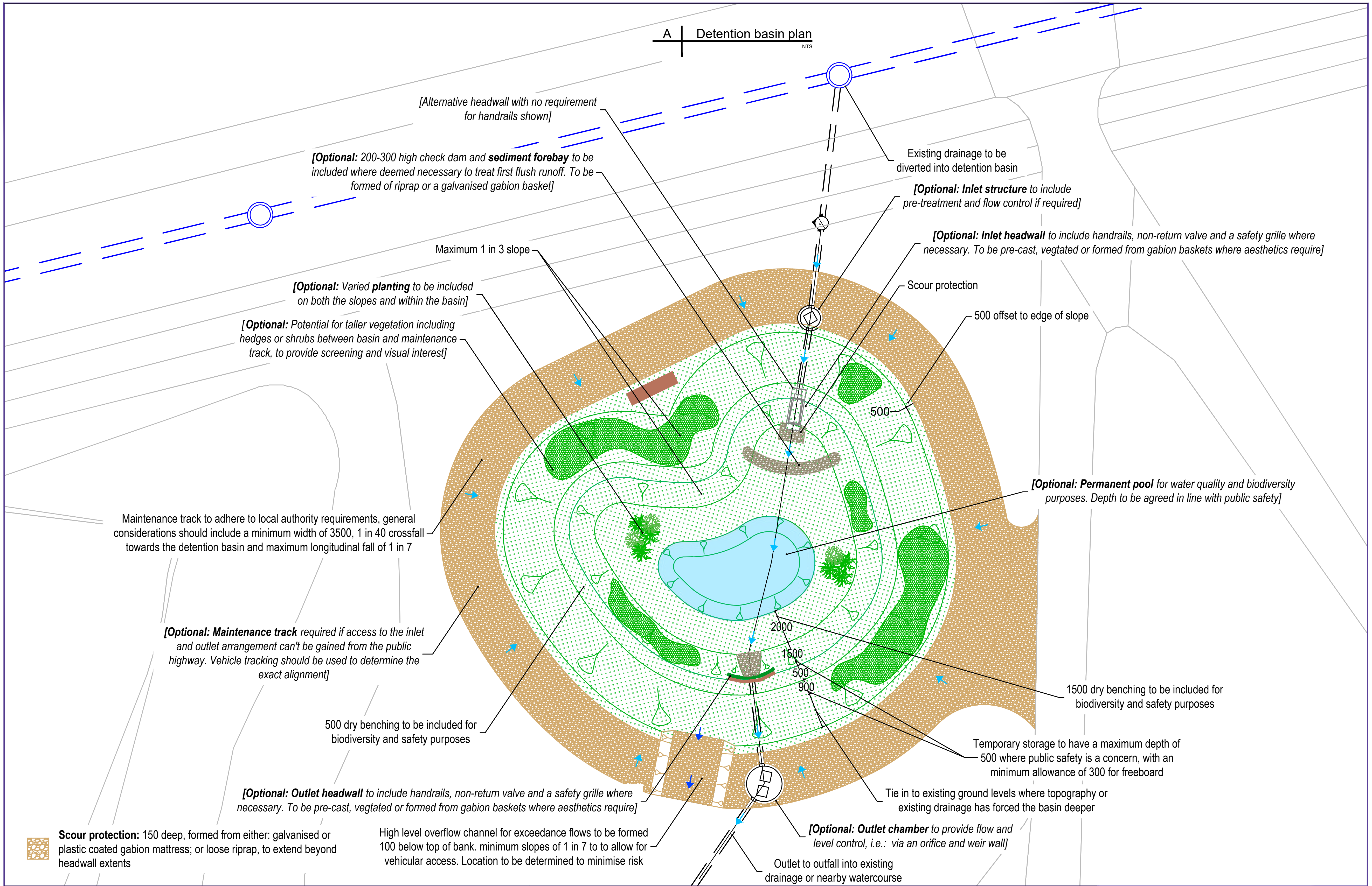
Detention basin 1 of 2



Drawn By	Drawing	Scale	Drawing Reference
Salford City Council	Detention Basin	NTS	010752-SCC-HDG-03-M2-CD-0001
Project	Plan	**Date**	
Standard Details	Sheet 1 of 2	22/05/2024	

Notes

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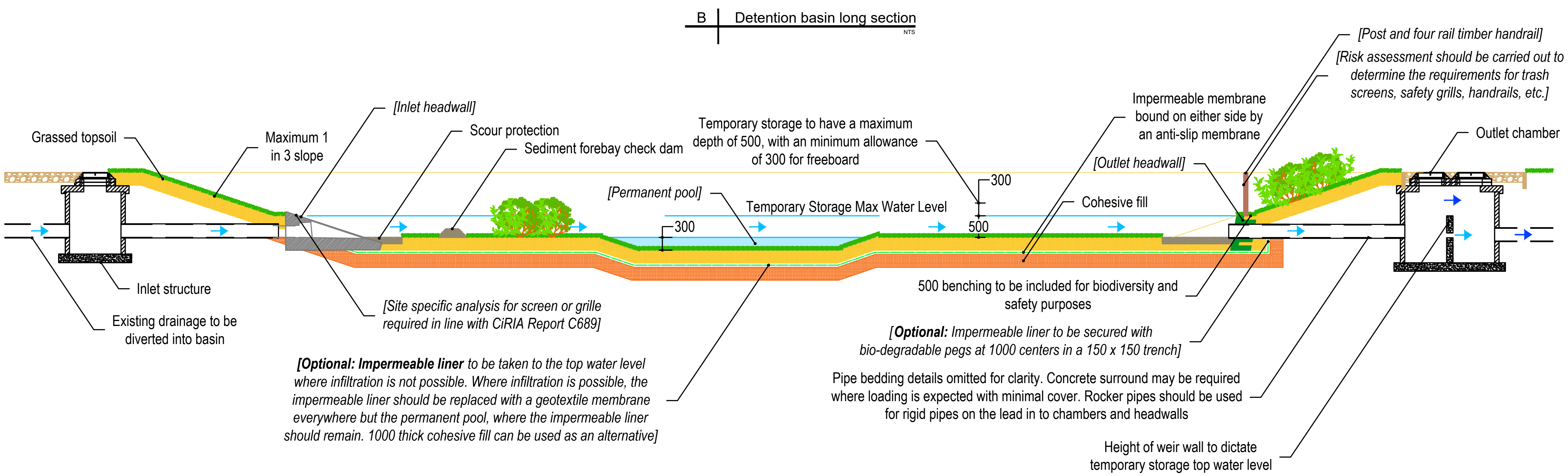
Detention basin 2 of 2



Scour protection: 150 deep, formed from either: galvanised or plastic coated gabion mattress; or loose riprap, to extend beyond headwall extents

Cohesive Fill: 300 cohesive fill to protect liner

Grassed topsoil: 300 sand / low nutrient soil mix

Drawn By Salford City Council **Project** Standard Details	**Drawing** Detention Basin Long Section Sheet 2 of 2	**Scale** NTS **Date** 22/05/2024	**Drawing Reference** 010752-SCC-HDG-03-M2-CD-0002

Notes
1. All dimensions in millimetres and all levels in metres unless shown otherwise.
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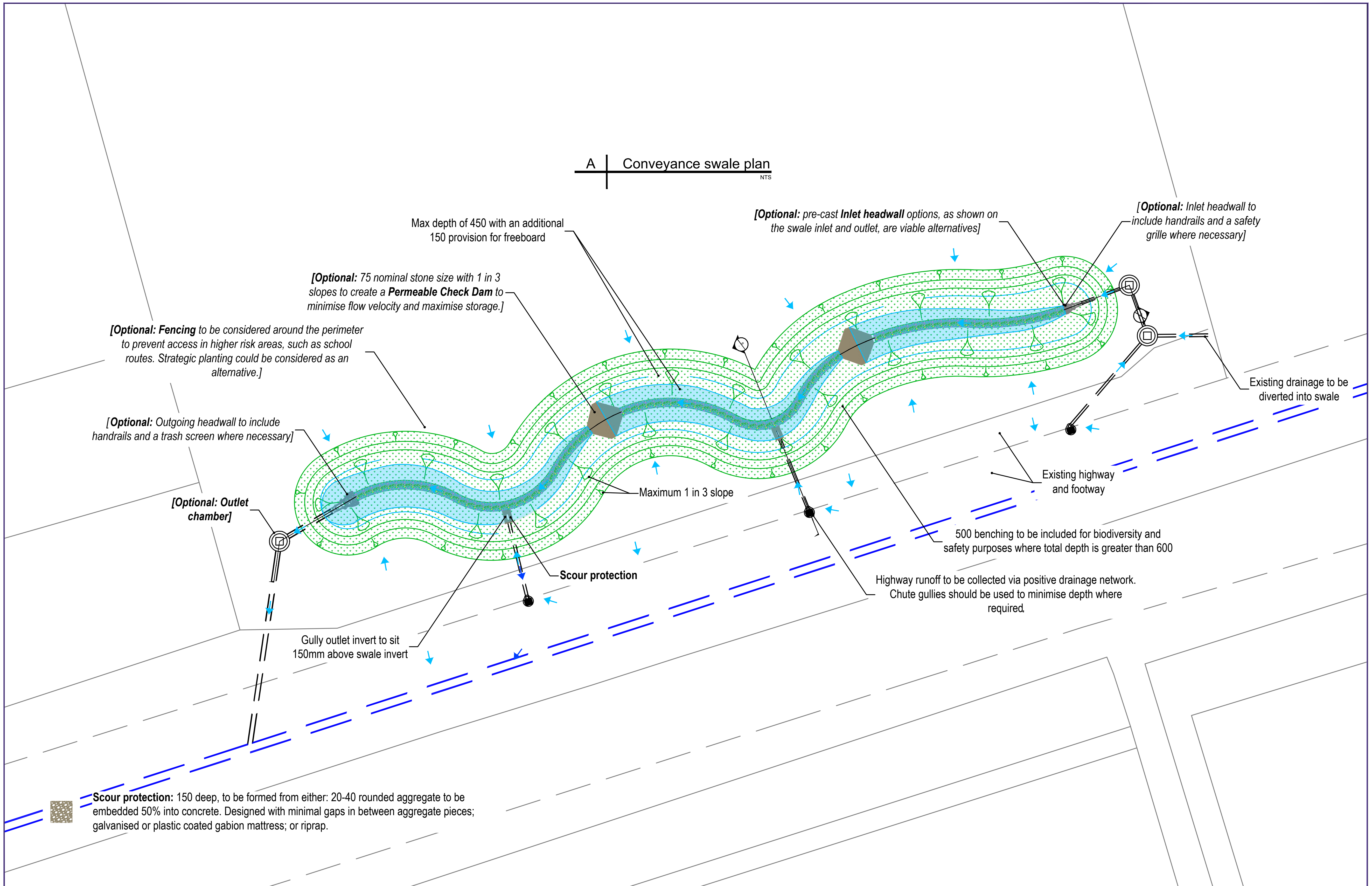
Conveyance swale 1 of 2



Drawn By	**Drawing**	**Scale**	**Drawing Reference**
Salford City Council	Swale	NTS	010752-SCC-HDG-04-M2-CD-0001
Project	Plan	**Date**	
Standard Details	Sheet 1 of 2	22/05/2024	

Notes

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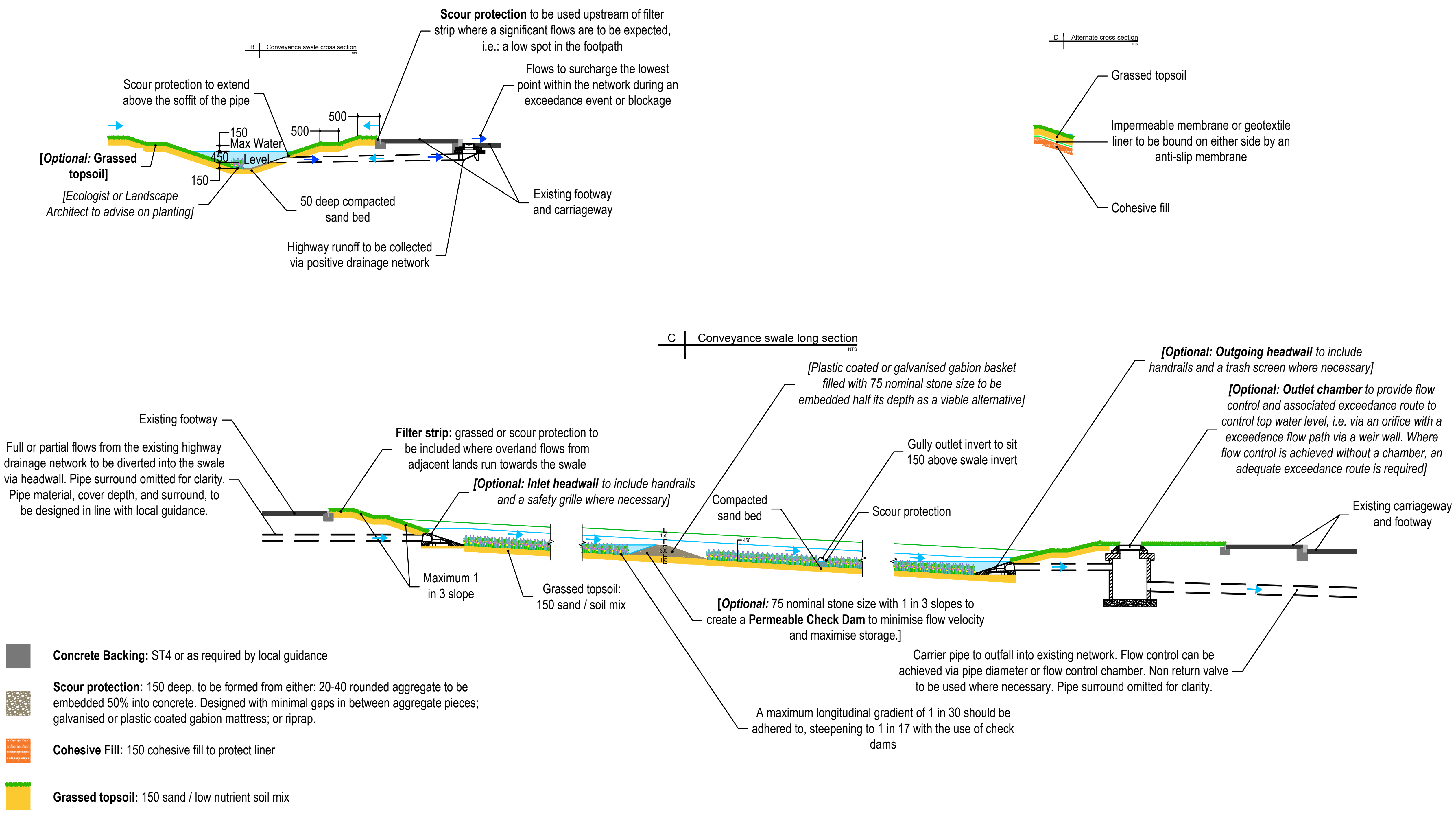
Conveyance swale 2 of 2



Drawn By	Drawing	Scale	Drawing Reference
Salford City Council	Swales	NTS	010752-SCC-HDG-04-M2-CD-0002
Project	Sections	**Date**	
Standard Details	Sheet 2 of 2	22/05/2024	

Notes
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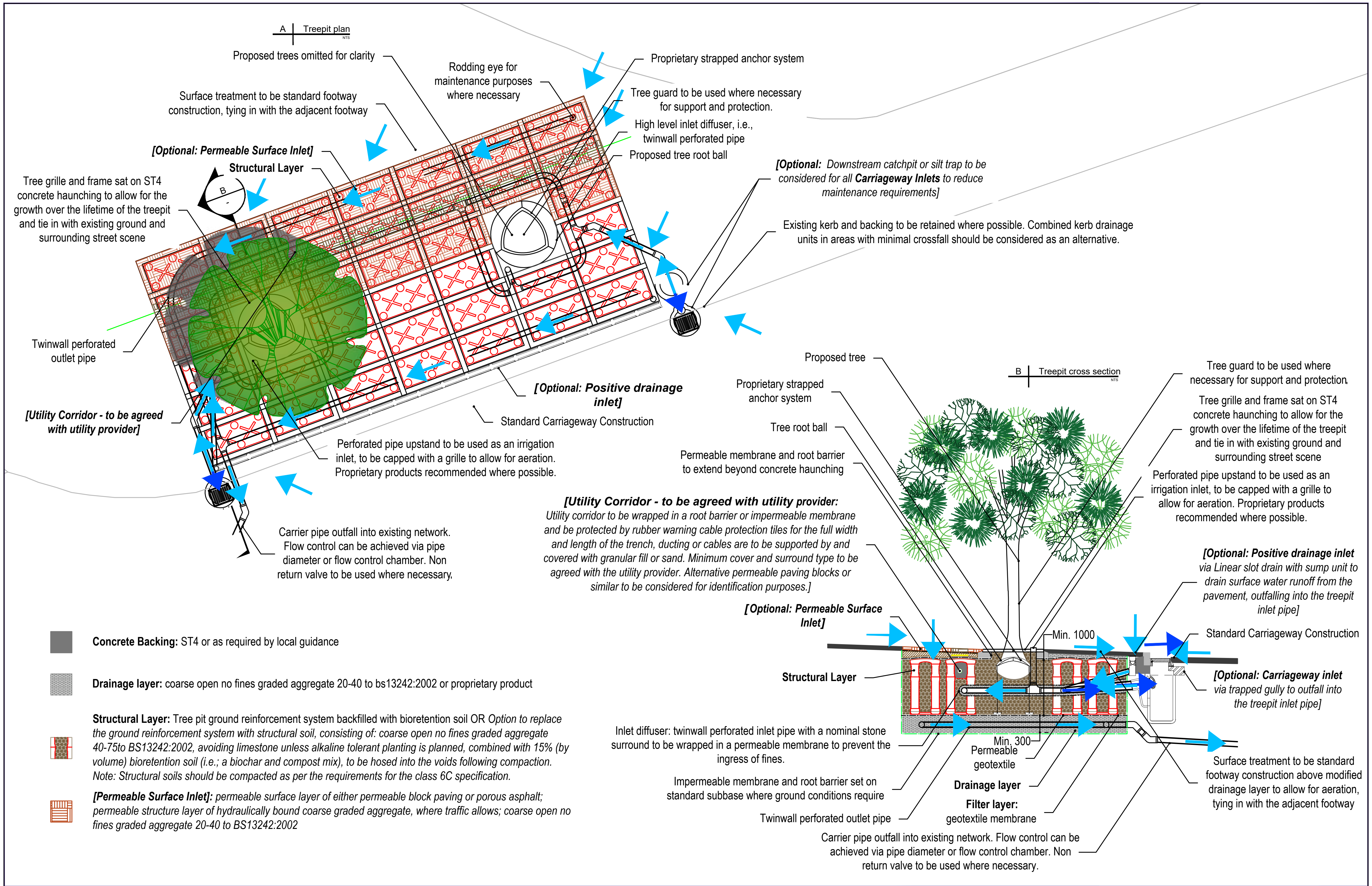
Suds-enabled tree pit



Drawn By	**Drawing**	**Scale**	**Drawing Reference**	**Notes**
Salford City Council	Treepit	NTS	010752-SCC-HDG-05-M2-CD-0001	1. All dimensions in millimetres and all levels in metres unless shown otherwise.
Project		**Date**		2. Do not scale from this drawing. use only printed dimensions.
Standard Details	Sheet 1 of 1	22/05/2024		3. This drawing should be read in conjunction with the 'Greater Manchester Sustainable Drainage Design Guide for Streets', with component specific design considerations included in section 3.2.

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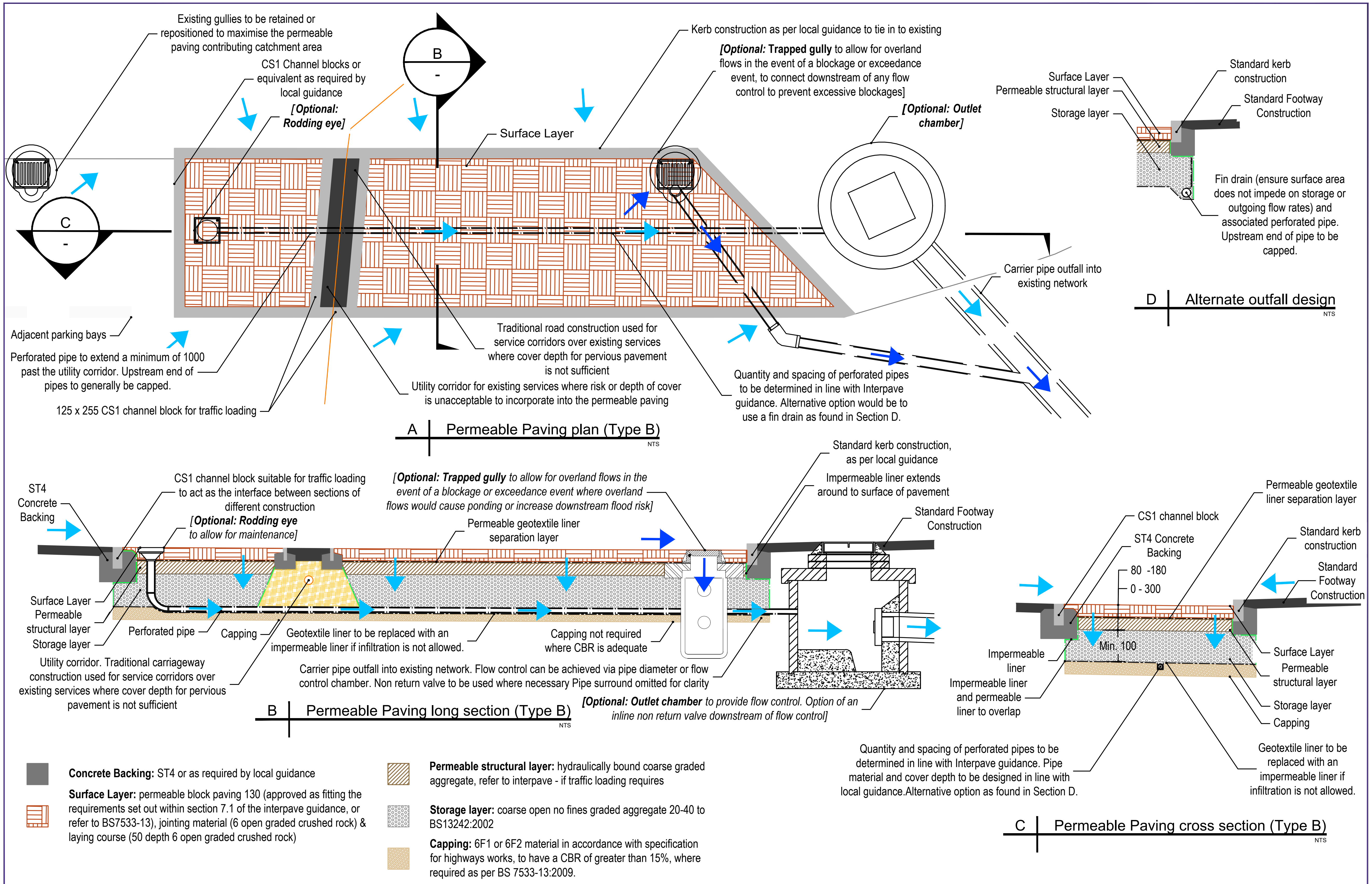
Permeable paving



Drawn By	Drawing	Scale	Drawing Reference
Salford City Council	Permeable Paving	NTS	010752-SCC-HDG-06-M2-CD-0001
Project	Sheet 1 of 1	**Date**	
Standard Details		22/05/2024	

Notes
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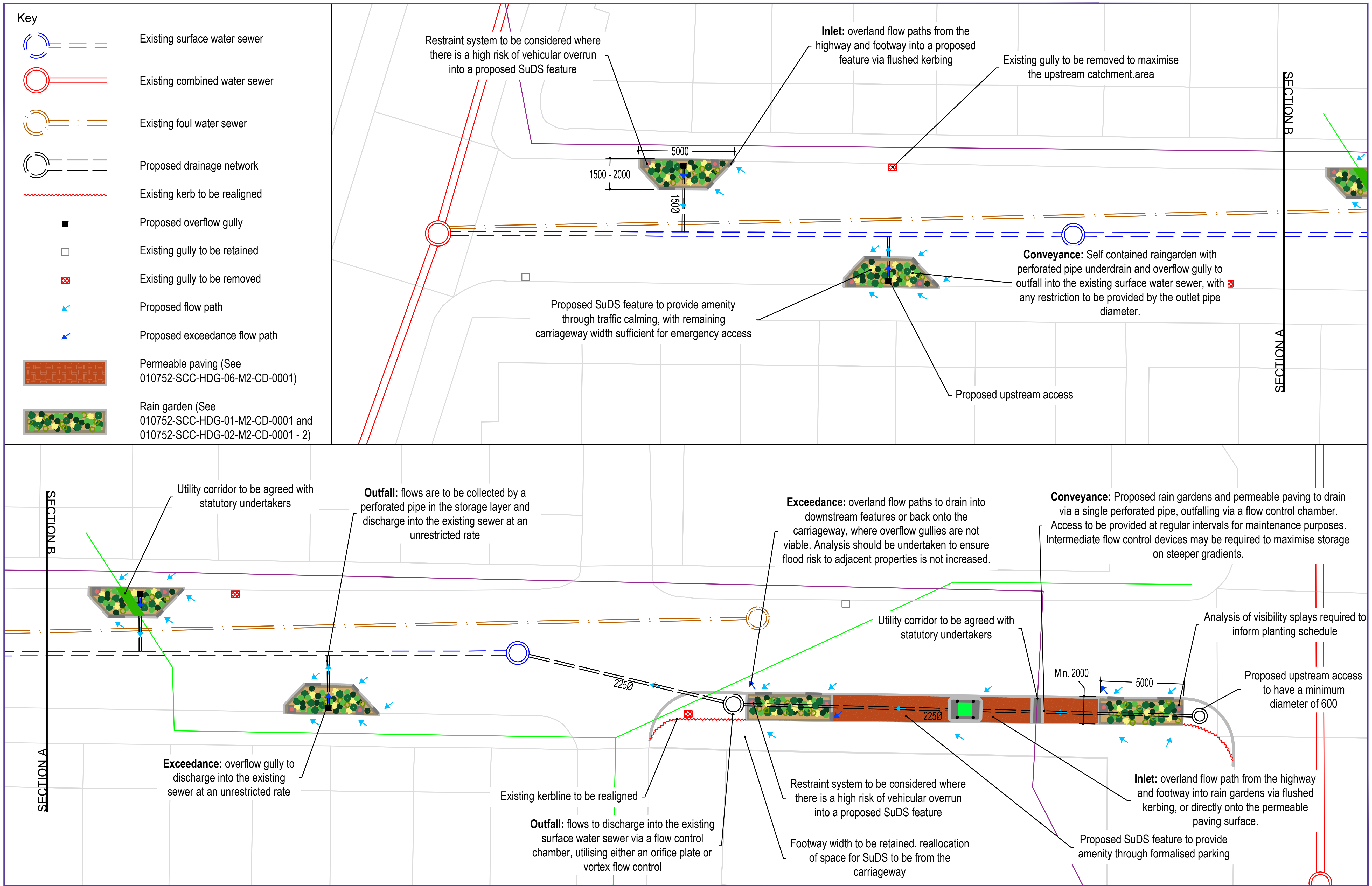
Appendix 2: SuDS in urban spaces technical drawings

Neighbourhoods (Terrace Street)



Drawn By	Drawing	Scale	Drawing Reference
Salford City Council	Neighbourhoods (Terrace Street)	NTS	010752-SCC-HDG-07-M2-CD-0001
Project	Sheet 1 of 1	**Date**	
Standard Details		07/10/2024	

Notes

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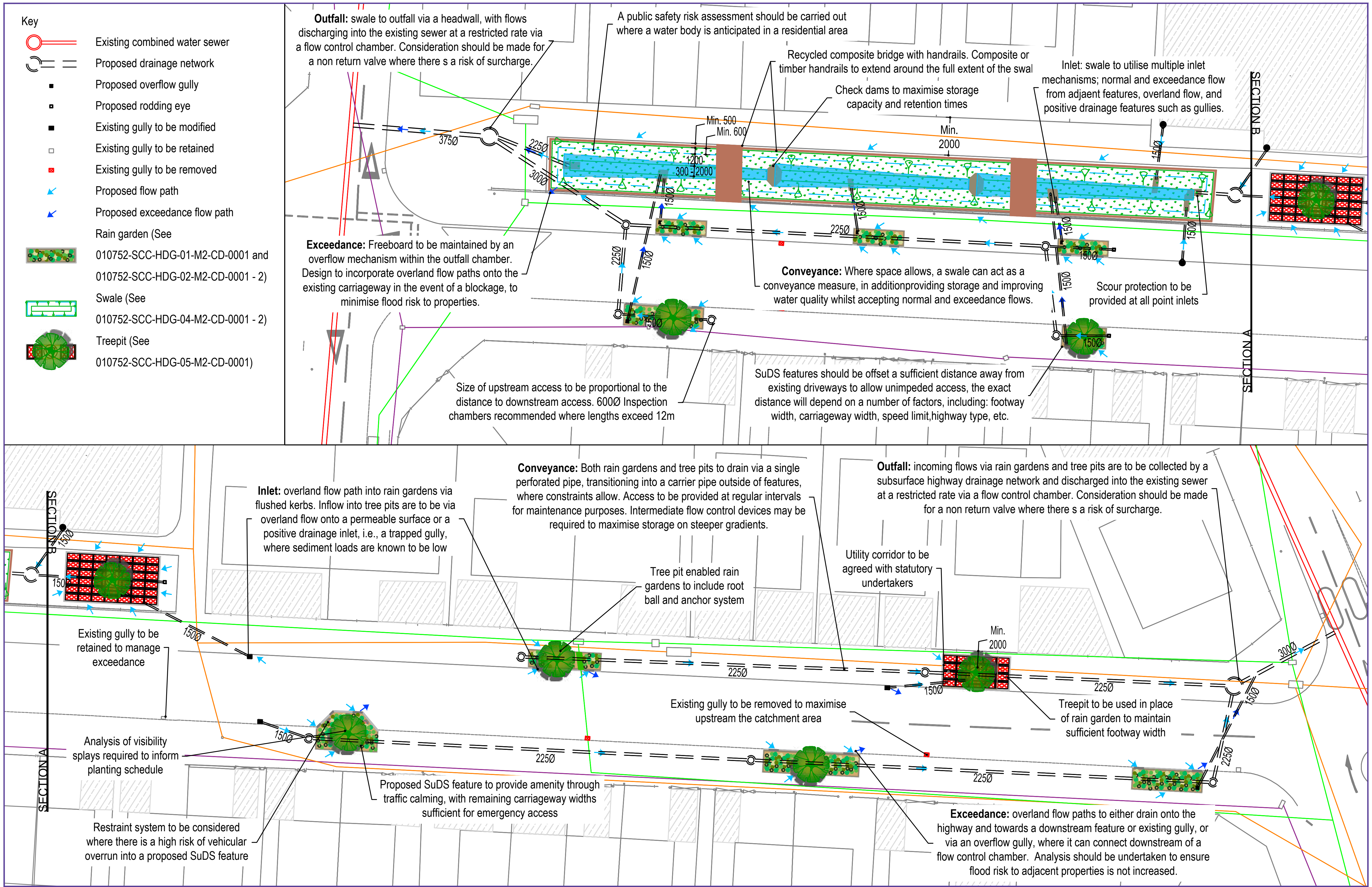
Neighbourhoods (Outer suburbs)



Drawn By Salford City Council **Project** Standard Details	**Drawing** Neighbourhoods (Outer Suburbs) Sheet 1 of 1	**Scale** NTS **Date** 07/10/2024	**Drawing Reference** 010752-SCC-HDG-08-M2-CD-0001

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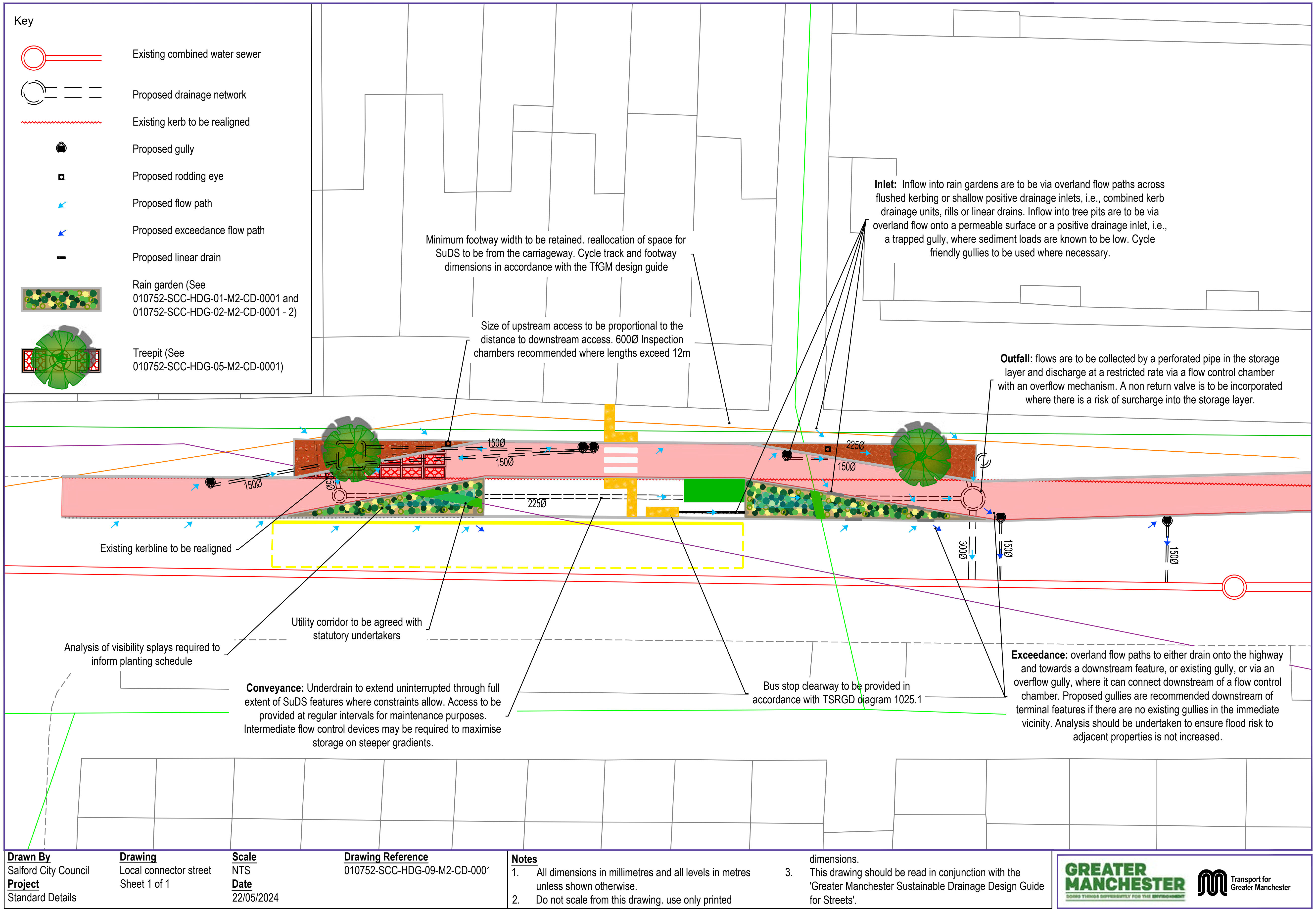
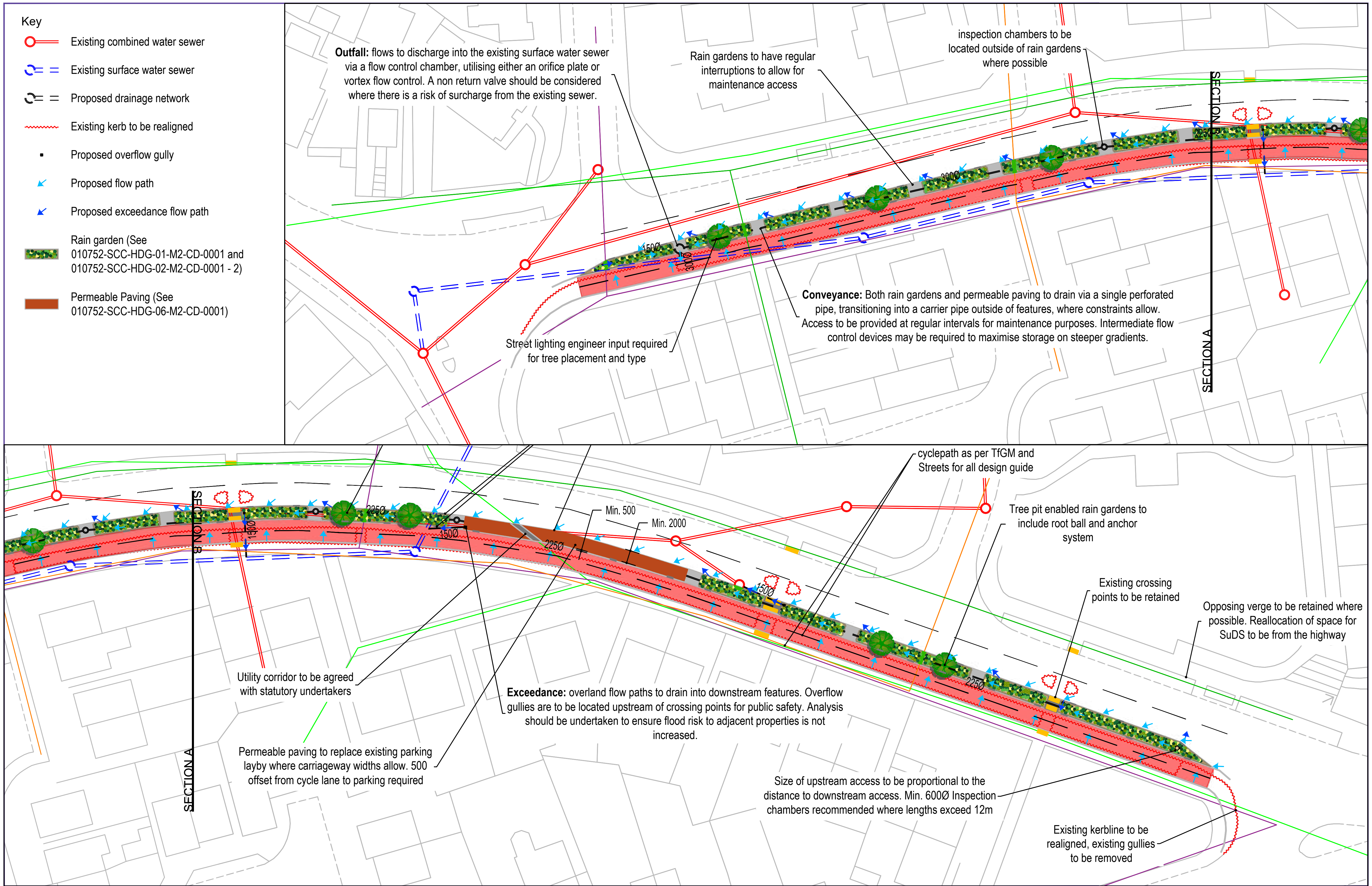
Local Connector Street



Connector Street



Drawn By	**Drawing**	**Scale**	**Drawing Reference**
Salford City Council	Connector Street	NTS	010752-SCC-HDG-10-M2-CD-0001
Project	Sheet 1 of 1	**Date**	
Standard Details		07/10/2024	

Notes

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Public Square

Drawn By	Drawing	Scale	Drawing Reference
Salford City Council	Public Square	NTS	010752-SCC-HDG-11-M2-CD-0001
Project	Sheet 1 of 1	**Date**	
Standard Details		07/10/2024	

Notes
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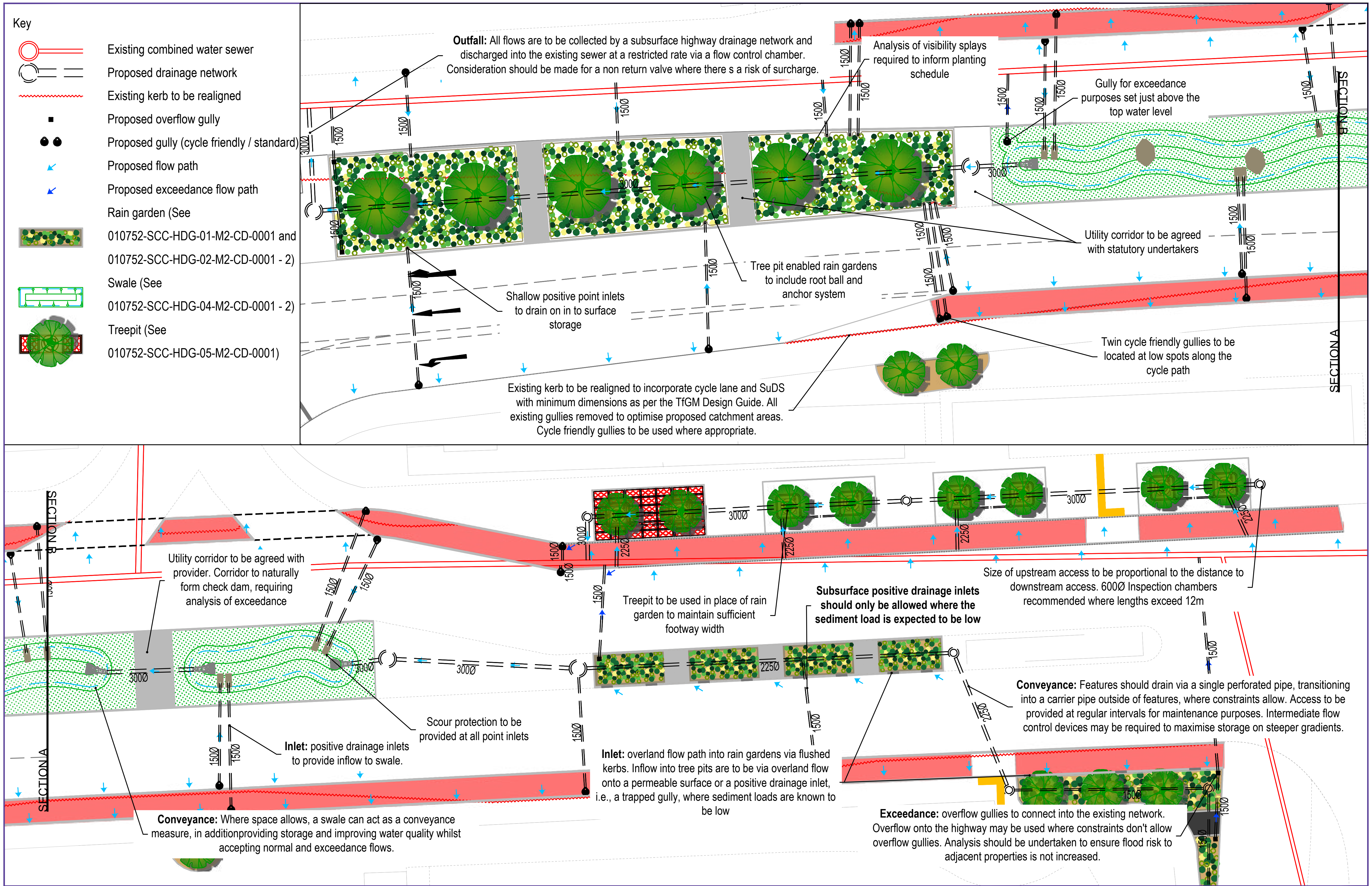
Multi-lane Connector Street



Drawn By
Salford City Council
Project
Standard Details

Drawing
Multi-lane connector street
Sheet 1 of 1

Scale
NTS
Date
07/10/2024

Drawing Reference
010752-SCC-HDG-01-M2-CD-0001

Notes
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Off-street Car Park

Drawn By	Drawing	Scale	Drawing Reference
Salford City Council	Off-street car park	NTS	010752-SCC-HDG-13-M2-CD-0001
Project	Sheet 1 of 1	**Date**	
Standard Details		07/10/2024	

Notes

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3. This drawing should be read in conjunction with the 'Greater Manchester Sustainable Drainage Design Guide for Streets'.

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Appendix 3: List of figures

Appendix 4: Definitions glossary

Adapted from the Flood Hub's glossary

Term	Definition
A	
Attenuation	Reduction of peak flow and increased duration of a flow event.
Attenuation Storage	Volume used to store runoff during rainfall events, comes into use once the inflow is greater than the controlled outflow. Storing runoff during the peak flow and releasing it at a controlled rate during and after the peak flow has passed.
B	
Basin	A ground depression acting as a flow control or water treatment structure that is normally dry and has a proper outfall but is designed to detain storm water temporarily.
Biodiversity	The diversity of plant and animal life in a particular habitat.
Bioretention Area	Depressed landscaping area that is allowed to collect runoff and percolate it through the soil below the area into an under-drain, thereby promoting pollutant removal.
C	
Catchment	Area contributing surface water runoff flow to a point on a drainage or river system. Can be divided into sub-catchments.
Component	Term used to identify different items or assets that come together to form a SuDS feature.
Control Structure	Structure to control the volume or rate of flow of water through or over it.
Conveyance	Movement of water from one location to another.
D	
Design Criteria	A set of standards agreed by the developer, planner, and regulator that the proposed development should satisfy.
Detention Basin	A vegetated depression that is normally dry except following storm events. It is constructed to store water temporarily to attenuate flows and may allow for infiltration into the ground.
Detention Pond or Tank	A pond or tank that has a lower outflow than inflow. Often used to prevent flooding by providing temporary storage volume.
Discharge	Rate of flow of water.
E	
Ecology	All living things, such as trees, flowering plants, insects, birds, mammals and the habitats in which they live.
Exceedance	The point at which the quantity of water from rainfall or snow melt is of a greater volume than the drainage system is designed to take. Therefore, exceedance events are rare occurrences of extreme weather.
F	
Filter Drain	A linear drain consisting of a trench filled with a permeable material, often with a perforated pipe in the base of the trench to assist drainage.
Filter Strip	A vegetated area of gently sloping ground designed to drain water evenly off impermeable areas and to filter out silt and other particulates.
Filtration	The act of removing sediment or other particles from a fluid by passing it through a filter.
Flood Frequency	The probability of a flow rate being exceeded in any year.
Flood Storage	The temporary storage of excess runoff or river flow in ponds, basins, reservoirs or on the floodplain during a flood event.
Flow Control Device	A device used for the control of surface water from an attenuation facility for example a weir.
Freeboard	Distance between the design water level and the top of a structure, provided as a precautionary safety measure against early system failure.
G	
Geocellular Structure	A plastic box structure used in the ground, often to attenuate runoff.
Green Roof	A roof with plants growing on its surface, which contributes to local biodiversity. The vegetated surface provides a degree of retention, attenuation, and treatment of rainwater, and promotes evapotranspiration.

Greenfield Runoff	The runoff that would occur from the site in its undeveloped and undisturbed state. Greenfield runoff characteristics are described by peak flow and volumes of runoff for rainfall events of specified duration and return period (frequency of occurrence).
Gully	Opening in the road pavement, usually covered by metal grates, which allows surface water runoff to enter conventional drainage systems.
H	
Habitat	The area or environment where an organism of ecological community normally lives or occurs.
Highways Agency	Government agency responsible for strategic highways in England, i.e. motorways and trunk roads.
Highway Authority	A local authority with responsibility for the maintenance and drainage of highways, maintainable at public expense.
Highway Drain	A conduit draining the highway, maintainable at the public expense and vested in the Highway Authority.
I	
Impermeable	A linear drain consisting of a trench filled with a permeable material, often with a perforated pipe in the base of the trench to assist drainage.
Inclusive design	Produces goods, services, or facilities designed to be usable by as many people as possible, taking in account all forms of human diversity, e.g. regardless of age, ability, socio-economic circumstances, without the need for additional measures or interventions. See also Universal accessibility.
Infiltration Basin	A dry basin designed to promote infiltration of surface water to the ground.
Infiltration Trench	A trench, usually filled with permeable granular material, designed to promote infiltration of surface water to the ground.
M	
Management Train	A method of managing surface water drainage in as natural a process as possible. Looking at the quantity and quality of runoff as it is conveyed from the point of precipitation to the final receiving water body.
N	
Non-return valve	A pipe fitting that limits flow to one direction only.
Nutrient	A substance providing nourishment for living organisms such as nitrogen and phosphorus.

O	
Offline	Dry weather flow bypasses the storage area.
Online	Dry weather flow passes through the storage area.
Orifice Control	Structure with a fixed aperture to control the flow of water.
P	
Pedestrian	References to pedestrians include people using mobility aids such as wheelchairs and rollators; powered wheelchairs; mobility scooters designed for use on the footway, and people with physical, sensory or cognitive impairments who are travelling on foot. Definition sourced from DfT Inclusive Mobility (2021).
Percolation	The passing of water (or other liquid) through a porous substance or small holes (e.g., soil or geotextile fabric).
Permeability	A measure of the ease with which a fluid can flow through a porous medium. It depends on the physical properties of the medium, for example grain size, porosity, and pore shape.
Permeable paving	A permeable surface that is paved and drains through voids between solid parts of the pavement.
Permeable Surface	A surface that is formed of material that is itself impervious to water but, by virtue of voids formed through the surface, allows infiltration of water to the sub-base through the pattern of voids, for example concrete block paving.
Pervious Surface	A surface that allows inflow of rainwater into the underlying construction or soil.
Pond	Permanently wet depression designed to retain storm water and permit settlement of suspended solids and biological removal of pollutants.
Porosity	The percentage of the bulk volume of a material is occupied by voids, whether isolated or connected.
Porous Surface	A surface that infiltrates water to the sub-base across the entire surface of the material forming the surface, for example grass and gravel surfaces, porous concrete, and porous asphalt.
Porous Paving	A permeable surface allowing the passage of water through voids within, rather than between, the paving blocks/slabs.
Proper Outfall	An outfall to a watercourse, public sewer and in some instances, an adopted highway drain. Under current legislation and case law, having a proper outfall is a prerequisite in defining a sewer.

Public Sewer	A sewer that is vested in and maintained by a sewerage undertaker.
R	
Rain Garden	A planted area providing storm water attenuation and infiltration.
Rainwater Harvesting	Capture and storage of rainwater which is then used in households and businesses for day-to-day activities. These can vary between tanked systems which provide water for flushing toilets and water butts for watering plants in the garden. The reuse of rainwater reduces the demand on clean water supplies.
Regional Control	Management of runoff from a site or several sites, typically in a balancing pond or wetland.
Retention Pond	A pond featuring a permanent body of water where runoff is detained for a sufficient time to allow settlement and biological treatment of some pollutants.
Rill	Open surface water channels with hard edges.
Runoff	Water flow (including flow from snow and other precipitation) over the ground surface which has not entered the drainage system. This occurs if the ground is impermeable, is saturated or rainfall is particularly intense.
S	
Sewer	A pipe or channel taking domestic foul and or surface water from buildings and associated paths and hardstanding from two or more curtilages and having a proper outfall.
Sewerage Undertaker	This is a collective term relating to the statutory undertaking of water companies that are responsible for sewerage and sewage disposal including surface water from roofs and yards of premises.
Site Control	Management of water in a local area or site (i.e., routing water from building roofs and car parks to a large soakaway, infiltration, or detention basin).
Soakaway	A sub-surface structure into which surface water is conveyed, designed to promote infiltration.
Source Control	The control of runoff at or near its source.
SuDS feature	A type of SuD.
SuDS Management Train	The management of runoff in stages as it drains from a site.
Surface Water	Water that collects above ground after falling as precipitation.
Surface Water Sewer	Drainage system designed to convey precipitation from property.
Sustainable Drainage Systems	Concept of surface water drainage which considers the quantity and quality of runoff, and in the case of green SuDS, amenity value of surface water in the urban environment. The focus is on source control and the mimicking of natural processes.
Swale	A shallow vegetated channel designed to conduct and retain water but may also permit infiltration. The vegetation filters particulate matter.
T	
Treatment Stage	A sustainable drainage component that protects or improves surface runoff by reducing suspended sediments or contaminants.
U	
Universal Accessibility	Universally accessible streets and places are where the design of the environment is usable by all people, to the greatest extent possible, without the need for adaptation or specialised design. Particularly focussed on accessibility requirements of disabled people. See also Inclusive design.
W	
Watercourse	A term including all rivers, streams, ditches, drains, cuts, culverts, dykes, sluices, and passages through which water flows.
Weir	A device to control the flow of water.
Wetland	A pond that has a high proportion of emergent vegetation in relation to open water.

GMCA GREATER MANCHESTER COMBINED AUTHORITY

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NATURAL COURSE OUR WATER, OUR FUTURE

North West Regional Flood & Coastal Committee

United Utilities