Designing green and blue infrastructure for active travel networks

October 2025. Issue 1.1

Walk Wheel Cycle Trust

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Technical review

ARUP

Cover image
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Issue	Purpose	By	Checked	Authorised	Date
A	Internal draft for comment	JR	CE & SS	-	28.03.24
B	External draft for comment	JR	CE & ZT	-	01.07.24
C	Final draft for comment	JR	ZT	-	02.05.25
1.0	Issue	-	-	WH	04.06.25
1.1	Minor update for UK release & re-brand	JR	JS	CE	24.10.25

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www.walkwheelcycletrust.org.uk

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1 Introduction

1.1 Why has this guidance been written?

Walking, wheeling and cycling networks are - by their very nature - green; helping people to reduce their personal carbon footprint through facilitating active travel. However, they have the potential to tackle many more of the challenges that the climate emergency presents if they include green and blue infrastructure.

The redesign of our streets presents a fantastic opportunity to promote biodiversity, sustainably manage surface water, reduce the effect of urban heat islands and much more. This guidance has been written to outline why and how, in the context of active travel, green and blue infrastructure should be incorporated.

The need for street-specific green and blue infrastructure design guidance was highlighted in a report by the Chartered Institution of Highways and Transportation. The report highlighted that lack of guidance was a vital factor in some local authorities not fully engaging in implementing green and blue infrastructure (CIHT, 2023).

1.2 Who is this guidance for?

This guidance is for anyone involved in advocating for, designing or delivering active travel infrastructure. Everyone from community groups to engineers, landscape architects and local authorities. Some sections contain detail that is more relevant to those involved in design and construction, but the majority of content is aimed at instilling a shared understanding and ambition for the design of green and blue infrastructure within the context of active travel.

Above: a roadside rain garden in Stobswell, Dundee
Image credit: Walk Wheel Cycle Trust

1.3 Some definitions

It is important to understand exactly what is meant by the terms green and blue infrastructure, and some associated terminology used throughout this guidance.

Blue infrastructure

A definition of blue infrastructure is provided in National Planning Framework 4, Scottish Government, p.145:

> "Water environment features within the natural and built environments that provide a range of ecosystem services. Blue features include rivers, lochs, wetlands, canals, other water courses, ponds, coastal and marine areas including beaches, porous paving, sustainable urban drainage systems and raingardens."

Carriageway

In a street, the carriageway refers to the space that is occupied by vehicles.

Climate emergency

The Oxford Dictionary defines the climate emergency as follows:

> "a situation in which urgent action is required to reduce or halt climate change and avoid potentially irreversible environmental damage resulting from it"

Footway

A footway is a route for pedestrians that runs alongside a carriageway. It differs from a footpath which is a route for pedestrians that is remote from the carriageway.

Green infrastructure

The European Commission, defines green infrastructure as follows:

> "A strategically planned network of natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services, while also enhancing biodiversity."

The ecosystem services referred to include: water purification, improving air quality, space for recreation, climate mitigation and adaptation.

Nature-based solutions

The essence of green and blue infrastructure is that they are nature-based solutions. According to the International Union for Conservation of Nature:

> "Nature-based solutions leverage nature and the power of healthy ecosystems to protect people, optimise infrastructure and safeguard a stable and biodiverse future."

Net zero

According to the United Nations:

> "Net zero means cutting carbon emissions to a small amount of residual emissions that can be absorbed and durably stored by nature and other carbon dioxide removal measures, leaving zero in the atmosphere."

Sustainable drainage systems (SuDS)

The management and use of rainwater close to where it falls, maximising the benefits that can be secured from surface water management. The main benefits are categorised as water quantity, water quality, amenity and biodiversity.

1.4 Structure of this document

Following this introductory section, the document comprises four distinct sections. Here is an outline of what is included in each of these:

Section 2: Why combine active travel with green and blue infrastructure?

The purpose of this section is to explain the reasons why combining active travel with green and blue infrastructure is a necessary and beneficial thing to do. From the climate emergency to government policy, and from efficiency in construction to the potential to create an active travel network that encourages and attracts more users.

Section 3: What green and blue elements can active travel infrastructure include?

In this section, a high-level overview is presented of the range of green and blue elements that active travel infrastructure can include. There is then guidance to help inform which of these elements should be included in any given scenario: from trees to rain gardens, how do you decide what to include?

Section 4: How do you include green and blue elements in active travel infrastructure?

This section gets into some of the detail of design and delivery, and how you implement green and blue elements in active travel infrastructure. How do plant trees alongside utilities? Is a rain garden always wet? Can surface water from the carriageway drain into a rain garden? These are the sort of questions that this section will explore.

Section 5: Case studies demonstrating best practice and further sources of information

The rate at which green and blue elements are being incorporated in active travel infrastructure is rapidly increasing. This section looks at several best practice examples, interviewing key members of the design teams involved to understand how they delivered successful infrastructure.

Section 6: Conclusions

In this concluding section, there is a summary of key takeaways from the preceding sections: focussing on what is most important to enable successful delivery.

Above: a roadside rain garden on Camley Street, London
Image credit: Walk Wheel Cycle Trust

2 Why combine green and blue infrastructure with active travel infrastructure?

2.1 Climate emergency

2.1.1 Why is there an emergency?

Considered as one of the biggest threats facing humankind, the Global Climate Emergency has been caused by the activities of mankind. Since the beginning of the Industrial Revolution, the concentration of greenhouse gases in the Earth's atmosphere - of which carbon dioxide CO_2 accounts for two-thirds - has been rising and this has resulted in rising global temperatures. An emergency has been declared because, if we don't act quickly, this damage could become irreversible.

Above: raging bush fires in Brisbane, Australia
Image credit: weatherzone.com.au

The burning of fossil fuels contributes to more than 75% of global greenhouse gas emissions and nearly 90% of carbon dioxide emissions. A major contributor to these emissions is the transportation sector, of which road vehicles account for the largest part (United Nations, no date).

2.1.2 What are the effects?

The burning of fossil fuels has led to a change in the composition of the Earth's atmosphere which has caused average global temperatures to rise between 1.3°C and 1.4°C (World Meteorological Organisation, 2025). Many of the resultant effects of this change are already being felt and will only continue to be exacerbated as temperatures continue to rise.

- Heightened regional and seasonal temperature extremes.
- Reduced snow cover and sea ice.
- Increasingly intense heavy rainfall.
- Significant impacts on habitats for plants and animals.

(Net Zero Scotland, 2023)

2.1.3 Is the UK already experiencing these effects?

Yes, definitely. An example was the 'Beast from the East' storm event that impacted the UK in February 2018, costing the nation an estimated £1 billion per day in disruption (Scottish Government, 2020). More recently, further changes in our climate have been documented:

- Summer 2025 was the United Kingdom's warmest on record (Met Office, 2025).
- October 2023 to March 2024 was the wettest United Kingdom winter on record (Royal Meteorological Society, 2025).

The expectation is that the UK will continue to experience hotter and drier summers, followed by milder and wetter winters, and an increased frequency of extreme weather events.

2.1.4 What is being done about it globally?

The short answer is: not enough:

- There is to be an expected **9% increase** in global greenhouse gas emissions by 2030.
- To keep global warming to no more than 1.5°C, what is needed is **45% decrease** in global greenhouse gas emissions by 2030.

(United Nations, 2023)

Greater, bolder steps need to be taken by those emitting greenhouse gases.

2.1.5 What is the UK doing about it?

The UK first set legally binding carbon targets to reach 'Net Zero' through the Climate Change Act 2008. Subsequently in 2019 the UK strengthened its position by declaring a Climate Emergency and accelerated targets to become Net Zero by 2050. In order to achieve this, the following actions are underway:

- Continued de-carbonisation of the electricity system, increasing renewable and nuclear sources.
- Increased adoption of nature-based solutions such as tree planting to absorb carbon and SuDS to reduce the local impacts of extreme rainfall.
- A National Adaptation Programme to better understand and plan for climate risks across key sectors.

Above: Scotland's sustainable transport hierarchy
Image credit: Transport Scotland

2.1.6 What is the role of active travel in our response to the climate emergency?

Domestic transport was responsible for 28% of emissions in 2022 (Department for Transport, 2024).

Across the UK, changing behaviours around how people travel and encouraging more trips by walking, wheeling and cycling is an important aspect in addressing this problem. At all levels of government, strategies are in place to adapt transport systems to climate change and enable people to make more sustainable choices.

This effort is closely associated with improving public health and reducing inequalities in travel choices, especially for those who do not have access to a car.

2.1.7 What is the role of green and blue infrastructure in our response to the climate emergency?

Nature-based solutions address socio-environmental challenges through the use of natural processes and systems. Blue and green infrastructure are examples of nature-based solutions that can help tackle many of the effects of the climate emergency.

- Trees can increase evapotranspiration and provide solar shading in urban areas. They also absorb CO_2 (greenhouse gas).
- Rain gardens, and other SuDS features, can mange increases in surface water run-off that may result from more intense storm events.
- If specified correctly, nature-based solutions can also enhance biodiversity.

2.2 Biodiversity crisis

2.2.1 Why is biodiversity important?

Biodiversity refers to the variety of life on Earth that has evolved over the last 4.5 billion years. Nature is central to our survival as a species, underpinning jobs, health and well-being. Over half of Gross Domestic Product is dependent on nature.

2.2.2 What is happening to biodiversity?

Globally, and locally, we are in the midst of a biodiversity crisis and nature is declining fast. It is estimated that 1,000,000 species globally are at threat of extinction. Closer to home:

16% **nearly one in six species are threatened with extinction from Great Britain**

19% **amount by which, across the UK, species studied have declined on average since 1970**

Above: deforestation in Indonesia
Image credit: © Ulet Ifansasti / Greenpeace

2.2.3 What is causing the decline?

The causes of the biodiversity crisis are well understood and can be summarised as follows:

- Changes in agricultural and fishing practices and the impact this has on the land, sea and wildlife.
- Climate change creating better conditions for invasive species to thrive and out-compete native species.

2.2.4 What is the link between climate change and biodiversity loss?

Climate change, and climate instability, has resulted in biodiversity loss. The health of ecosystems is directly impacted by climate, and changes determine shifts in where plants, animals and - increasingly - humans can live and thrive.

However, there is a flip-side to this relationship: biodiversity is also a very important part of how we respond to the climate emergency. A report in by the Intergovernmental Panel on Climate Change (IPCC) demonstrated that 54% of man-made greenhouse gas emissions in the preceding 10 years were absorbed by natural ecosystems.

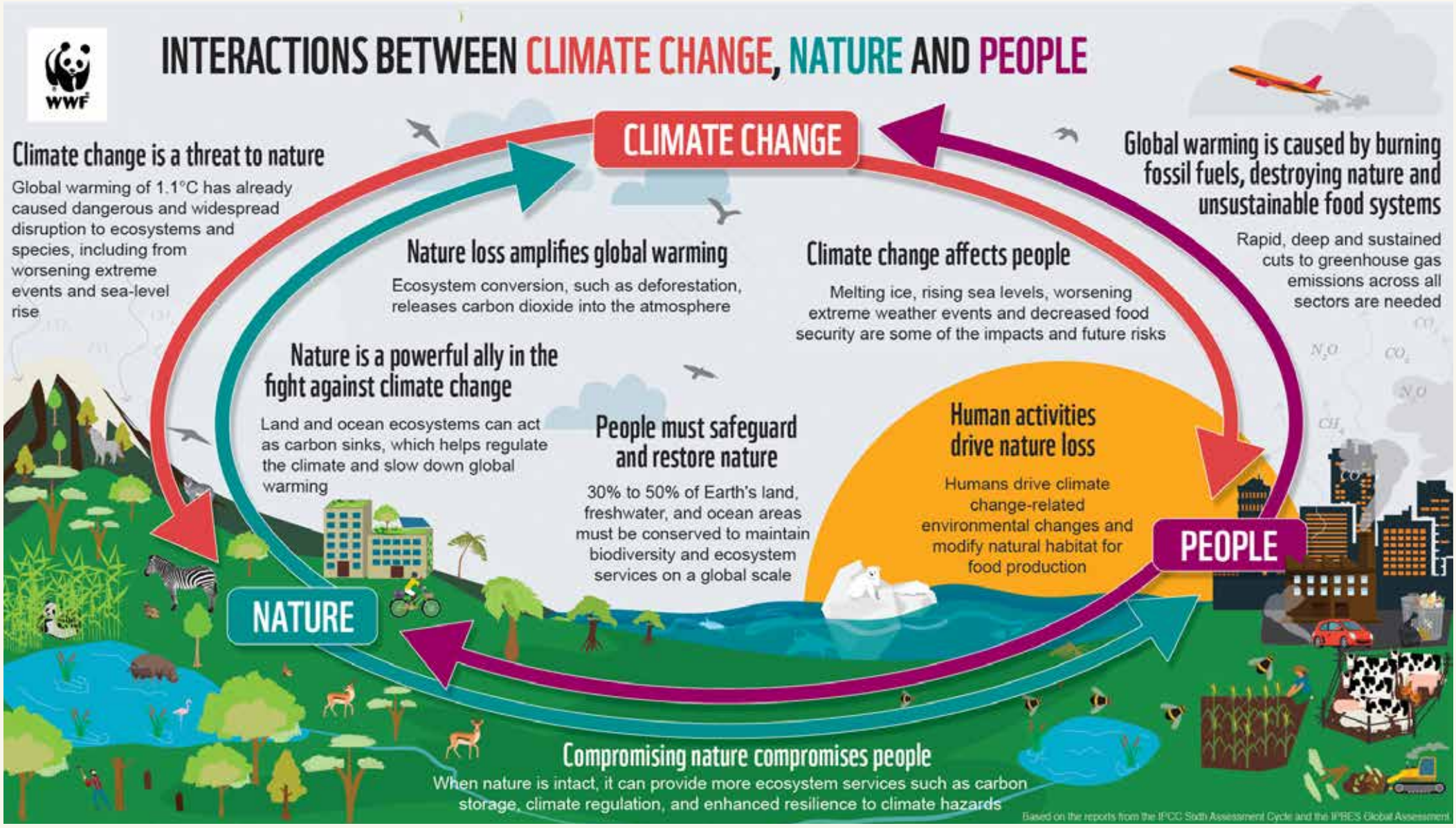
Above: Himalayan balsam, an invasive species
Image credit: Walk Wheel Cycle Trust

2.2.5 Climate change, nature and people

The interaction between climate change, nature and people is important to understand: we, as people, impact both climate change and nature, and climate change and nature both then impact us directly. Therefore, when we do something, we should be considering how this impacts both climate change and nature.

2.2.6 What needs to be done?

Without nature, and it's abilities to help regulate climate, it will be impossible to avoid the worst effects of climate change and will place more people at risk. We therefore need to protect existing nature and enhance biodiversity in order to maximise the benefits of nature in acting as a carbon sink.



Above: interactions between climate, nature and people
Image credit: WWF International - Climate and Energy

2.3 Encouraging active travel

In addition to mitigating climate impacts, green and blue infrastructure also has an important role in creating an environment that supports and encourages active travel.

2.3.1 Streets for people

Streets can be spaces for people to enjoy, to socialise and where community can flourish. But to do this, streets need to be designed primarily around the comfort of people, not vehicles. 'People are less likely to be active in car-dominated environments, and there is the invisible threat of poor air quality.' (Walk Wheel Cycle Trust, 2023).

2.3.2 Placemaking

Providing high quality public realm with trees and planting at locations along active travel networks can encourage people to stop and spend time. This can help nurture community and attract more people to use the network.

2.3.3 Creating an attractive environment for economic investment

When streets are comfortable spaces for people to spend time in with cleaner air and shade to shelter beneath, footfall increases, helping to create a more attractive environment for economic investment.

Above: a green, attractive street in Grangetown, Cardiff, encouraging people to spend time.
Image credit: Walk Wheel Cycle Trust

2.4 Policy imperative

In 2015 the United Nations adopted 'The 2030 Agenda for Sustainable Development' containing 17 Sustainable Development Goals (SDG's) that address poverty, health, education, economic development, inequality and climate change.

In line with these 'SDG's' the UK Government has set out ambitious targets to de-carbonise and reduce greenhouse gas emissions across all sectors of the economy.

Achieving modal shift away from car journeys to active travel and public transport is recognised as one of the most cost-effective means of reducing emissions in the transport sector and is leading to the extensive development of active travel infrastructure across much of the UK.

Promoting everyday walking, wheeling and cycling into active lifestyles also improves health outcomes and reduces health-based inequalities.

To realise these positive outcomes policy makers are increasingly promoting the importance of linking multiple and aligned objectives, the joining up of development and services planning across localities and communities.

2.4.1 Scotland

In Scotland's National Planning Framework 4, planning policy promotes the Place Principle and the creation and maintenance of sustainable and liveable places.

Policy 1 requires that in decision making "When considering all development proposals significant weight will be given to the global climate and nature crisis". This emphasises the increased priority given to environmental matters.

And Policy 20 specifically seeks to ensure that "Blue and green infrastructure are an integral part of early design and development processes; are designed to deliver multiple functions including climate mitigation, nature restoration, biodiversity enhancement, flood prevention and water management".

National Planning Framework 4, 2023
Scottish Government

"Blue and green infrastructure are an integral part of early design and development processes; are designed to deliver multiple functions including climate mitigation, nature restoration, biodiversity enhancement, flood prevention and water management." p.70

At the local level planning, housing, transport and environment are intricately linked and quality development aims to achieve a balance across these areas by integrating green and blue infrastructure into planning and building. This will often be guided by an Environmental Impact Assessment.

Even small-scale 'local' developments can contribute to improving biodiversity by applying NatureScot's guidance 'Developing with Nature'.

These policies and approaches are together applicable across all types of development in urban and rural areas, on the High Street, in public spaces and across residential neighbourhoods, retail centres, business districts and commercial areas.

Green and Blue infrastructure should be promoted as contributing to a sustainable form of development that addresses climate, nature, health, attractiveness of place and resilience.

2.4.2 England

In England, linking active travel infrastructure to green and blue infrastructure helps support government aims.

The Department for Transport has a target that half of all short journeys in towns and cities will be walked, wheeled, or cycled by 2030. This is supported in both transport guidance – including Local Transport Note 1/20 – and development planning documents, such as the National Planning Policy Framework. This supports the creation of "street layouts that allow for easy pedestrian and cycle connections".

Additionally, the Department for Environment, Food and Rural Affairs has aims related to biodiversity and access to nature which can be addressed at the same time. The Environment Act 2021 set requirements to halt and reverse decline in nature and restore water qualities. Meanwhile, in their Environmental Improvement Plan, they set an aim that everyone lives within 15 minutes' walk of a green or blue space. Again, this is supported within the development planning system in the National Planning Policy Framework (NPPF).

This was supported in 2024 by a commitment by the new government to open nine national river walks. They also created a new subsidy under the Sustainable Farming Initiative for landowners choosing to increase permissive access to nature.

The emphasis on travel to nature presents a number of opportunities for active travel routes. Firstly, the government is considering the time it takes people to walk or wheel to nature, not just the distance as the crow flies. High-quality active travel routes can therefore help with this. It also means that they're considering how the route itself can provide access to nature, meaning that the creation or improvement of green and blue infrastructure alongside active travel routes will be seen particularly favourably.

SuDS is encouraged through the Flood and Water Management Act 2010 which requires local authorities to manage the risk of floods. There was initially an intention for a SuDS approving body for each council, but this was not enacted. Instead, the NPPF strongly recommends the use of SuDS in new developments, especially in areas at risk of flooding or where the development will itself affect drainage. These are approved by local planning authorities, who also have to ensure they're appropriately maintained.

2.4.3 Northern Ireland

In Northern Ireland the Strategic Planning Policy Statement produced by the Department for Infrastructure lays out the Core Principles for the planning system and planning for sustainable development. It addresses the impacts of the climate emergency by promoting development that will be both sustainable and improve well-being by working with natural environmental process e.g. through green networks and SuDS.

The 'Improving Health & Well-being' policy seeks the protection and provision of green and blue infrastructure and supports the development of green networks for a range of connected purposes and quality of life benefits for communities.

These policies also support delivery of the draft Green Growth Strategy and the Environmental Action Plan.

2.4.4 Wales

In Wales, the integration of green and blue infrastructure with active travel is strongly supported by legislation and policy focused on sustainable development, climate resilience, and well-being.

The Well-being of Future Generations (Wales) Act 2015 sets a legal requirement for public bodies to work toward seven well-being goals, including a resilient Wales, a healthier Wales, and a globally responsible Wales. This provides a strong foundation for nature-based solutions, such as green corridors and SuDS, within active travel schemes.

The latest edition of Planning Policy Wales (edition 12, 2023) identifies green infrastructure as a vital part of sustainable placemaking. For the first time it requires all planning applications to be submitted with a 'Green Infrastructure Statement'. The statements should be proportional to the size of the development but are intended to promote multifunctional spaces that can support biodiversity, enhance visual amenity, reduce flood risk, and encourage physical activity and mental well-being.

The Active Travel (Wales) Act 2013 and associated Active Travel Guidance (2023) require local authorities to plan and deliver walking and cycling infrastructure that is attractive, safe, and coherent. The guidance encourages the inclusion of natural features, trees, and green spaces along routes, not only to improve user experience but to deliver co-benefits such as air quality improvements, shade, and biodiversity gain.

Since 2019, Schedule 3 of the Flood and Water Management Act 2010 has been in force in Wales. This mandates SuDs in all new developments of more than one house or where the construction area is 100m^2 or more, with all drainage systems designed and built in accordance with statutory SuDS standards. Uniquely in the UK, Wales has created SuDS Approving Bodies (SABs): local authority teams responsible for reviewing and approving SuDS to ensure they meet the statutory standards.

Taken together, these policies and others establish a strong mandate and indeed a requirement for combining investment in active travel with green and blue infrastructure in Wales. Doing so can help achieve multiple Welsh Government priorities: modal shift, climate adaptation, public health, biodiversity recovery, and equitable access to nature-rich places.

2.5 What do we do in response?

2.5.1 Change

The climate emergency and biodiversity crisis are both devastating challenges that we must respond to. Given that both have been caused by our actions, it is obvious our response must be a change in what we do and how we do it.

Threats **Climate Emergency & Biodiversity Crisis**

Response **Global, National & Local Policy**

Action **Change what we do and how we do it**

2.5.2 Going beyond modal shift

Encouraging people to make more sustainable choices when deciding how they will travel has the potential to make a significant impact on greenhouse gas emissions and help mitigate climate change. However, when considering both the scale of the climate emergency and the related biodiversity crisis, there is a need to do more.

The design of active travel infrastructure can - as this guidance attempts to highlight - do more than just facilitate modal shift and the movement of people from A to B: appropriately designed infrastructure can also help our streets adapt to the effects of the climate emergency and help in our response to the biodiversity crisis.

Above: Grey to Green in Sheffield: adapting and responding to the climate emergency and biodiversity crisis.
Image credit: Arup

2.5.3 Redefining our streets

Including green and blue infrastructure in the scope of design for active travel infrastructure can - in addition to facilitating and encouraging active travel - greatly help in responding to the challenges of both the climate emergency and the biodiversity crisis. To do this requires thinking about streets in a holistic manner; considering all users and functions that the street environment can benefit.

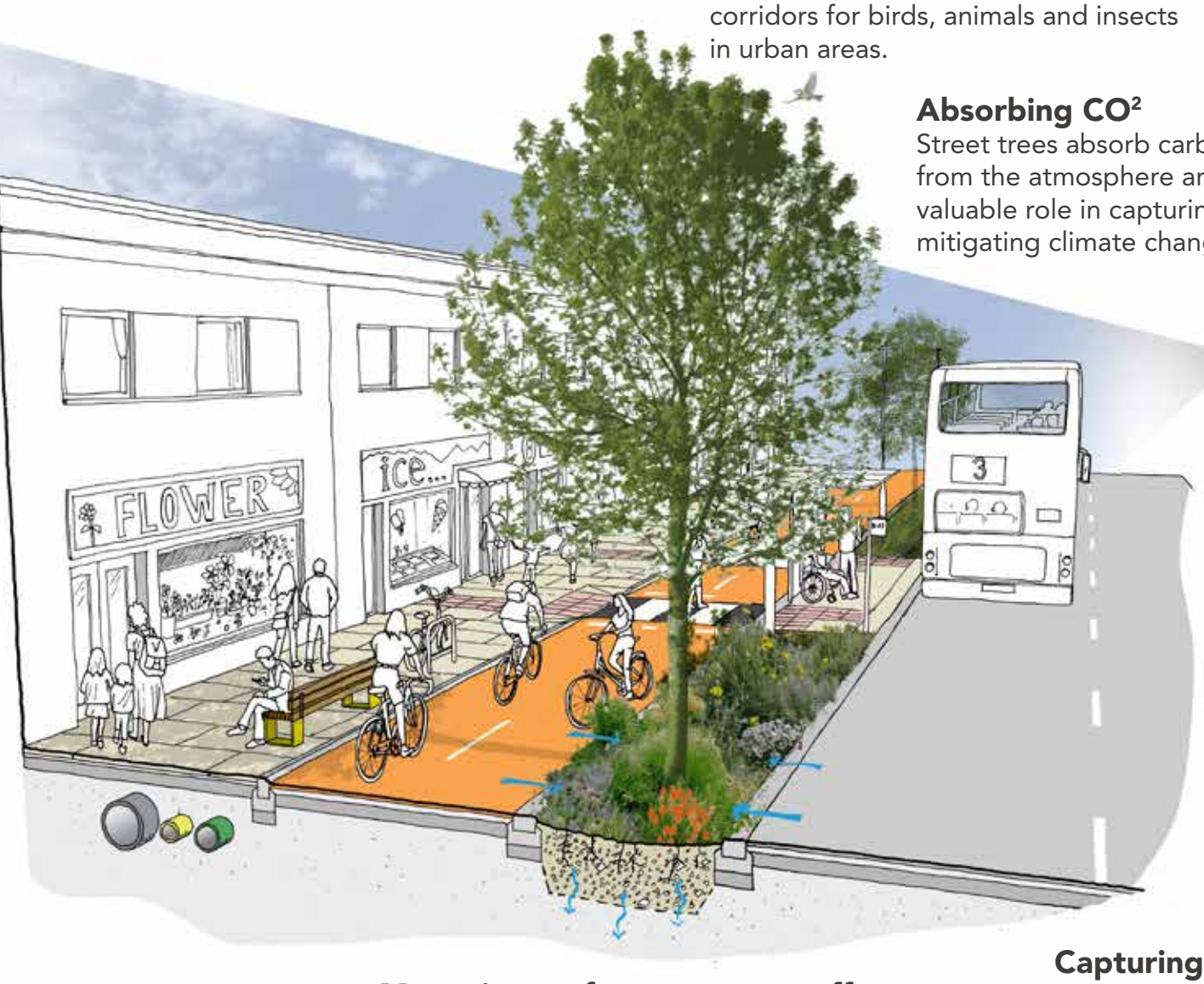
The illustration below shows some of these users and functions with reference to an urban street.

Creating ecological corridors
Linear green networks provide valuable corridors for birds, animals and insects in urban areas.

Absorbing CO^2
Street trees absorb carbon dioxide from the atmosphere and play a valuable role in capturing carbon and mitigating climate change.

Enhancing biodiversity
Many types of flora and fauna can thrive in urban areas. As our streetscapes are redesigned to better accommodate active travel, there is a huge opportunity to initiate and encourage greater biodiversity.

Combating urban heat islands
Trees, especially those with large canopy spread, have the ability to create effective shade and cooling.



Managing surface water run-off
Incorporating sustainable urban drainage in street design allows for collection, storage and filtration of surface water run-off from adjacent pavements and carriageways.

Capturing air pollutants
Planting alongside the carriageway can trap and absorb airborne pollutants, providing a cleaner and safer environment for pedestrians and cycle users.

Above: a sketch showing green and blue elements integrated with active travel infrastructure.

3 What green and blue elements can active travel infrastructure include?

3.1 Design elements

In terms of green and blue infrastructure, there are a wide variety of design elements that can be implemented in response to different challenges in the urban environment. An integrated approach to how our streets are designed, where these elements are integrated alongside active travel infrastructure, can lead to greater overall benefits: environmental, social and economic.

These design elements include those shown below (note: more information on these can be found following the page references given).

Trees

see p.20-25

Image: Jon Rowe

Rain gardens (bioretention)

see p. 26-31

Image: Walk Wheel Cycle Trust

Filter strips & drains

see p. 32-34

Image: Walk Wheel Cycle Trust

Planting (urban greening)

see p. 35-36

Image: Jon Rowe

Permeable surfaces

see p. 37-49

Image: Walk Wheel Cycle Trust

The above is not an exhaustive list: in addition there are green roofs, bioswales, rainwater harvesting, underground storage tanks, detention and attenuation ponds and basins, and much more. This guidance, however, will focus on the elements above that are considered most relevant to active travel infrastructure development.

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3.2 Responding to challenges in the urban environment

In order to response to the challenges in the urban environment, there are a wide variety of design elements that can be employed. The table below provides a simplified categorisation of the benefits that some of these elements can deliver. It is worth highlighting that the effectiveness of each element in delivering the benefits stated below is dependent on the detailed design and specification of that element: for example, a poorly designed rain garden may not do anything to treat polluted surface water run-off.

	Trees	Rain gardens (bioretention)	Filter strips	Planting (urban greening)	Permeable surfaces
Managing increased quantities of surface water run-off	Yes*	Yes	Yes	Partial	Yes
Treating polluted surface water run-off from the carriageway	Yes*	Yes	Yes		Yes
Providing increased solar shading	Yes				
Capturing airborne pollutants	Yes**	Yes**		Yes**	
Increasing biodiversity in the urban environment	Yes	Yes	Yes	Yes	
Providing ecological corridors for wildlife	Yes	Yes	Yes	Yes	
Providing amenity value for people	Yes	Yes		Yes	Partial
Positive benefits to heat island effects	Yes	Yes		Yes	
Carbon capture and storage	Yes	Yes	Yes	Yes	
Health and well-being	Yes	Yes		Yes	

Table 1: design elements and benefits

* if using bioretention tree pits
** dependent on species selection

3.3 Planning strategically

In responding to the challenges described previously and choosing a design strategy or approach for the inclusion of green and blue elements in active travel infrastructure, it is really important to be aware of the wider context and to make decisions that fit strategically with existing plans.

3.3.1 What happens if you don't plan strategically?

Whilst introducing - for example - a rain garden into any street can deliver a positive benefit, the greatest benefits can be had by planning strategically and locating rain gardens in those streets where storm water flow isn't at peak within that immediate area. This is because - in the case of rain gardens - reducing the cumulative flow on streets should be the goal in order to reduce the overall impact of storm events. This is just one example of how planning strategically, at a catchment scale, can help deliver greater benefits.
Strategic planning is also important in planning for green infrastructure: in towns and cities, green infrastructure can become fragmented if not planned in such a way that links are created between different elements. The resultant network of green infrastructure can help promote biodiversity and connect habitats.

A further benefit to planning strategically is that it can assist in the development of an integrated approach with other types of infrastructure planning e.g. active travel, highways, parks, regeneration. This approach can open up opportunities for shared funding and design collaboration. Through collective thinking, the benefits of infrastructure development can be maximised and disruption reduced.

3.3.2 Case study

The following case study illustrates this top-down approach in Hamburg, a prominent and major port city in northern Germany.

The Hamburg City Green Network Development Plan (GDNP) exemplifies a strategic approach to green blue infrastructure planning.

GDNP creates a framework for an ambitious plan to replace auto-transport with walking and cycling, substantially increasing levels of cycling in the city's modal split with benefits for mental and physical health, quality of life, public realm quality, biodiversity, and climate change adaptation. GDNP therefore has a role as a strategic design strategy and for delivering ecosystem services. The city is creating a Grünes Netz (green network) of interconnected open areas (parks, playgrounds, sports fields, bike routes etc.) to enable pedestrians, wheelers and cyclists to more safely and efficiently navigate through the city. The green network will cover approximately 40% of the city, complementing sidewalks and bike lanes on roadways with a separate transport system dedicated to walking, wheeling and cycling modes.

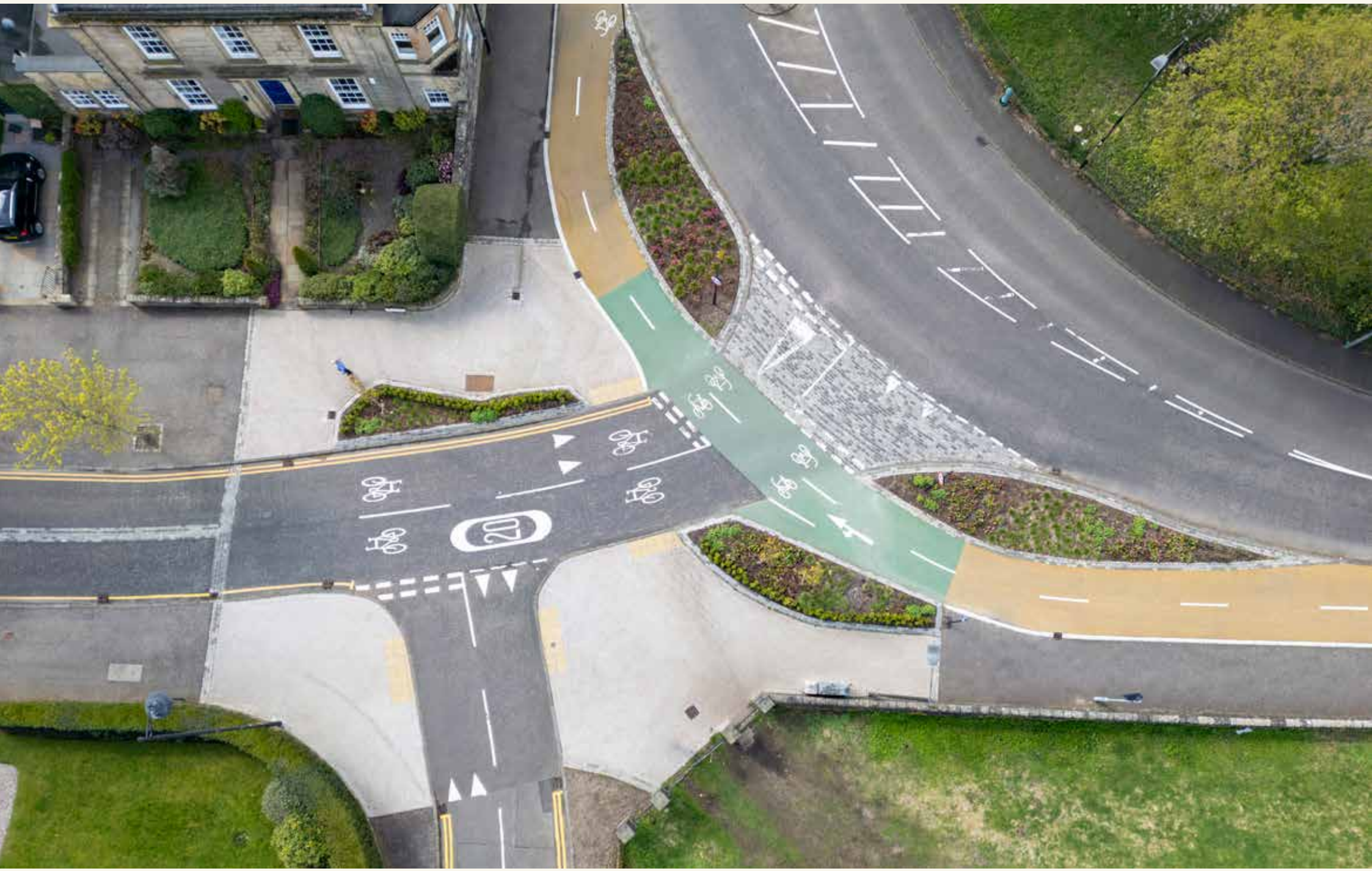
Wider project objectives promote change at many scales, from macro-improvements (e.g. improving climate change adaptation, including the reduction of the heat island effect, limiting the effects of floods caused by precipitation and sea storms, making the city more pedestrian and bicycle friendly and decreasing the use of cars in the city, providing green corridors that connect animal habitats and increase biodiversity, attracting people to live in the city) to micro-improvements (including improving key recreational areas, connecting parks to the green network, creating new green streets and squares and improving signposting).

3.4 Site design

Active travel networks are, by their very nature, linear. This linear form often presents inherent spatial challenges for designers tasked with incorporating elements of green and blue infrastructure alongside the movement of people and vehicles.

However, this linear form can also be a benefit and present the opportunity to capture surface water run-off from the adjacent footway, cycle track and carriageway (if space allows). It can also serve as an effective buffer between pedestrians, cycle users and vehicles. As a buffer, it not only improves safety and comfort for pedestrians and cycle users but also - with the appropriate planting - can help in capturing airborne pollutants emitted by cars.

The example below shows how a junction incorporating green and blue



Above: a great example of how green and blue infrastructure can be incorporated into a junction design in Stirling
Image credit: Walk Wheel Cycle Trust/McAteer, 2024

3.4.1 Linear streets

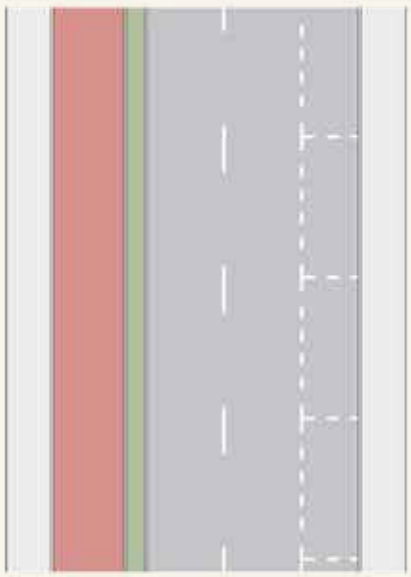
In this section, some potential design responses are outlined for a typical linear street environment. These are not intended as an exhaustive array of options, but are included to highlight how green and blue infrastructure can be incorporated into our existing streets. In all cases, green and blue infrastructure is used to not only deliver SuDS functionality and biodiversity benefits, but also to make active travel more comfortable: providing a multi-functional separation between vehicles and active travel routes.

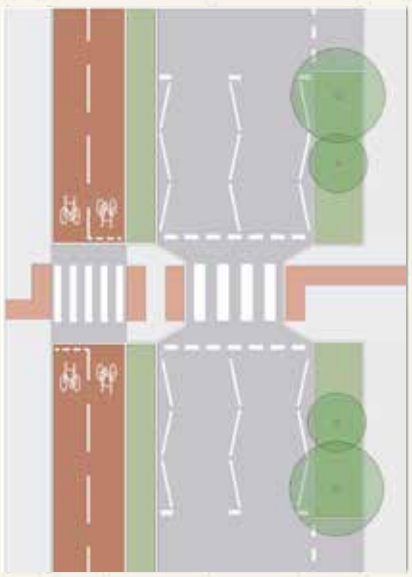
Existing street

- Wide carriageway.
- Parking on both sides.
- No green or blue infrastructure.

Green buffer / filter strip

- Narrower carriageway.
- Some parking retained.
- Two-way (bi-directional) cycle track introduced.
- Filter strip between cycle track and carriageway.



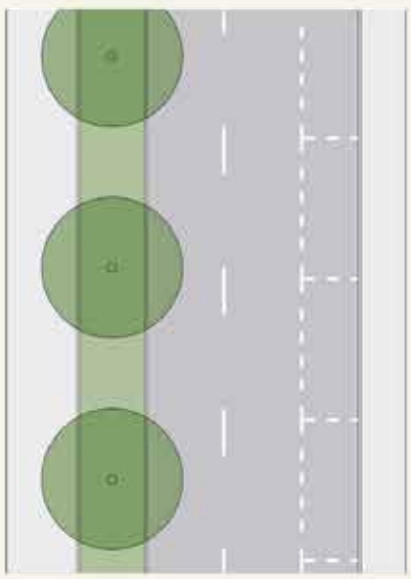


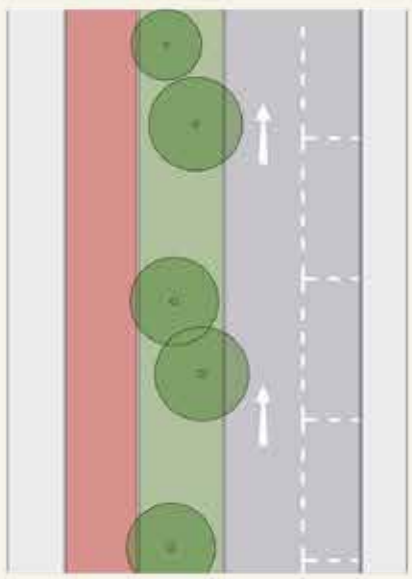
Green build-outs

- In-street rain gardens.
- Narrower carriageway.
- Some parking retained.
- Most efficient design for capturing carriageway surface water flows on a cambered street.

Green corridor

- Linear verge rain gardens or bio-swales
- Narrower carriageway.
- Some parking retained.
- Wider footway created.
- Recommended 1.5m minimum width.





Greening a lane

- Linear verge rain gardens or bio-swales
- Traffic redirected to permit removal of one lane.
- Some parking retained.
- Two-way (bi-directional) cycle track introduced.
- Recommended 1.5m minimum width.

3.4.2 Junctions

In this section, some potential design responses are outlined for junction environments. Similar to the linear options, this is not exhaustive, but is included to highlight how green and blue infrastructure can be incorporated into a junction.

Above: a great example of how green and blue infrastructure can be introduced to a junction and realise multiple benefits.
Image credit: Walk Wheel Cycle Trust

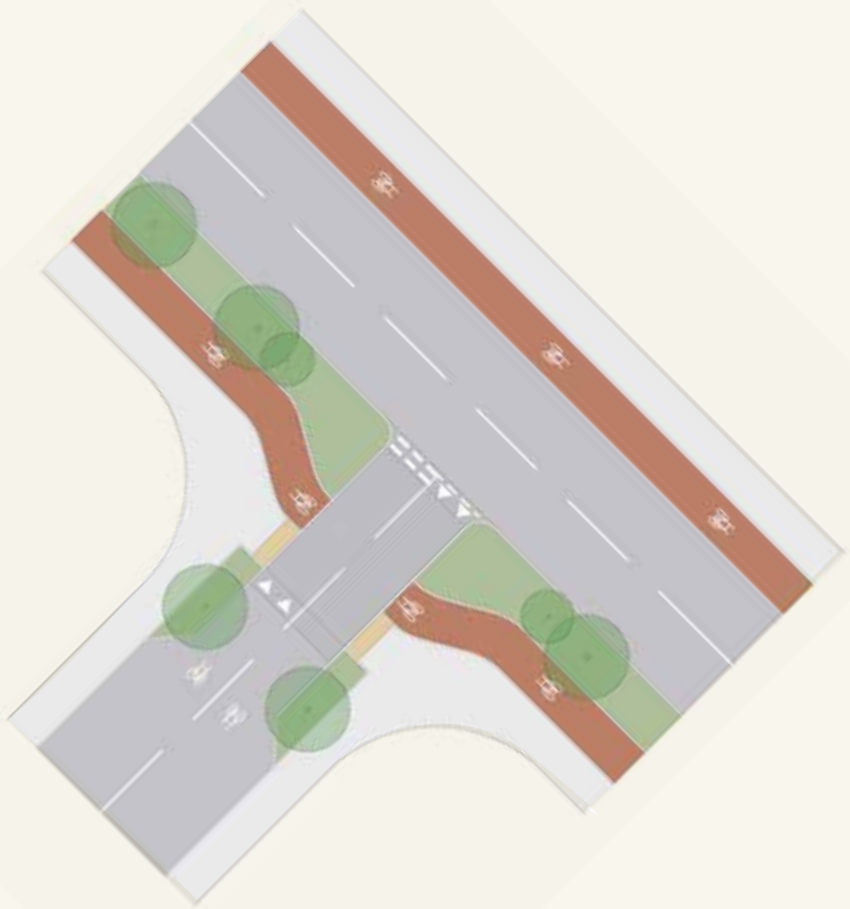
Existing junction (above)

- Wide carriageway.
- Parking on one side.
- Wide mouth to side road.
- No green or blue infrastructure.

A greener junction (right)

- Narrower main carriageway.
- Narrower road mouth to side road with reduced corner radii to reduce vehicle speed and improve safety.
- Reduced crossing distances
- Opportunities seized to include green and blue infrastructure.

Note: example shown is a ‘give way to side road bend-out layout’ taken from Cycling by Design (Transport Scotland, 2021).



4 How do you include green and blue elements in active travel infrastructure?

4.1 Engage the right people

In order to successfully include green and blue elements in active travel infrastructure it is - first and foremost - really important to engage the right people at the right time in the project. Landscape architects and engineers should work together in collaboration to assess the opportunities for green and blue interventions within active travel infrastructure in the project location: assessing together what could work in that location.

4.1.1 Understand who does what

It's not always easy to know who does what in relation to green and blue infrastructure: there's a broad range of professional disciplines that all have potentially valuable contributions to make towards design and delivery. Below looks at some of the disciplines most commonly involved with the detailed design and construction of green and blue elements in active travel infrastructure.

Landscape Architect

- Design and specification of public realm (from concept to construction).
- Design and specification of green and blue infrastructure in collaboration with others.
- Contribute to Environmental Impact Assessments (if relevant).
- Contract management and site supervision during construction.
- Assessment of SuDS inlet design and locations.
- Specification of functional soil requirements and associated plant selection.

Ecologist

- Ecological surveys of project sites (including Preliminary Ecological Appraisals).
- Contributing to Environmental Impact Assessments.
- Licence application and management for site works.
- During construction phases advising and working with others to protect, enhance and develop habitats.
- Advising on appropriate approach/response to biodiversity loss and biodiversity net gain.

Transport / Civil Engineer

- Feasibility studies into new routes.
- Detailed design of active travel infrastructure.
- Earthworks design.
- Drainage design: calculation and design of catchment and storage areas, working with others.
- Contract management and site supervision during construction.
- Utilities management and design.

Arboriculturist

- Tree surveys (from single trees to woodland).
- Arboricultural impact assessments.
- Advice on specialist tree protection during construction (beyond BS 5837).
- Advice on mitigations for tree losses during developments.

Urban Designers, Planners & Others

- Advocate for green and blue infrastructure at early project stage.
- Work with Landscape Architects and Engineers in developing designs beyond concept stage.

Collaborative multidisciplinary working

4.1.2 Right people at the right time

Early stages of project

Green and blue infrastructure should be designed into a project from the outset, with the following stages recommended:

- Development of a place-led feasibility plan to both test high level opportunities and to set ambition for the wider benefits.
- Development of sketch plans of these opportunities to inform and present a more easily understood plan of what's possible.
- Early engagement with all relevant stakeholders in the project.

From the local authority, it is essential to include green-space, roads, lighting, maintenance and waste teams in early conversations, as well as tree and landscape officers. Aside from the local authority - and, in England, it is often a two-tier local authority - conversations with the relevant water authority and national environmental regulator should also be initiated. Early conversations need to inform stakeholders of the multi-functional benefits of proposals, and to talk directly to the potential issues likely to be raised by each. It may be that proposals present a new way of addressing challenges in the street environment and this may raise fears: talking to these fears and outlining viable solutions will be really important.

Above: getting the right people involved at the right time.
Image credit: Walk Wheel Cycle Trust

Setting out expectations and exploring these opportunities with stakeholders early on will also support those projects using a carbon management framework e.g. PAS2080: Carbon Management in Buildings and Infrastructure. Using natural instead of manufactured materials can reduce the embodied carbon impact of project, and the earlier these elements are factored into the scheme, the greater the potential carbon savings through the whole project lifecycle.

From the local community, there is great benefit to gaining early support for proposals. Ultimately, the community's support - or lack thereof - will help determine the smooth progression and long-term success of the project. In short, if the community can see the benefit, they are likely to support it and the local authority is likely to take note of this.

Design stage

Green and blue infrastructure requires a multi-disciplinary design team to achieve success. Planners, urban designers, landscape architects, ecologists, arboriculturists and engineers all have knowledge and expertise in different, but vital, aspects of the design. Only by engaging the right team can you ensure that all aspects of the design will deliver what is required to ensure a project's success.

In-use / maintenance

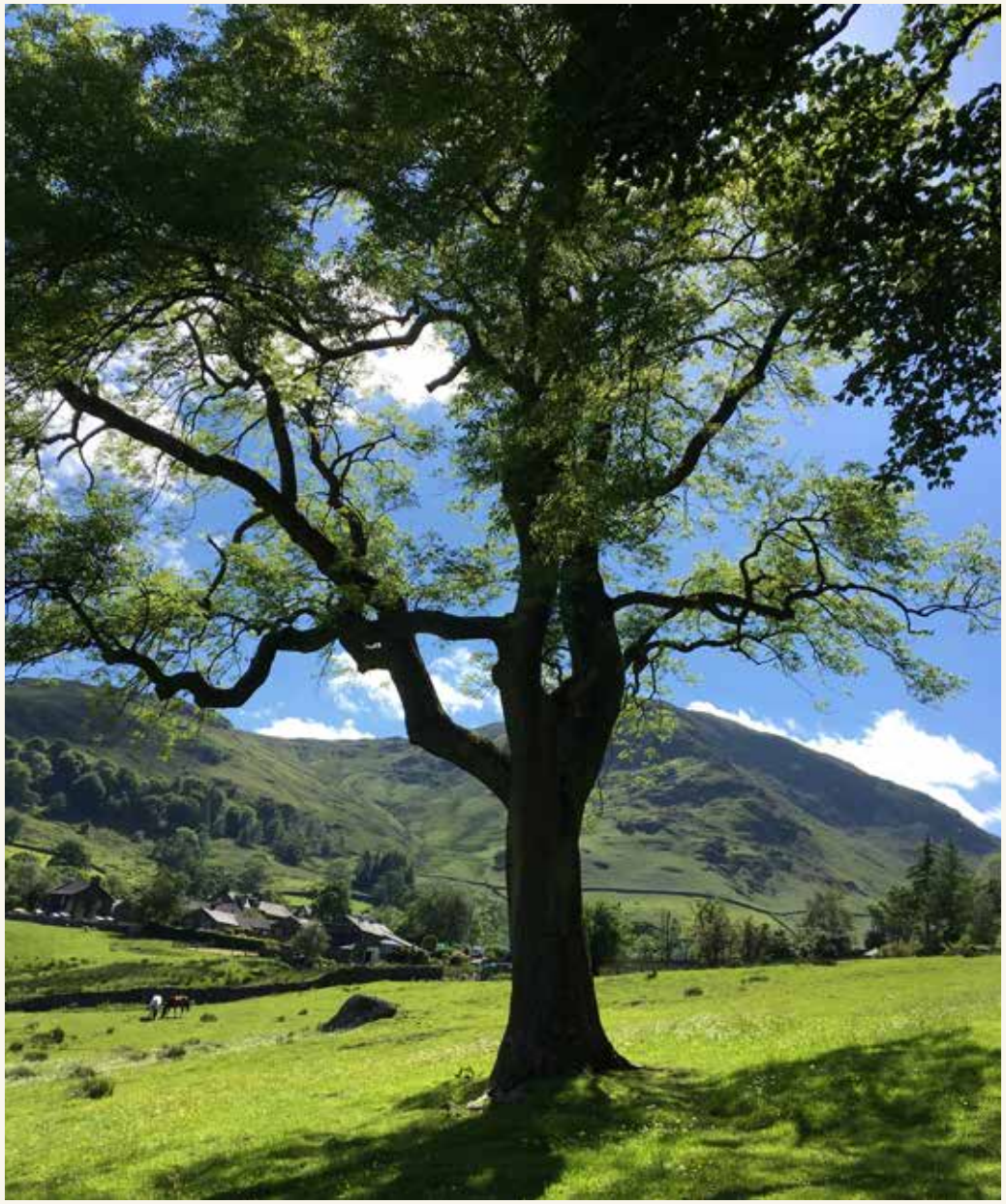
Initiating maintenance discussions at an early stage is really important to prevent maintenance concerns unnecessarily hindering progress. This should include speaking to local authority maintenance teams to understand their skills and capabilities, in addition to engaging with local community groups with an interest in maintaining all things green. In all these conversations, highlighting exactly what maintenance is likely to be required (taking information from this guidance, for example) can help dispel misunderstanding and get people engaged in a viable solution.

4.2 Elements

This section will look at some of the common challenges and questions faced when looking to include different green and blue elements in active travel infrastructure.

4.2.1 Trees

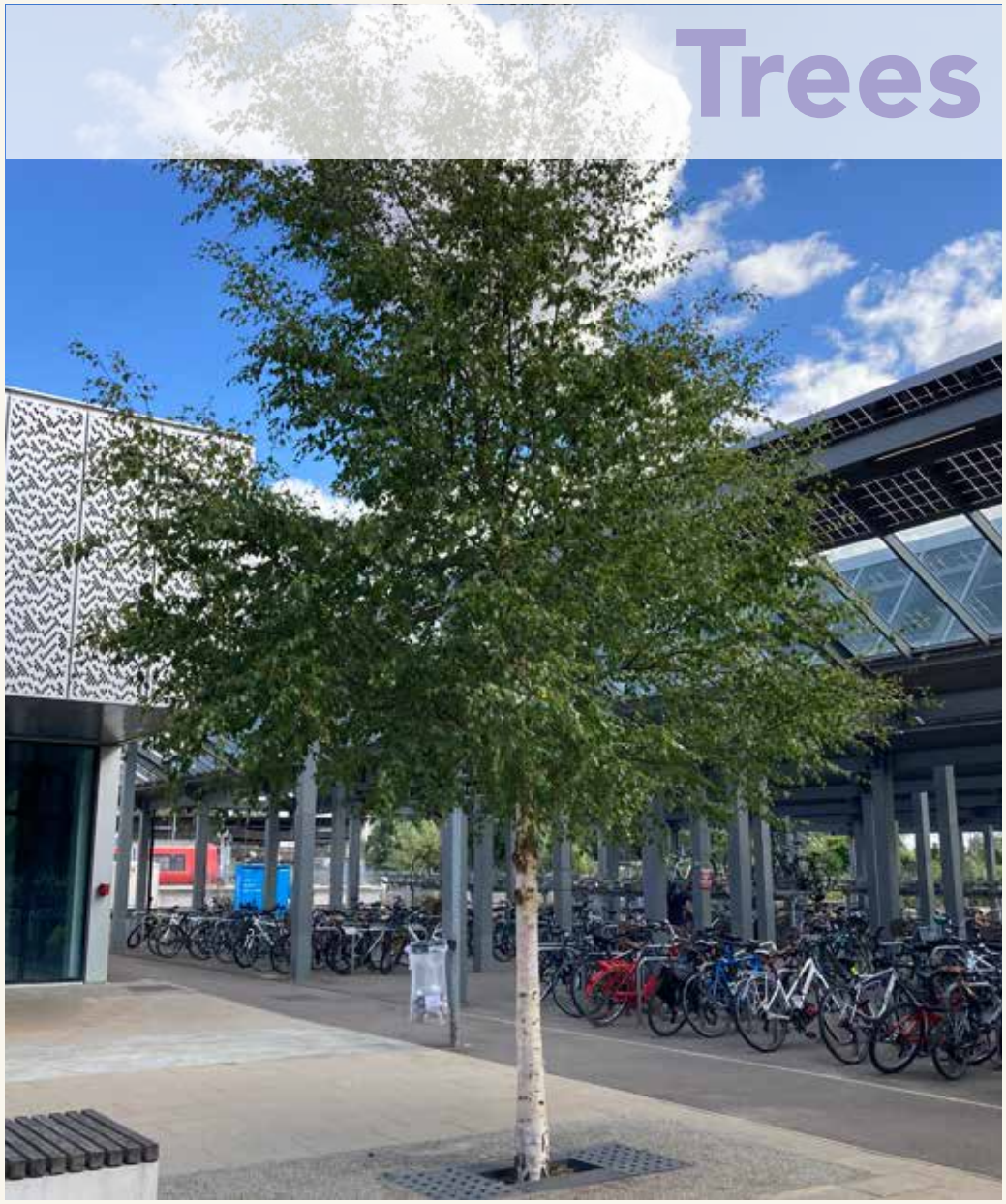
What conditions does a tree need to enable it to thrive?



Above: a healthy tree in the Lake District, England
Image credit: Jon Rowe

A tree, in its natural setting, needs the following in order to establish and thrive:

Sunlight Nutrients Air Water



Above: healthy tree at Cambridge North Station
Image credit: Jon Rowe

In an urban environment, a tree still needs all the same things - air, sunlight, nutrients, water - despite the additional pressures placed on it by the surrounding environment e.g. paved/hard surfaces, pollution from vehicles, utilities beneath the ground, tall buildings overshadowing. It is the challenge for the designer to create a healthy environment for the tree despite these additional pressures. In addition to the challenge, there is also an opportunity for the designer to incorporate bioretention (SuDS) function into the tree pit design.

What do you need to do if you're proposing to construct active travel infrastructure next to an existing tree?

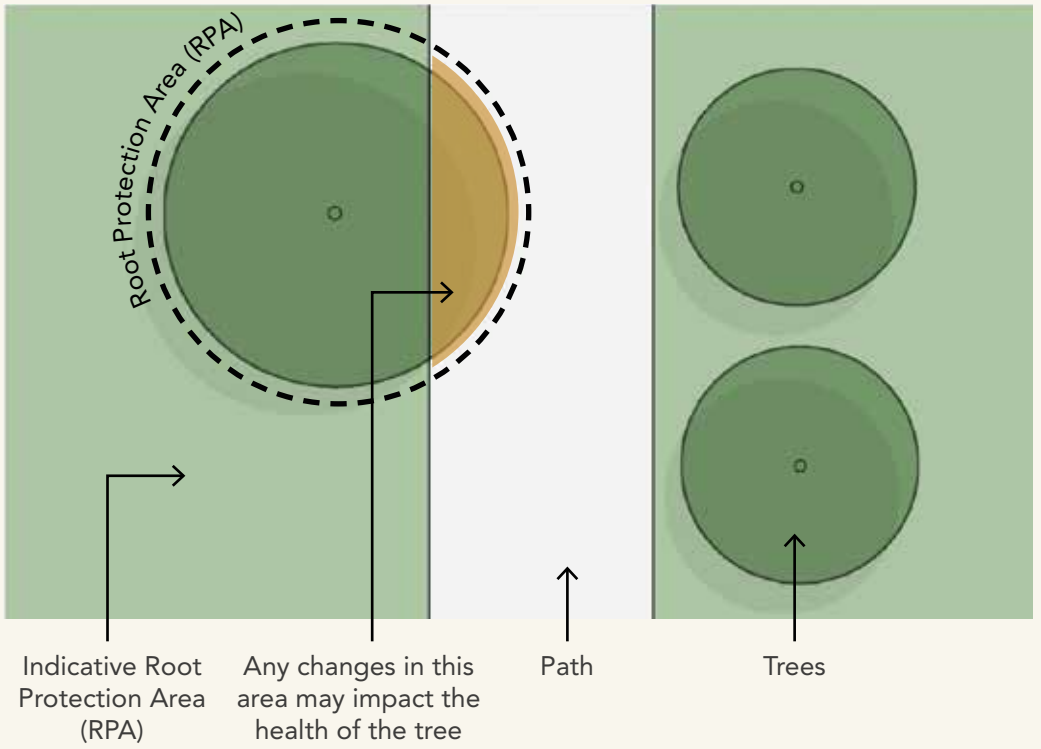
Any construction activity near trees has the potential to negatively impact on the health of those trees. The biggest risk is that construction activity damages the roots of the tree, or changes the conditions surrounding the roots such that the tree's health suffers. This doesn't mean that construction can't happen - it could also be taken as an opportunity to alleviate current stresses on the tree - but there are some important steps that must be taken during the design phase of a project.

- **Find out if the tree subject to a Tree Preservation Order or any other form of protection**
  The local authority may have made a Tree Preservation Order (TPO) in order to protect the tree(s) from damage or loss. This is a legal protection and requires permission to be sought from the local authority before any work is carried out. This is important even if work is only being proposed next to the tree, because that work could place the protected tree at risk and any actions are therefore liable to criminal prosecution. Local authorities hold registers (often accessible online) listing which trees they have made subject to TPO.

  In addition, trees are similarly protected if they are located in a Conservation Area, or if they are subject to a condition upon the granting of Planning Permission. If a tree is protected, permission must be sought from the local authority and it is recommended that advice is sought from an arboriculturist.

- **Consider the tree's Root Protected Area**
  A tree's Root Protection Area (RPA) gives an indication of where the tree's roots are likely to be. In general, any changes within the RPA - either above or below the surface - will impact the tree's health. An arboriculturist can advise on RPAs but an approximate guide, helpful when first looking at a location for a new path or changes to an existing path is to consider the extent of the tree canopy (as illustrated below). Whilst not the most accurate method, it can help determine how challenging the construction of that route might be where there are trees in close proximity.

  It is important to highlight that when considering an RPA in relation to an existing path, any changes or construction activity within that RPA - even if there is already hard surfacing present - can pose a risk to the tree. It isn't just the creation of new paths that can cause damage or loss to trees, but changes to an existing one.



Above: illustrative plan showing a tree's RPA overlapping a path
Image credit: Walk Wheel Cycle Trust

- **Decide when to engage an arboriculturist**
  An arboriculturist is a qualified professional who can advise on the care and management of trees; advising on tree preservation and conservation, trees in relation to planning, and tree surveys and inspections.

  Following undertaking a tree survey, they can produce a tree constraints plan which will include the RPA for each tree together with an assessment of the tree's condition and life expectancy. This can help inform design proposals i.e. where a path might be routed. It is also an essential document should the proposals require planning permission.

  Another document which arboriculturists can produce is an Arboricultural Method Statement (AMS). An AMS details how trees (both in the in the immediate and any neighbouring sites) will be protected during construction and post-construction. These may be accompanied by Tree Protection Plans (TPP) and Arboricultural Impact Assessments (AIAs), further documents detailing the impact of any proposed development on the existing trees.

  These documents are produced according to British Standard BS5837:2012 Trees in relation to design, demolition and construction.

How do trees survive when they are planted in the middle of - or adjacent to - a hard, paved surface?

Urban settings can be a harsh environment for a tree. In order to thrive, a tree needs access to sufficient sunlight, nutrients, air and water. Within an urban environment, where the tree pit will be typically be surrounded by hard surfaces, this is particularly challenging. The design of a tree pit - into which a tree is planted - therefore needs to ensure that all these factors are considered.

When a tree grows in its natural habitat, air and water can permeate through the soil surface and into the roots. When a tree is planted in hard surfaces, water and air cannot pass naturally through the surface to reach the roots. Additionally, there is the risk of the soil which accommodates those roots becoming compacted. When soil is compacted (i.e. squashed down) it's difficult for air to circulate or water to pass through. This can happen due to pressure caused by heavy vehicles or machinery, or even from pedestrians or cyclists crossing repeatedly over the soil surface.

There are several potential solutions to these challenges: the choice of which is applicable will depend on the context. The table below outlines the benefits and disadvantages of each solution:

In paved tree pits, supplying water to tree roots (often called root irrigation), can be achieved - for example - by using a pipe that reaches from the surface level down into the earth below. Rainwater can then enter the pipe from above ground, before being carried down to the soil around roots where it can be absorbed. If the tree pit has been designed to perform a bioretention function (SuDS), then the design will need to allow for surface water to enter the tree pit.

Supplying air to tree roots (often called aeration) can be accomplished in a similar manner. A small gridded plate or vent can be placed into the above ground surface, allowing air to pass through to the soil underground: this reduces the risk of anaerobic conditions developing beneath the surface. In some instances, water and air may be provided to the tree routes using the same pipe or system.

The design of a tree pit should be undertaken by a landscape architect. Specifics of the design will vary according to the specific context:

What is the solution?	Why might it be a good solution?	Why might it not be suitable?
Greater soft area surrounding the tree If the soft area surrounding the tree is of sufficient size, and there is little risk of compaction from surrounding uses, this may allow for sufficient uncompacted space for root growth.	• Cost effective. • Good for tree growth. • *Potential to add wildflowers or other ornamentals to the soft area for increased amenity and biodiversity value.	• Given typical constraints in a street environment, there may not be space to accommodate a soft area of sufficient size.
Use of root cells beneath the surface Root cells are open containers (normally made of plastic) filled with soil that sit below ground. The cells aim to maintain an uncompacted root volume even when there is paving or road surface above.	• Good for optimal tree growth in hard urban spaces. • Could be effectively used to plant a specimen / feature tree within a scheme to ensure maximum growth and impact.	• Root cells are expensive. • Involves leaving plastic in ground. • If the tree subsequently dies, the cells may need excavating. • Their shape can make it more difficult to design around existing utilities.
Use of structural soils beneath the surface Structural soils are soils that contain crushed stone in addition to traditional organic soil. The stone is graded to allow water to permeate through the soil and is also penetrable by root growth.	• Compared with root cells, it is a very cost effective solution. • Prevents water from accumulating around the roots. • Flexibility: can be used in a tree pit in combination with traditional topsoil e.g. use of topsoil in the top 500mm layer.	• The space for roots is limited compared to other options, so tree growth will be constrained by this.

* Note: care should be taken adding shrubs and bulbs to the bases of newly planted trees, they will compete for water and nutrients and could therefore damage the - more expensive - newly planted tree.

What maintenance might trees need?

On the whole, trees should require minimal maintenance and be largely self-sustaining. However, following initial planting there is need for a more considered maintenance schedule and - longer term - there are also some recommended activities to be undertaken. Design choices should be informed by both the availability and skill levels of maintenance provision and should also consider the adjacent uses of the space. For example, planting a fruit tree adjacent to a busy route for walking or cycling would not be appropriate if the expected fruit fall is likely to litter the route and cause a slip hazard.

- **Maintenance following initial planting**
  It is crucial that newly planted trees receive care and maintenance if they are to survive: a tree has undergone shock in being transplanted to it's new environment and will take time to establish and adapt. This period of establishment maintenance should run for at least five years (TDAG, 2014), covering at least two growing seasons.

  One of the most important aspects of establishment maintenance is watering. For newly planted trees, water bags with small outlets can be placed at the base of the tree trunk. These allow water to drip from the bag directly into the soil directly around the tree trunk. Alternatively, the tree pit can incorporate irrigation devices that are filled from a cap located at ground level.

  Other activities that may be needed during this period include: pruning and crown lifting; adjustment of any tree protection cages fitted; clearing of debris from any aeration or irrigation inlets; topping up of mulch surround trunk; checking and adjustment of tree ties or anchors.

  In advance of planting, a maintenance plan should be prepared by the project's landscape architect.

- **Longer term maintenance**
  In times of drought or severe heat, watering will also help established trees. Longer term, the health of trees should also be monitored for signs of distress.

  Pruning and crown lifting may also be required depending on the growth of the tree: if located alongside a walking or cycling route, or a carriageway, this may be of particular importance to ensure clear lines of sight.

  Additionally, it will be necessary to inspect and unblock irrigation and aeration vents and - if a bioretention tree pit - ensure surface water inlet routes remain free from debris.

How do you choose tree species for urban areas?

Similar to choosing any plant, choosing a tree species for an urban area should consider a range of criteria:

- **Size and shape of tree at maturity**
  When the tree is fully grown, what is the expected size of the tree in terms of both height and width? How would that look and fit into the environment in which you're planting it? Does the shape of the mature canopy suit the location?

- **Salt and pollution tolerance**
  Some trees are better than others at tolerating both salt and pollution. What is the environment like in the location you propose to plant?

- **Successful species nearby**
  One of the best indicators as to what species might be best suited to a given location is observation of trees nearby that are doing well.

- **Climate**
  Climatic considerations - both now and in the future - are important in determining a suitable species. Is the location in shade or sun? Is the location subject to strong winds? Is the species being considered resilient to potential rises in temperature?

- **Ornamental value**
  Some trees have spectacular blossom in spring, others have rich, colourful canopies in autumn. These variations in ornamental value are important to consider for every proposed planting location.

- **Crown density**
  Different tree species have different crown densities, which result in differing environments beneath e.g. from full to partial shade.

- **Fruit and dew drop**
  Some trees drop fruit, others emit sap / dew. In some locations - e.g. urban - this may not be welcome, so alternatives may be preferable.

An understanding of these considerations can help inform species selection, but final selection should be made in consultation with the project's landscape architect.

How big does a tree pit need to be?

One of the most common reasons for new trees not surviving in urban areas is insufficient space for their roots. A tree needs an adequate volume of healthy, uncompacted soil in order to grow and survive. As a general rule of thumb:

Large shrub (3m canopy width) : $5m^3$
Small Tree (5m canopy width) : $12m^3$
Medium Tree (6m canopy width) : $17m^3$
Large Tree (7-8m canopy width) : $24\text{-}30m^3$

However, if multiple trees share a single tree trench, these volumes can be reduced. A landscape architect can advise on the specific volumes required in this scenario.

The depth of a tree pit will vary according to the type and size of tree being planted, together with the context, but - as an approximate guide - a single tree pit could be 1m deep. This depth includes both space for the roots and for a 200mm deep drainage layer at the base of the tree pit.

What time of year should you plant trees?

When tree planting should take place depends on how the tree has been grown.

If it has been grown in a container, it can theoretically be planted at any time of year. However, it is easier if this takes place in autumn or winter because less watering will typically needed during the establishment period.

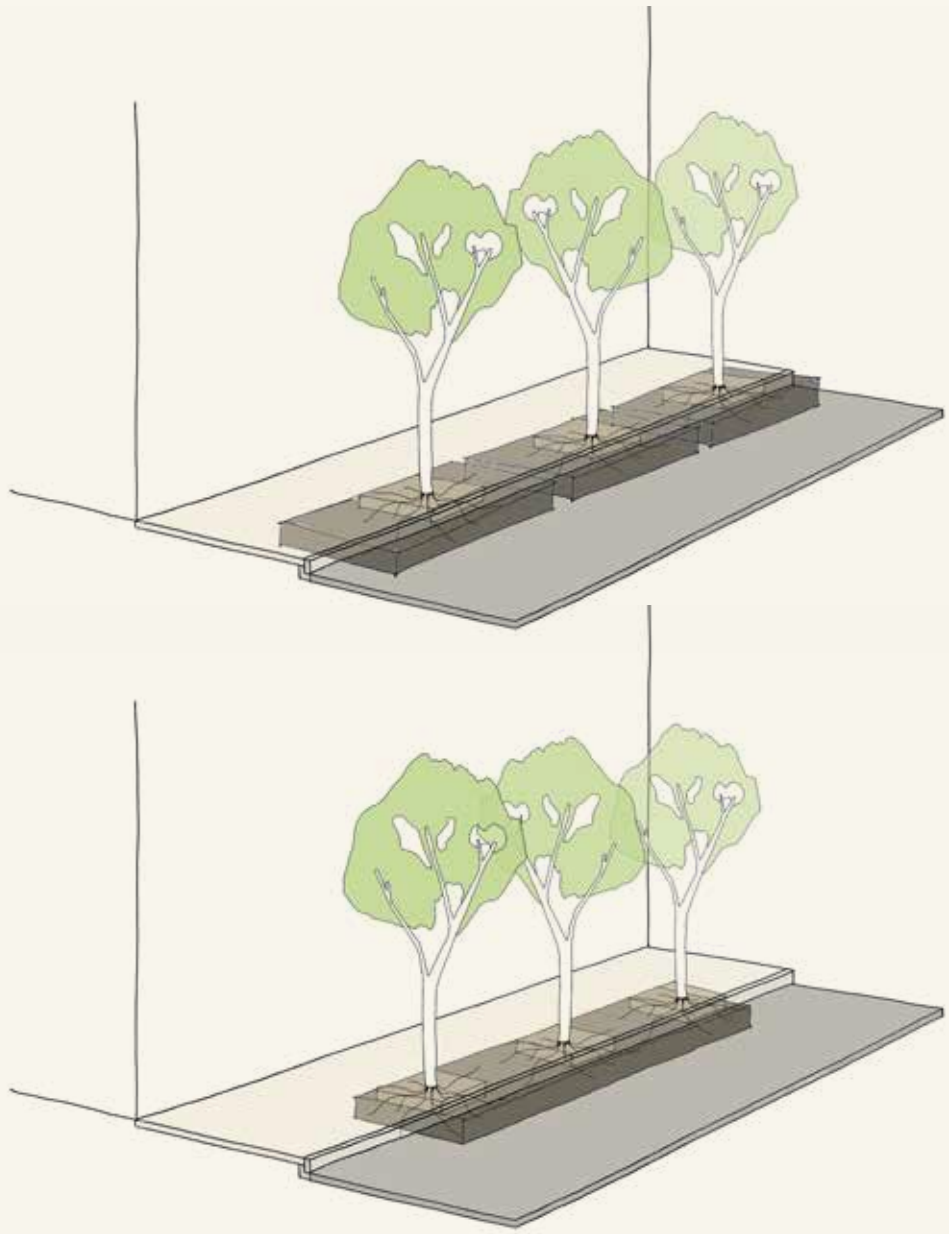
If the tree has been grown in the soil and therefore has either bare roots or a root ball - where the roots and growing media are clumped together at the base of the tree - then the tree can only be planted in autumn or winter.

The method for transferring a tree from a container, or from the soil, to it's new location should be carefully specified by a landscape architect before the move takes place.

What is the most efficient way to plant multiple trees in the middle of a hard, paved surface?

Within a street environment, there is a lot of competition for space beneath the surface: tree pits have to compete for with multiple utilities and services.

If multiple trees share a single tree trench, then the overall volume of space their roots require is less per tree. There is an economy of scale in the shared space they occupy.



Above: three trees in individual tree pits require a greater volume of soil and root space beneath the surface compared with (below) three trees planted in a tree trench where the soil volume is shared.
Image credit: Walk Wheel Cycle Trust

Can you plant trees next to existing utilities?

It is possible to plant trees next to utilities however there are some important steps to take:

- **Consider utilities both above and below the ground**
  When planning for new trees, utility companies, landowners and local authorities need to be contacted to minimise any future risk that proposals may pose to existing utilities. Utility companies can provide all existing utility information, both above and below ground. It must be noted, however, that information will typically be indicative of location rather than precise: further on-site surveys should therefore be carried out prior to any construction activity.

  Above ground utilities: consideration should be given to satellite dishes and masts and drop wires because future tree growth could impact on their operations.

  Below ground utilities: it is worth noting the general depth of utility services below ground varies with different utilities. The access requirements to these utilities will also vary and should be checked and discussed with the relevant company before any designs are agreed. The diameter and design of pipes will affect their susceptibility to any potential damage from tree roots.

Above: illustration showing utilities at varying depths beneath the footway (typical scenario).
Image credit: Walk Wheel Cycle Trust

- **Design for trees and for services**
  Tree planting needs to be designed to allow ease of access to future maintenance. Some things to consider include:

  - Maximisation of common utility enclosures.
  - Use of root-intrusion resistant pipe technology whenever possible.
  - Choosing tree species carefully (the intrusive ability of roots will vary by species).
  - Carefully designing the tree–rooting environment in the tree pit e,g, considering non-square or where the tree isn't centrally located in order to reduce utility interaction.

  For further design guidance of tree planting in relation to existing underground utilities refer to TDAG guidance (TDAG, 2014).

- **Consider the use of root barriers next to utilities**
  In urban environments, the competition for space between utility services underground can be further complicated by the introduction of tree roots. The need for tree root barriers or tree deflectors is strongly recommended in order to minimise conflict, enabling the utility services to operate unaffected whilst allowing street trees to thrive. Root barriers are typically installed surrounding a tree pit or alongside the edge of a footway. Their role is to block tree roots from growing in a particular direction. They are particularly effective at stopping interference with infrastructure (footways, cycleways and carriageways etc.) and underground utilities. They contribute significantly to reducing the risk of tree roots breaking up street pavements and roads. There are different types of root barriers available, each type is selected and used differently depending on their setting and purpose. Landscape architects can advise on the specification of root barriers.

- **Take care during installation**
  When planting, it is vital that excavation work for tree pits doesn't damage existing services. At all stages of the work, site operatives, designers and land owner client must make themselves aware of Health and Safety Executive's guidance note HSG47 – 'Avoiding Danger from Underground Services' as well as any additional information the apparatus owner provides.

  Trial holes need to be carried out before any excavation work begins to cross check against the detection survey information and confirm the exact position and depth of the apparatus.

4.2.2 Bioretention / rain gardens

In this section, we'll look at some of the common challenges and questions faced when looking to include bioretention / rain gardens in active travel infrastructure.

A rain garden is an example of a bioretention system: 'shallow planted depressions that allow runoff to pond temporarily on the surface before filtering through vegetation and underlying soils for collection or infiltration' (The SuDS Manual, CIRIA, p.333). They are effective in intercepting and managing surface water run-off.

Benefits of rain gardens for active travel infrastructure

- **Managing surface water run-off**
  Carriageways and footways are typically surfaced using non-porous materials (meaning water cannot pass through). This results in high volumes of water running across surfaces following periods of rainfall. Active travel infrastructure, often located at the edge of a carriageway, has the potential - when rain gardens are included - to help manage this run-off. In doing so, water is prevented or delayed from entering the overloaded traditional drainage system.

- **Flexibility**
  Rain gardens are a very flexible component in surface water management: flexible in shape, form, dimensions and materials and therefore are well-suited to integrating into active travel infrastructure where - as highlighted on p.16 - there is competition for space.

- **Streetscape & traffic calming**
  Rain gardens can be attractive and should be designed to enhance the streetscape in which they're located. Where appropriately located, they can also help traffic calming through providing visual clues about activity and prioritisation.

- **Pollution treatment**
  Engineered soil mixes in the rain garden can filter particulates and effectively treat polluted water.

- **Habitat and biodiversity**
  Particularly within the urban context, where trees and plants have limited space to grow, rain gardens offer the opportunity of space for growth and potential habitat for invertebrates.

- **Micro-climate**
  Evapotranspiration from rain gardens can help to cool the surrounding environment and tree canopies provide solar shading: both have the potential to create an environment more encouraging of active travel.

Above: rain gardens providing amenity value in Enfield, London
Image credit: Walk Wheel Cycle Trust

Where should a rain garden be located?

For a rain garden to work and function, it needs to be located in a position that allows water to easily flow into it. Given that water flows downhill, this typically means locating the rain garden at low points in the project area. Topographical surveys, combined with site observations, can provide the necessary information to determine where these low points are.

However, there are a few other important factors that may help determine suitable locations:

- Consideration of the size of the catchment area that is to drain into the rain garden. This, coupled with sizing of the rain garden, may be a determinant of where it is to be located.
- If a street is to be completely redesigned and re-engineered there is the possibility that existing levels i.e. the existing low and high points, can be adjusted to create more suitable locations for rain gardens.
- Flow accumulation modelling - a computer modelling technique that shows where water flows within a given catchment - will indicate where the peak flows are. Whilst not always possible, due to where a project area is located, it is potentially more beneficial to locate a rain garden in a location that isn't subject to peak flow. The rationale behind this is that by locating a rain garden in a position that is not subject to peak flow, you are reducing the amount of water that reaches the (existing) peak flow location, thereby improving the capacity and resilience of the peak flow location.

How does the water get into a rain garden?

There are range of design options to enable surface water run-off to reach and enter a rain garden. The choice of option will be determined by the specific context for that rain garden: both the location and the preferences of relevant stakeholders.

Flush kerb - carriageway

Image: Nigel Dunnett

Flush kerbs are the most efficient means of allowing water into a rain garden.

Dropped kerb

Image: Walk Wheel Cycle Trust

A potential solution when flush kerbs are deemed unsuitable.

Channel

Image: Walk Wheel Cycle Trust

Channels can be useful when the rain garden is not located adjacent to the area being drained.

Flush kerb - footway

Image: Arup

Flush kerbs are the most efficient means of allowing water into a rain garden.

Gaps between kerbs

Image: Walk Wheel Cycle Trust

Potential for blockages in the gaps if not adequately maintained.

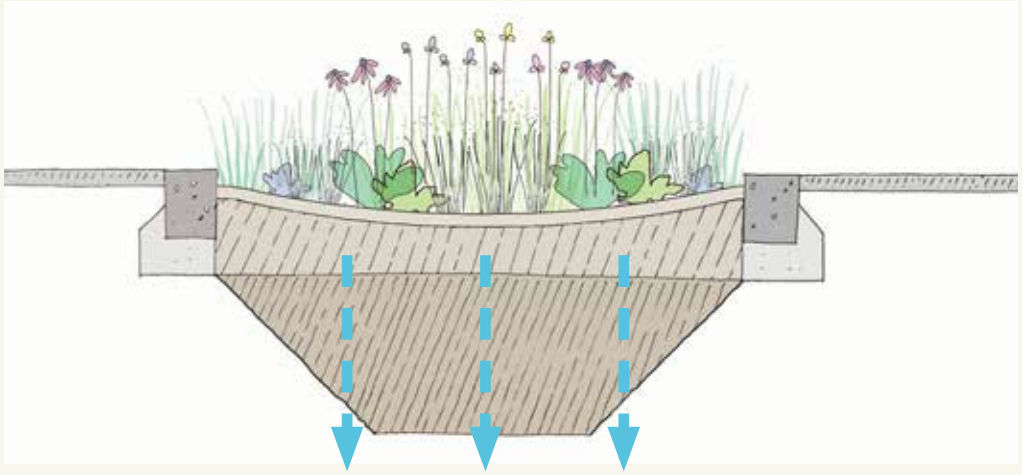
Where does the water go to?

Some water will be removed through evaporation and plant transpiration, but water that has filtered through a rain garden may end up in one of two places:

- **Connection to a pipe or under-drain**
  A perforated pipe running beneath the rain garden can take water away to either infiltrate the ground elsewhere or to connect to a traditional drainage system. If the latter, the rain garden has still played a valuable role in slowing down the rate at which water from a storm event reaches the drainage system.

- **Infiltration**
  Preferably, if ground conditions allow, water can permeate the ground beneath the rain garden and soak away naturally. It is important, if infiltration is to take place, that adequate filtering of pollutants has taken place through the rain garden.

To determine which of these approaches is most suitable, it needs to be determined whether infiltration is possible (via an infiltration test) and where any piped water could be taken to.



Above: water permeating through the rain garden infiltrates the ground beneath.
Image credit: Walk Wheel Cycle Trust

Above: water permeating through the rain garden is taken away via a perforated pipe. Sometimes referred to as a lined system.
Image credit: Walk Wheel Cycle Trust

How big does a rain garden need to be?

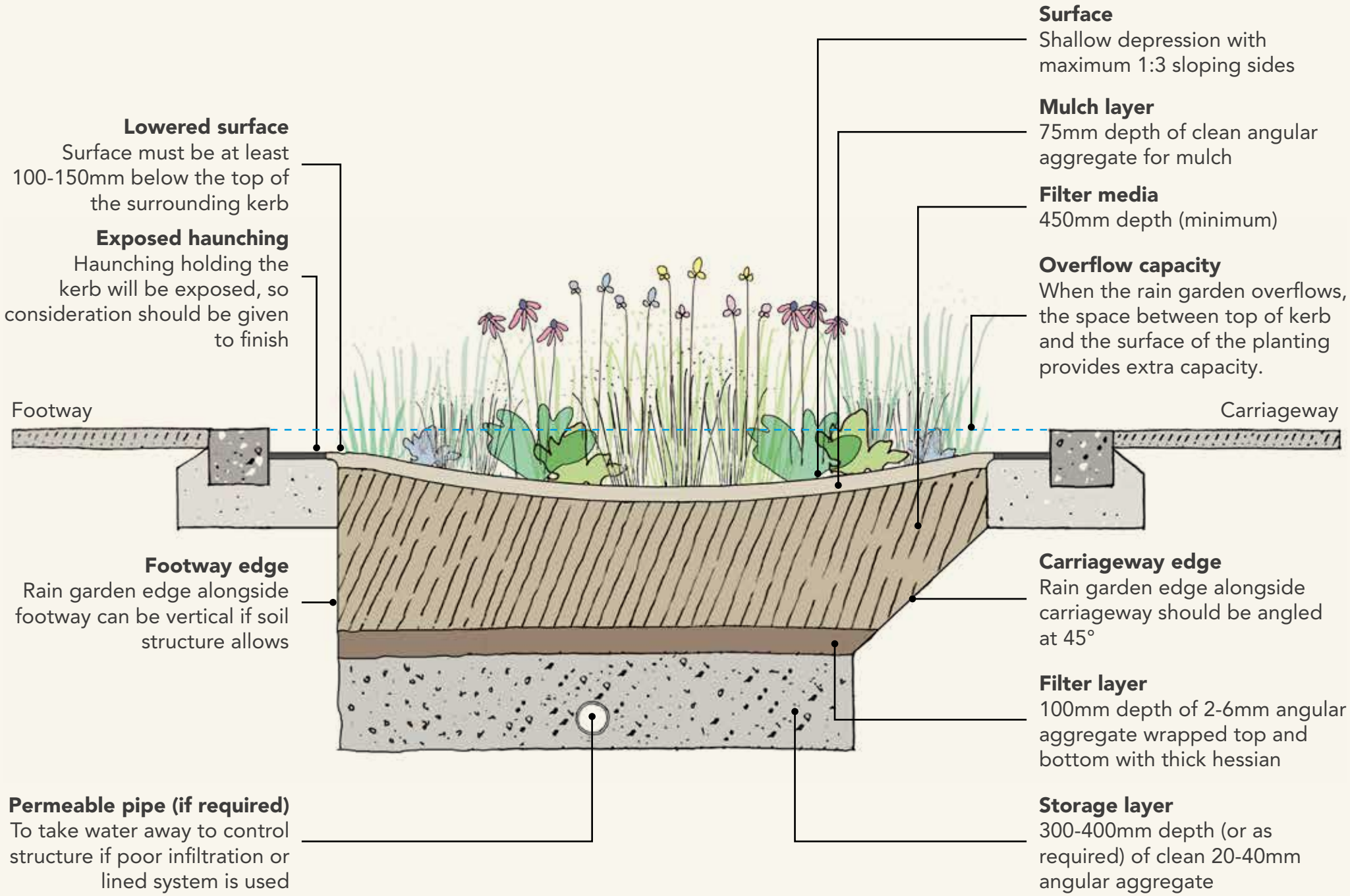
The bigger the rain garden, the more water it will be able to handle and the more benefit it will provide in terms of storm water management. However, the bigger a rain garden is, the more space it will require and the more it will cost to construct. Within the constrained environment of a street, the sizing of the rain garden will need to balance the volume of rainfall in the catchment against the capacity of the rain garden.

Where there isn't space for a rain garden of sufficient size to take all the water within the catchment, alternative options will need to be considered. The design will need to ensure that there is either an overflow mechanism to allow water to reach the traditional sewerage drainage system, or that some water in the catchment by-passes the rain garden altogether and is handled by the sewer.

However - in reality - there are many other factors to consider beyond simple volumes: interception loses, infiltration and storm duration will all have an impact. The design team for a rain garden should therefore include a suitably qualified drainage or civil engineer, in addition to a landscape architect.

What does a typical construction detail look like?

What is shown below is a typical detail. It has been included to highlight some of the important design features in a rain garden. It is definitely just a illustrative example: landscape architects , together with civil and drainage engineers, should be involved in determining the specific detail for any given project.



Note: the rain garden also needs to consider what happens if total capacity is exceeded (not shown above).

Are rain gardens always wet?

Contrary to what they name suggests, rain gardens are dry most of the time due to typically being well-drained. However, they need to be designed to cope with occasionally being inundated with water.

What can you plant in rain gardens?

The choice of planting depends on the type of soil specified for that rain garden (refer to p.31). In the example on p.29, which has a high rate of infiltration, plants and trees need to cope with both dry and wet conditions. These might include the following:

- Plants that typically grow in habitats that are regularly moist: these species are often able to also survive fairly well in drier soils. However, note that the opposite isn't always true and plants that are adapted to dry conditions tend not to cope with the waterlogged soil conditions occasionally present in a rain garden.
- Ornamental grasses are very popular in rain gardens, but herbaceous perennials and some tree species can add increased functionality to the rain garden.

Alternatively, in soils with a lower rate of infiltration, marginal perennials may be more suitable: these are plants that grow naturally at the edges of ponds.

It is also important to consider the varied conditions across a single rain garden. Some locations, for example - when close to an inlet - will be subject to water moving at a higher velocity. Therefore, in these locations, more robust planting will be a better choice e.g. shrubs such as geraniums, or grasses e.g. Calamagrostis, which are typically better at withstanding the movement of water.

What functions does planting perform?

Planting is multi-functional within a SuDS landscape. The following factors will all influence species choice:

- Ecological value / habitat (consult an ecologist).
- Biodiversity.
- Climate resilience.
- Aesthetic and amenity value.
- Potential for air quality improvement.
- Tolerance of pollution and salt.
- Likely level of maintenance required.
- Ability to effectively prevent soil erosion.
- Ability to trap silt and capture pollutants, whilst slowing flow of water.

A landscape architect will be able to advise on plant selection and specification to achieve different functions and outcomes.

Above: a recently planted rain garden in Stirling
Image credit: Walk Wheel Cycle Trust

Above: a roadside rain garden on Camley Street, London
Image credit: Walk Wheel Cycle Trust

What sort of soil does a rain garden need?

Talking about ‘soil’ in a rain garden doesn’t adequately cover the necessary functionality of the material in that rain garden, particularly in an active travel context when the rain garden may be alongside a carriageway. Specifically, the ‘soil’ used needs to facilitate the following:

- Drainage: allowing the drainage of water.
- Pollution control: filtering out contaminants.
- Growing medium: enabling plants to grow.

As a result, the material used in rain gardens is more appropriately termed ‘filter media’ requiring knowledge and input from landscape architects, horticulturists, soil scientists and engineers. It is worth highlighting that this filter media is a designed component, and the design will be a response to site conditions and what you are trying to achieve.

Above: rain garden alongside the carriageway in Stobswell, Dundee
Image credit: Walk Wheel Cycle Trust

Do they need lots of maintenance?

The amount of maintenance a rain garden needs is dependent on the design: maintenance requirements can be lowered through appropriate plant species selection, filter media selection and the design of inlets, check-dams and other features of the rain garden.

In common with any planted area, the most intensive period of maintenance in a rain garden is during the establishment phase, when the newly introduced plants are getting used to their environment. During this period, watering (irrigation) will be a vital activity to give plants and trees the best chances of survival. The establishment period will vary according to what has been planted:

- Grasses and short-lived perennials - 1 year
- Perennials and small shrubs - 2 years
- Trees and large shrubs - 3-5 years

Beyond the establishment period, there are some recommended maintenance tasks:

- Additional watering during exceptionally dry periods.
- Removal of litter and debris from inlets - annually.
- Replace of top-up mulch (if used) - annually.
- Pruning back of shrubs, grasses and perennials - annually
- Removal of any self-seeded invasive species.
- General management of planting, remove dead of damaged.
- Removal of any silt build-up - every 5 years.
- Inspection and clearance of gullies, inlets and dams - as required.

Maintenance of rain gardens vs traditional drainage

Traditional drainage systems use piped networks to move water around. One of the advantages of rain gardens compared with these traditional drainage solutions is that maintenance tasks can be carried out from the surface i.e. no costly excavations are required to repair or unblock pipework.

An additional point to consider - when discussing the cost of maintaining a rain garden - is that if a rain garden isn’t used as a solution there will still be a cost in maintaining whatever solution is used.

4.2.3 Filter strips / drains

In this section, we'll look at some of the common challenges and questions faced when looking to include filter strips / drains in active travel infrastructure.

What are filter strips?

Filter strips are linear strips of soft landscape that are gently sloped to catch and treat runoff from adjacent footways, cycle routes and roads.

How do filter strips work?

Filter strips work by capturing water from an adjacent area, which can then flow across the filter strip at a low speed. This low velocity allows the filter strip to help reduce pollutants in the water. As the water travels over the filter strip, above ground vegetation captures any sediments, organic or mineral materials in the water. The vegetation will soak up the available nutrients, with any excess material filtering into the soil below.

Filter strips can be used independently, or in conjunction with other green-blue elements such as swales, bioretention systems and filter drains (shallow trenches filled with gravel that can temporarily hold surface water runoff). Filter strips are best for managing everyday small water events, as their capacity to capture and treat runoff during storm water events is limited.

Why are filter strips relevant to active travel infrastructure?

Filter strips are well suited for managing run off from linear elements such as roads, pavements and cycle tracks. They are particularly useful in locations where there is limited space for the incorporation of green-blue elements and are suitable for retrofit design.

Filter strips can be used to treat polluted water and remove sediments, which are common in runoff from transport routes. This can be used as pre-treatment process before water is directed into rain gardens or swales, or as an independent feature.

Filter strips

Above: example of a filter strip in Stirling, located between carriageway and cycle track.
Image credit: Walk Wheel Cycle Trust

What planting can be used?

Filter strips can make a great contribution to biodiversity by incorporating wildflowers or perennial and herbaceous planting that supports local wildlife such as pollinators, birds and other invertebrates. Grass planting, either turf or seed, is also an option, but mono-species will have less benefits for biodiversity and require higher maintenance input than naturalistic planting such as wildflowers.

Any planting should be able to tolerate both wet and dry conditions, as well as a degree of sediment build-up. For use along carriageways or car parks, salt tolerant planting is advised.

Planting must be sufficiently dense to help capture pollutants as the water travels across, ideally covering >80% of the surface. Any tree planting should be paired with suitable ground level species that can accommodate shade from tree cover, to avoid bare patches across the soil surface.

What is the build-up beneath the surface?

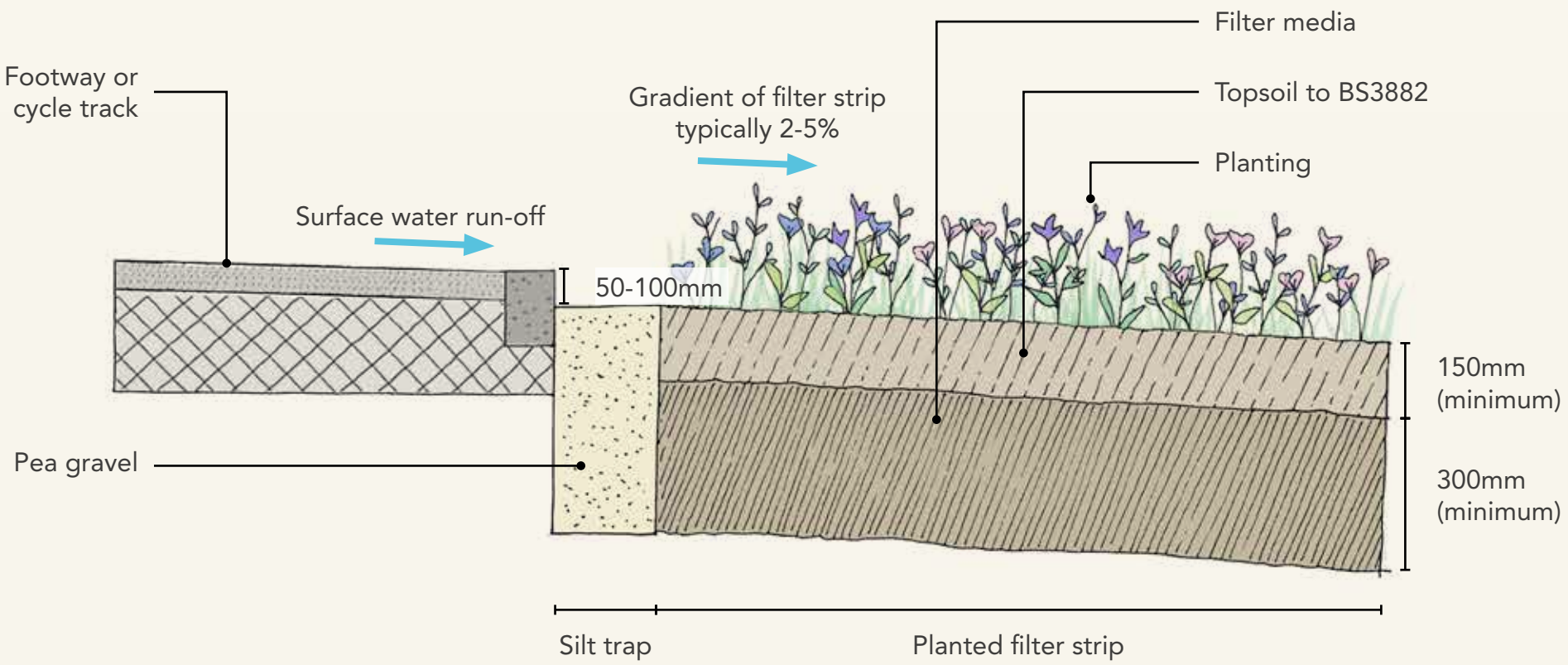
Filter strips should have a build-up of subsoil, topsoil and above ground vegetation. The topsoil should be a minimum of 150mm and free draining, allowing water to quickly reach the sub soil below. Subsoils should have a minimum depth of 300mm and be uncompacted, to allow the vegetation to properly establish.

To avoid polluting any groundwater, the maximum likely groundwater level should be at least 1m below the lowest point on the filter strip. In sites with sensitive groundwater conditions, filter strips may incorporate an impermeable geo-membrane liner. This liner should be at least 0.5m below ground level, and the potential for water-logging should be carefully considered during the design and construction.

Unlined filter strips are not recommended for use on brownfield sites. Unlined filter strips must only be used on brownfield sites if it is demonstrable that any risks of spreading contaminants will be managed to acceptable levels.

What does a typical construction detail look like?

What is shown below is a typical construction detail: it has been included to explain how filter strips function. This detail is an adapted version of that included in CIRIA's SuDS Manual (p. 292). The details, depths and specifications shown will necessarily vary. Civil engineers and landscape architects would collaborate in determining this below-ground detail.



How does water get into the filter strip?

The edge between the catchment area and the filter strip needs to be carefully designed to allow water to flow smoothly and avoid any blockages. A level-drop of between 50mm-100mm from the catchment area onto the filter strip is advised to prevent clogging. Optional use of a gently graded strip of fine gravel, at least 150mm wide, at the upper edge of the filter strip is recommended to help maintain even water flows.

Where there is likely pedestrian, cycle or vehicle activity adjacent to the filter strip, creating a protective barrier to prevent access across the surface will help avoid the soil becoming compacted. Options could include use of large rocks, bollards or low railings at the adjoining interface. However, ensuring sufficient width in the adjacent footway or cycle track will always be the most effective means of reducing this issue occurring in the first place.

How does the filter strip work?

For filter strips to work effectively, it is important they maintain 'sheet flow'. Sheet flow is the above ground movement of water in a consistent, shallow and non-concentrated flow.

- Surface water run-off from adjacent surfaces should be able to flow towards the filter strip. For cycle tracks, the cross fall should be a maximum of 2.5% (1: 40 gradient).
- Filter strips should be designed to that the gradient is consistent across the direction of flow. Filter strips should have a minimum longitudinal slope of 1% (1:100 gradient) to prevent the water pooling, and a maximum longitudinal slope of 5% (1:20 gradient) to prevent the water travelling too fast.
- Where slopes above 5% are necessitated by the site, a strip of fine gravel with a shallow, even gradient can be used at the top of the filter strip to help maintain sheet flow. This strip should be at least 150mm wide to enable it to distribute the water flow effectively.
- The depth of flow should be lower than the height of the surface vegetation to ensure optimal treatment can occur. A maximum flow depth of 100mm is advised.

Note: further technical detail on filter strips can be found in CIRIA's SuDS Manual (CIRIA, 2015). In addition, for advice on cross fall on cycle tracks, please refer to Cycling by Design (Transport Scotland, 2021).

How wide does a filter strip need to be?

The filter strip should run the full length of the catchment area. As a general rule, 1m width of filter strip should be provided for every 6m width of catchment area. It is not advised to use filter strips for catchment areas with a width of >50m.

- For longitudinal slopes around 1% (1:100), a width of at least 3m is recommended for optimum water treatment to be achieved.
- For longitudinal slopes up to 5% (1:20), a width of at least 5m is recommended for optimum water treatment to be achieved.

Do filter strips need lots maintenance?

In most cases, filter strips are very low maintenance and require little more than a litter pick or - depending on the type of planting specified - seasonal trim of vegetation.

Following storm events, it may be necessary to repair any damage to the filter strip. If required, planting should be replaced to maintain suitable vegetation densities across the surface. If stormwater or similar events are considered likely to occur, an excess water bypass (basically, an overflow) can be integrated into the design.

Care needs to be taken to ensure filter strips are not compromised by ongoing activity - such as vehicles parking or pedestrians walking over. This can result in the soil becoming compacted and limit the filter strip's ability to function.

The location of filter strips should be clearly defined and designed to minimise accidental damage on behalf of pedestrians, cyclists or motorists. Signposting filter strips can be helpful in improving awareness of their function and preventing unintentional damage.

What are the advantages of filter strips?

- Really good where space is limited: filter strips provide a useful solution for managing surface water where there is limited space available. They are particularly well suited alongside active travel routes and carriageways where space may be constrained.
- Flexible in their function: filter strips can be used independently or form part of wider green-blue networks.
- Suitable for retrofit design.
- Low maintenance.
- Potential to increase biodiversity and create nature corridors.
- Potential amenity value (though this is dependent on location, carriageway locations will limit amenity potential).

4.2.4 Planting

In this section, we'll look at some of the common challenges and questions faced when looking to include planting in active travel infrastructure.

Is all planting a form of SuDS?

All planting absorbs rainfall and, where there's a route available to the planting bed, surface water run-off. However, a typical planting bed **doesn't** have the ability to perform the following functions:

- Store a significant quantity of water.
- Substantially slow down the rate of infiltration.
- Provide an overflow route when maximum storage capacity has been exceeded in that planting bed.
- Filter pollutants from surface water run-off, where that water has a route into the planting bed.

Planting beds which aren't designed to perform as rain gardens or bioretention are therefore not considered a SuDS component in the management of water.

What is the benefit of including (non-SuDS) planting in active travel infrastructure?

Even when not designed to perform a SuDS function, planting does still play a valuable role in absorbing water and improving the 'sponginess' of an urban area. Sponginess refers to how towns and cities can work with nature to absorb rainwater, rather than use concrete to channel it away.

In addition to the absorptive benefits of planting, there are also great potential benefits to be had in terms of increased biodiversity, amenity and attractiveness, the absorption of air pollutants, and provision of solar shading. Planting (whether SuDS or non-SuDS) is also an effective means of separating different modal users (e.g. cycle users and vehicles).

How important is the soil used for planting?

Very. There are different soil types for different plants and different planting scenarios. If soil needs to imported to a site, there are standards (BS 3882 & BS 8601) to ensure suitable quality and important guidelines on provenance provided by the Scottish Environment Protection Agency. The project's landscape architect can advise on specification and provenance requirements.

Above: wildflower planting at Easter Bush, University of Edinburgh
Image credit: Jon Rowe

Are raised planters a good idea?

Raised planters offer an option for including planting in an active travel scheme where it isn't possible to break-up hard ground and plant at ground level. In this scenario, a raised planter does allow for an increase in biodiversity and provision of some amenity value to the surrounding area. However there are some shortcomings to using raised planters:

- Raised planters generally require more watering: they have a tendency to dry out because they don't benefit from either surface water run-off or groundwater.
- If trees are grown in raised planters, their growth is constrained by the size of the planter: there is a limit to how much their roots can grow beneath the surface. Their lifespan is also much reduced.

The image on the right shows a raised planter in the foreground and rain gardens in the background. They have both have received equal amounts of maintenance (watering), but the planting in the raised planter is clearly suffering compared to that in the rain garden.

Above: example of a raised planter (rain gardens in background)

How do you choose what to plant?

Choosing what to include in a planting palette requires knowledge, skill and experience. The following are all factors that should be considered in making an informed choice:

- Competition: will one species in the palette out-compete others and dominate the planting bed?
- Layers: create aesthetic layers vertically as well as horizontally.
- Provenance: think about what species work well together in nature, these combinations are more likely to feel harmonious rather than jarring.
- Seasonal interest: ideally, choose 2-3 species in a palette to be at their best through each season.
- Particular consideration to early spring and late autumn when other food sources for pollinators (e,g, bees) and invertebrates is limited. Biodiversity rich street design has the capacity to help support the recovery of many pollinating insects which are in serious decline nationally (Baldock, K. C. R. et al, 2015).
- Visual interest: balance ground-cover with design and structural layers. There are different species suited to each of these layers.
- Maintenance: different species require differing levels of maintenance, both watering and in terms of pruning/care.
- Salt and pollution tolerance: some plant species cope better than others with salt sprayers in winter and the pollution carried in surface water run-off.

Biodiversity rich streets have the capacity to provide valuable habitat for both common and rare species of wildlife, even small spaces can be important (Helden, A.J. & Heather, S.R. , 2004). The urban landscape is often incompatible with how wildlife might forage, breed, or move. Well-designed biodiversity rich streets can provide valuable stepping stones and corridors for these species to move between urban green spaces, and the wider landscape. Studies have shown that urban green spaces users derive more benefit from these spaces if they are perceived to be of high biodiversity value (Dallimer, M. et al., 2014).

Native or non-native planting?

Native plant species occur naturally in a given country, whereas non-native plants have been introduced by humans to that country.

In Britain, of the 3.500 plant species present, 51% are non-native. The decline in native species that this figure represents has been caused by centuries of species introduction, together with the impacts of both agriculture and climate change.

There is a long-running debate as to whether it is acceptable to plant non-native species: it is a debate for which there is no clear answer. However, the following themes are generally accepted:

- Invasive, non-native species should always be avoided.
- Growing native species is generally good for encouraging wildlife.
- Non-native species can also encourage wildlife. There is often a distinction made between non-native and exotic species: the latter are much less likely to encourage wildlife in the UK's environment.
- The rate at which our climate is changing is faster than the rate at which our plant species are able to adapt to cope. The UK is getting warmer, so it is therefore often advisable to look at plant species from locations a few degrees south e.g. northern France. Whilst these species will be non-native to the UK, they will be better able to cope with rising temperatures.

4.2.5 Permeable surfaces

This section looks at permeable surfaces and how they can be used to help manage surface water. Not all these surfaces are suitable for all scenarios, but they offer choices for both place and movement.

Are permeable surfaces SuDS?

Yes, definitely, permeable surfaces are really good at handling large volumes of water. They can also be used effectively in combination with other SuDS components.

Are permeable surfaces easy to maintain as a drainage component?

One of the benefits of using permeable surfacing to deal with water volumes is that - compared to other drainage features - the maintenance required is inexpensive: often, nothing more that a good brushing and cleaning of the surface every few years is all that is needed. This cleaning removes the build-up on any silt and maintains the permeability of the surface. In contrast, traditional drainage systems in pipes require access underground by specialist, skilled persons to address any maintenance issues.

Permeable surfaces

Above: permeable block paving in Stobswell, Dundee
Image credit: Walk Wheel Cycle Trust

Walk Wheel Cycle Trust

What do they look like?

	Permeable block paving	Self-binding / compacted gravel	Resin-bound gravel	Porous asphalt
	 Image: Walk Wheel Cycle Trust	 Image: Jon Rowe	 Image: Walk Wheel Cycle Trust	 Image: Copyright 2025 The City of New York
Initial cost	Varies, depends on type / product selected	Low cost	High cost	Medium cost
Durability	Average durability	Poor durability	Average durability	Good durability
Active travel design guidance compliance	Poor compliance bound surfaces preferred, unless very well laid		Good compliance though higher rolling resistance	Excellent compliance
Ease of repair	Easy to repair	Easy to repair but needed regularly	Hard to repair	Average to repair non-specialist repair
Accessibility	Average accessibility	Average accessibility poor, if not maintained	Good accessibility	
Sustainability - embodied carbon	High carbon cost	Low carbon cost	High carbon cost	Medium carbon cost
Sustainability - recylability	Easy to recycle	Medium recyclability	Hard to recycle	Easy to recycle

Where can permeable paving be used?

Whilst popular as a surface for car park spaces, there is often no reason permeable surfaces cannot be used in other circumstances: from public spaces to footways to cycle tracks (but compliance with relevant design guidance must be considered in specifying a surface).

Can construction traffic damage permeable surfaces?

Yes, there is a risk that construction traffic can damage permeable surfaces: dirt, dust and debris from construction sites can clog up permeable surfaces (e.g. in the gaps between individual block paving units) and ruin their permeability unless maintenance is carried out.

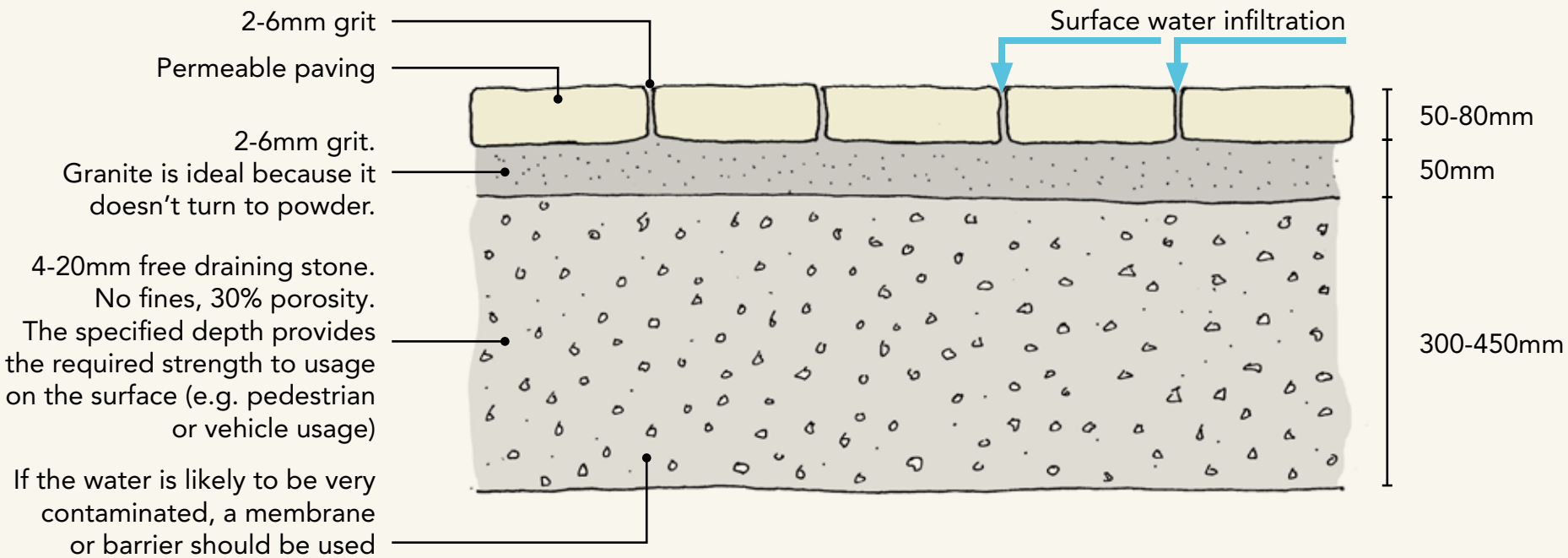
What happens under the surface?

The construction detailing - how the surface is laid and the build-up beneath - is as important for permeable surfaces as it is for standard footway surfaces. A civil engineer should be engaged in this detailing to ensure the following:

- The surface can withstand the intended usage and loading.
- The sub-base has adequate sizing to hold the anticipated volume of water (unless that water will be transferred via pipes to locations elsewhere).
- There isn't any conflict with existing services / utilities: the existence of these doesn't necessarily prohibit the use of permeable surfaces but does need careful consideration.

What does a typical construction detail look like?

What is shown below is a typical construction detail: it has been included to explain how permeable paving functions. However, the details, depths and specifications shown will necessarily vary. Civil engineers and landscape architects would collaborate in determining this below-ground detail.



Note: in some circumstances, a perforated pipe may be included at the base of the free draining stone layer to move water away.

How does water pass through permeable paving?

The water doesn't pass through the paving itself, but instead through the gaps between individual paving blocks. The grit between the blocks (shown in the detail above) acts as a filter medium, preventing dirt and pollutants from passing through.

Should permeable surfaces be used alongside rain gardens?

Typically, permeable paving isn't used alongside a rain garden. The rain garden should be designed to handle the volume of surface water run-off from adjacent impermeable surfaces. Adding permeable paving would, in most cases, be overcomplicating the design solution and be likely to add cost unnecessarily.

However, in some cases, permeable paving can positively compliment raingardens. For example by using permeable paving in areas that cannot drain to the raingardens due to levels, or by reducing the catchment that would reach a raingarden that is limited in size by other constraints.

5 Case studies demonstrating best practice and further sources of information

Moore Brook Green Link, Haselbury, Enfield

active travel biodiversity SuDS road safety amenity space

Above: rain gardens promoting traffic calming
Image credit: Walk Wheel Cycle Trust

Walk Wheel Cycle Trust

5.1 Moore Brook Green Link

Much of the following case study is based on conversation with - and information supplied by - Martin Jones, Senior Landscape Architect at Enfield Council and a site visit with Sustrans' London team.

What was included in the project?

The project incorporates safer routes for pedestrians and cycle users, enhanced public realm and amenity space, together with improved flood risk management incorporating rain gardens.

How did the project come about?

The project began as a response to flood risk in an urban residential area. Beneath this area ran a 'lost' river, the catchment of which was subject to flash flooding. Initially, in response, two wetlands were created: Firs Farm and Pymmes Park. However, as identified in the London Strategic SuDS Pilot, there remained a risk of surface water flooding that could be addressed through green and blue infrastructure interventions e.g. rain gardens.

Green infrastructure and SuDS then became an integral part of a wider ambition in the borough called the Haselbury Neighbourhood Improvements Scheme. This project aimed to make walking and cycling safer, in addition to improving the public realm, reducing flood risk and slowing traffic near schools. The Moore Brook Green Link was a major part of the project linking Firs farm and Pymmes Park.

Above: biodiverse wetlands provide beautiful amenity space, whilst sustainably managing storm water and educating about wildlife.
Image credit: Walk Wheel Cycle Trust

Who funded it?

The funding for the project came from a number of sources: Thames Regional Flood and Coastal Committee, Greater London Authority, London Borough of Enfield, Environment Agency, Thames Water, Cadent Gas Ltd. This funding totalled nearly £470k.

Key stakeholders

- Local businesses and community
- Local school
- Enfield Council

Project team - Enfield Council

- Landscape architects
- Drainage engineers
- Civil engineers

What has the project achieved?

- Reduced surface water flood risk.
- Improved water quality in Enfield's rivers by removing harmful pollutants from the drainage system.
- Enhanced biodiversity by planting a wide variety of species.
- Slowed traffic speeds in proximity to schools.
- Making several roads more pedestrian-friendly.
- Aesthetic enhancement of the road and the surrounding area
- Improved public understanding and perception of urban drainage issues and SuDS through school and community engagement.
- Inspiring more Green Infrastructure SuDS development and collaborative approaches to public realm projects.

5.1 Moore Brook Green Link

Above: a birch tree in a rain garden aiding drainage and solar shading
Image credit: Walk Wheel Cycle Trust

What made it possible?

The project was made possible by the fact that the proposals aligned the objectives of multiple stakeholders, namely:

- The opportunity to serve as a strategic pilot project for the Thames Regional Flood and Coastal Committee.
- Alignment with the Enfield Healthy Streets project team's interest in active travel routes.
- The opportunity to both create safer streets and to reduce surface water flood risk through the use of rain gardens as a traffic calming measure.
- Link two wetland areas through the development of a biodiverse corridor between the two.

Packaging the above ideas into a single concept design enabled engagement with multiple different potential funding sources.

Above: cycle racks with rain gardens and parking in background. A design responding to multiple ambitions.
Image credit: Walk Wheel Cycle Trust

5.1 Moore Brook Green Link

How was the issue of maintenance approached?

It was a challenging issue because, against the backdrop of budget cuts in local authorities, the scheme was ostensibly adding additional work to maintenance teams.

However, in common with other local authorities, maintenance expenditure comes from the revenue budget and not the capital budget. The focus was on reducing capital budgets and - in this respect - the project proposals contributed a lot to savings: reduced flood risk, improved street environment and enhanced road safety. Making senior managers aware of these savings was important when broaching the subject of maintenance work.

The reality is that, due to limitations in the capacity of maintenance teams, there has been very little maintenance carried out on the rain gardens in recent years.

Above: amenity benefits provided by rain gardens in residential areas
Image credit: Walk Wheel Cycle Trust

Above: biodiverse rain gardens line a pedestrian route
Image credit: Walk Wheel Cycle Trust

Grey to Green, Sheffield

biodiversity SuDS reallocated roadspace climate resilience regeneration

Above: a pedestrian walks past a child playing in a thriving rain garden in Sheffield's Grey to Green
Image credit: Arup

Walk Wheel Cycle Trust

5.2 Grey to Green, Sheffield

Much of the following case study is based on conversations with Zac Tudor, Associate Landscape Architect at Arup, previously of Sheffield City Council, and Roger Nowell of Sheffield City Council.

How did the project come about?

Despite Sheffield experiencing a severe storm event in 2007 - where the River Don breached its banks resulting in the tragic loss of life of two people, and hundreds of millions of pounds worth of damage - the initial driver for the project was actually related to a change in the city's road layout.

In 2010, construction of a new outer ring road meant that the existing inner ring road could be reduced from a dual carriageway to a single carriageway. This change created surplus space that could then be used for something new.

In determining what this 'new' use could be, it is important to understand that Sheffield was already developing a strong track record in successfully proposing change in its urban environment: the Gold Route became an award-winning, seamless sequence of streets, squares, gardens and spaces that link the city's two university campuses. In addition, there has also been a lot of work in introducing SuDS solutions to some of the more suburban areas of the city (e.g. the Manor Estate), resulting in these areas becoming effectively 'unplugged' from the traditional sewer network.

Against this backdrop of space becoming available and Sheffield's embracing of nature-based solutions, combined with an ambition to regenerate an area of the city, the concept for Grey to Green emerged.

Design concept

The design concept that developed for the former inner ring road, against this confident and innovative backdrop, sought to bring nature back into the city centre, to use SuDS to address pluvial flood risk and to build-in an element of climate resilience.

A photograph of a 'child running through a prairie' was an effective and successful means of illustrating this concept to stakeholders!

Above (both): people immersed in green in the heart of the city centre
Image credit: Arup

5.2 Grey to Green, Sheffield

Above: a cycle user riding between biodiverse rain gardens
Image credit: Arup

Who funded it?

The funding for the project came from a number of sources: Sheffield City Region, the European Regional Development Fund and Sheffield City Council. Phase 1 included a contribution from the Canal and Rivers Trust. Phase 2 includes a contribution from Yorkshire Water.

Project team

The composition of the team was important in giving Sheffield City Council the confidence that - collectively - the right people were engaged in the project. In addition to landscape architects from the council, who were the design leads, and engineers, the project team was supplemented by SuDS specialists from Robert Bray Associates and planting expertise from Nigel Dunnett of the University of Sheffield.

Green estates helped in the research and supply of a new functional and sustainable soils system. They also delivered the soft works for phase 2 of the project and, post-completion, work in partnership[p with the council's highway maintenance provider Amey to undertake the annual maintenance tasks.

What has the project achieved?

- 1.3km of new footpaths and cycleways.
- Transformation of part of a former carriageway into a green public space that encourages active travel.
- '24,000 bathtubs' worth of water is prevented from entering Sheffield's sewage system every year.
- Reduction in the amount of surface water that reaches the River Don every year, thereby reducing flood risk.
- Pedestrians protected from air pollutants due to being separated from vehicular traffic by the linear rain gardens.
- Major catalyst to the economic regeneration of this area of Sheffield.
- Improvements to urban biodiversity throughout the area.
- As the vegetation has matured this has also had the direct benefit of reducing the ambient local air temps creating a more comfortable and healthy urban environment.

Key stakeholders

- Local businesses
- Sheffield City Council

5.2 Grey to Green, Sheffield

Above: a cycle user riding between biodiverse rain gardens
Image credit: Arup

What sort of filter media was used?

The filter media was composed of the following elements:

- 70% crushed sandstone aggregate: locally sourced, promotes drainage and gives structure to the substrate.
- 20% composted green waste: slowly releases nutrients to plants and retains water for plant growth.
- 10% sandy silt loam: containing sand, silt and clay, a standard soil type to promote plant growth.

Carriageway - design

The design features a flush kerb between the carriageway and rain gardens. Acceptance of this was helped, in part, by the knowledge that the aggregate in the rain gardens could - if needed - bear the load of a vehicle. Traffic calming was helped by the lack of central line along the carriageway.

What sort of criteria were used in specifying planting?

The planting specification was undertaken by Zac Tudor, Sheffield City Council, and Nigel Dunnett, University of Sheffield, and was guided by some clear criteria:

- Stress tolerance: water and a low nutrient environment.
- Biodiversity: species selected need to positively contribute.
- Tolerant of simple maintenance: it has got to be easy.
- Visual attractiveness: city centre needs to look good.
- Creation of a structurally diverse habitat, helping with the wider benefits of biodiversity and capturing air pollutants.

What level of maintenance does the scheme benefit from?

The initial aim was to not create a 'burden' for Sheffield City Council. The scheme was only watered in the first year. Since then, there have been litter picks and a single annual cut for all planting in addition to weeding visits in late spring and early summer. This is done using shears by Green Estate Ltd, a locally-based social enterprise, and weeding visits in late spring and early summer.

How did the design cope with pollution carried in surface water run-off from the carriageway?

No specific measures were taken when specifying planting to take account of pollutants. The plants, together with the filter media in which they reside, have been capable of handling any pollutants that have entered the rain gardens. There has been very minimal observed damage as a result of such pollutants.

What were the key lessons learned?

Somewhat surprisingly, the answer to this question was related more to active travel than to green and blue infrastructure. In phase 1 of the project, pedestrians and cycle users shared the same path, without separation between the two. In phase 2, pedestrians and cycle users were physically separated. Phase 1, as a result, attracted some negative feedback from users.

Greener Grangetown, Cardiff

biodiversity SuDS reallocated roadspace climate resilience regeneration

Above: a cycle user riding past rain gardens in Grangetown, Cardiff
Image credit: Walk Wheel Cycle Trust

Walk Wheel Cycle Trust

5.3 Greener Grangetown, Cardiff

Much of the following case study is based on discussion with colleagues local to Cardiff, in addition to information from both Arup and Susdrain.

Delivery

The project was delivered by the following partners: Cardiff Caerdydd | Cardiff Council, Dwr Cymru | Welsh Water, Cyfoeth Naturiol Cymru | Natural Resource Wales, Arup, ERH Communications & Civil Engineering.

Completed in July 2018, the total cost was £3million.

Overview of project

The original aim of the project was to reduce the amount of surface water that entered the combined sewer network, to be eventually discharged into the Severn Estuary (8 miles away): reducing operational costs for Dwr Cymru Welsh Water and increasing resilience against the impacts of climate change.

In order to achieve these aims, a project area - across 12 Victorian streets, encompassing 550 residential properties - was chosen and a design for a network of rain gardens and tree planting developed. Both of these elements perform a bioretention function, helping mitigate against pollutants (particularly in the first 5mm of rainfall). Filter media helps remove pollutants through physical and biological processes before allowing water to reach perforated pipes at the base of the rain gardens.

For more information, please refer to https://www.susdrain.org/case-studies/pdfs/greener_grangetown_case_study_lightv2.pdf

Community benefit

The community were engaged extensively throughout both the design and construction phases. Two key issues were the availability of parking and litter: both of these were positively addressed in the design with more parking and more bins.

Above: rain garden in Grangetown, Cardiff
Image credit: Walk Wheel Cycle Trust

Benefits delivered

The following benefits were delivered as part of the project:

- 4.4 Ha surface water removal from combined sewer.
- 127 new trees planted and 1,700m^2 of new green space created.
- 108 Rain Gardens.
- 14 road junctions improved for safety and inclusive mobility.
- 550m of new Bicycle Street (giving priority for cyclists) along the Taff Trail.
- 550m of new footway for pedestrians along the Taff Trail.
- Improved public realm with new street furniture and surfacing.
- Estimated value of the wider benefits of the project of over £8.4 million.

Taken from Greener Grangetown Case Study (Susdrain, no date)

5.3 Greener Grangetown, Cardiff

Above: rain garden in Grangetown, Cardiff
Image credit: Walk Wheel Cycle Trust

Active travel

Borrowing a concept from the Netherlands, a bicycle street was designed along 555m of the Taff Trail. The concept flips the existing hierarchy and intends to ensure the street is perceived as a cycle path with cars using the space as guests. Green and blue elements help in reinforcing this concept: for example, in using rain gardens in the narrowing of junctions, making it safer for walking, wheeling and cycling.

6 Conclusions

6.1 Change is necessary

Change in how active travel infrastructure is designed is necessary if that infrastructure is to deliver a more impactful response to two of the greatest threats facing humankind: the climate emergency and the biodiversity crisis. The need for a more impactful response is clear: human actions have triggered and accelerated both threats, so the onus is on us to do all we can to redress the balance.

6.2 Change benefits all

There are a multitude of benefits that can be delivered when incorporating green and blue infrastructure elements in active travel infrastructure:

- Storm-water can be sustainably managed to help prevent flooding.
- Biodiversity can be enhanced in urban areas.
- Air pollutants can be caught in planting, resulting in healthier environments for people.
- Carbon dioxide can be captured and stored by planting and healthy soils, helping to minimise the accumulation of greenhouse gases in the atmosphere.
- Tree planting can provide shading from the sun and help reduce the risks associated with urban heat islands.
- Walking, wheeling and cycling routes can be made more attractive and comfortable to people, encouraging their usage.

6.3 Change is possible

Whilst change can sometimes be challenging, there is fantastic precedent that has proven change is possible. Change, in the context of active travel infrastructure, can be made possible by:

Engaging the right people at the right time

This applies to both project stakeholders (funders, clients, local authorities, communities) and the team involved in realising the change.

Engaging project stakeholders at an early stage allows time for design proposals to be fully explored and understood. It gives people time to become familiar and thereafter supportive of the change.

Engaging a multi-disciplinary team to plan, design and implement the change is crucial. Planners, urban designers, landscape architects, arboriculturists, ecologists and engineers, **all** have their roles to play in making things happen.

Demonstrating the multitude of benefits

In addition to engaging the right people at the right time, it is also vital to ensure that the potential benefits of incorporating green and blue infrastructure are fully understood.

In many of the successful precedents, support and funding has come from more than one source. This has been possible because design proposals have responded and resonated with more than one funding objective and policy agenda. Active travel, biodiversity net gain, health, flood risk management and traffic calming are just some of the policy agendas that green and blue infrastructure can respond to. All of these policy agendas represent potential sources of funding.

An integrated approach to design and delivery helps encourage not only an integrated approach to funding, but can also help unlock support and resources from wider cross-departmental sources, further improving the project outcomes and benefits.

Not letting maintenance become a barrier

It is really important to demonstrate, at an early stage, that maintenance regimes for green and blue infrastructure can be viable.

Fear of the unknown, or misunderstanding of what is actually required can lead to an early refusal to engage positively in discussion. Therefore, demonstrating a viable reality for maintenance should be amongst one of the earliest conversations with stakeholders.

Green and blue infrastructure can be simple and can be designed with low maintenance in mind. It can also help to reduce maintenance burdens overall by reducing or removing the need for traditional buried infrastructure.

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