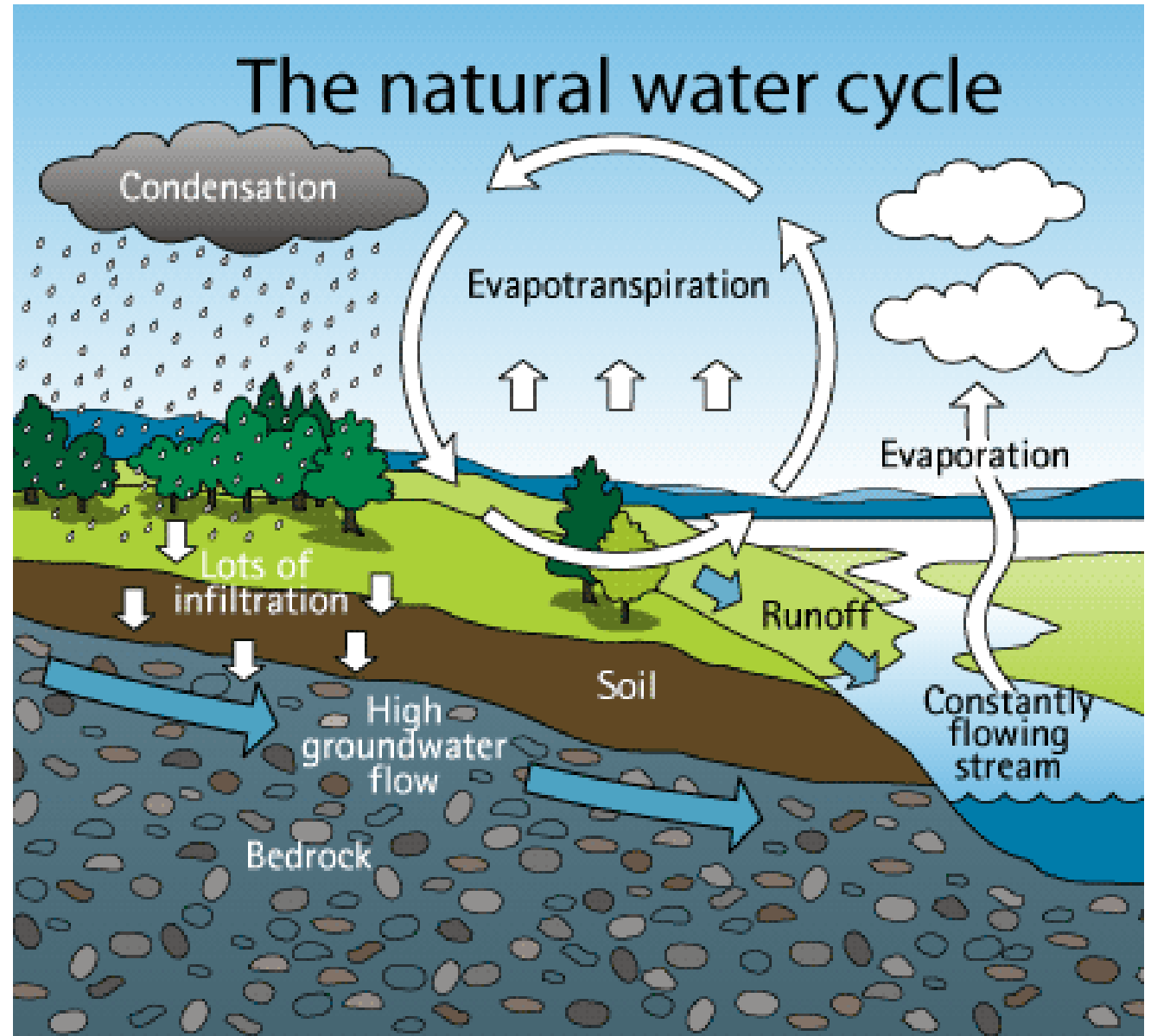




Sustainable Urban Drainage Systems

Surface Water Runoff

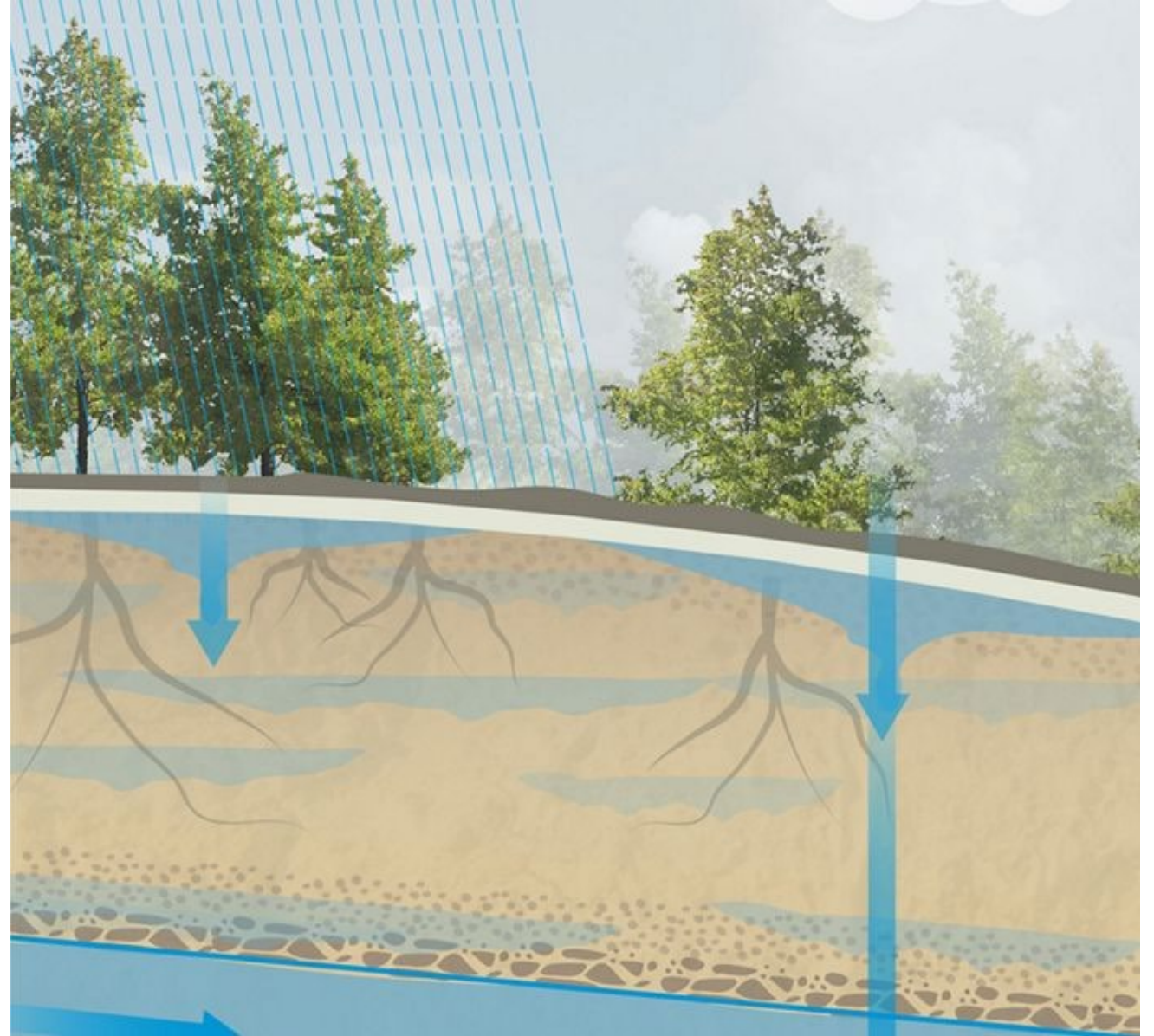
When rain falls on a natural landscape, several things can happen to it.



Surface Water Runoff

When rain falls on a natural landscape, several things can happen to it.

1. Infiltration



Surface Water Runoff

When rain falls on a natural landscape, several things can happen to it.

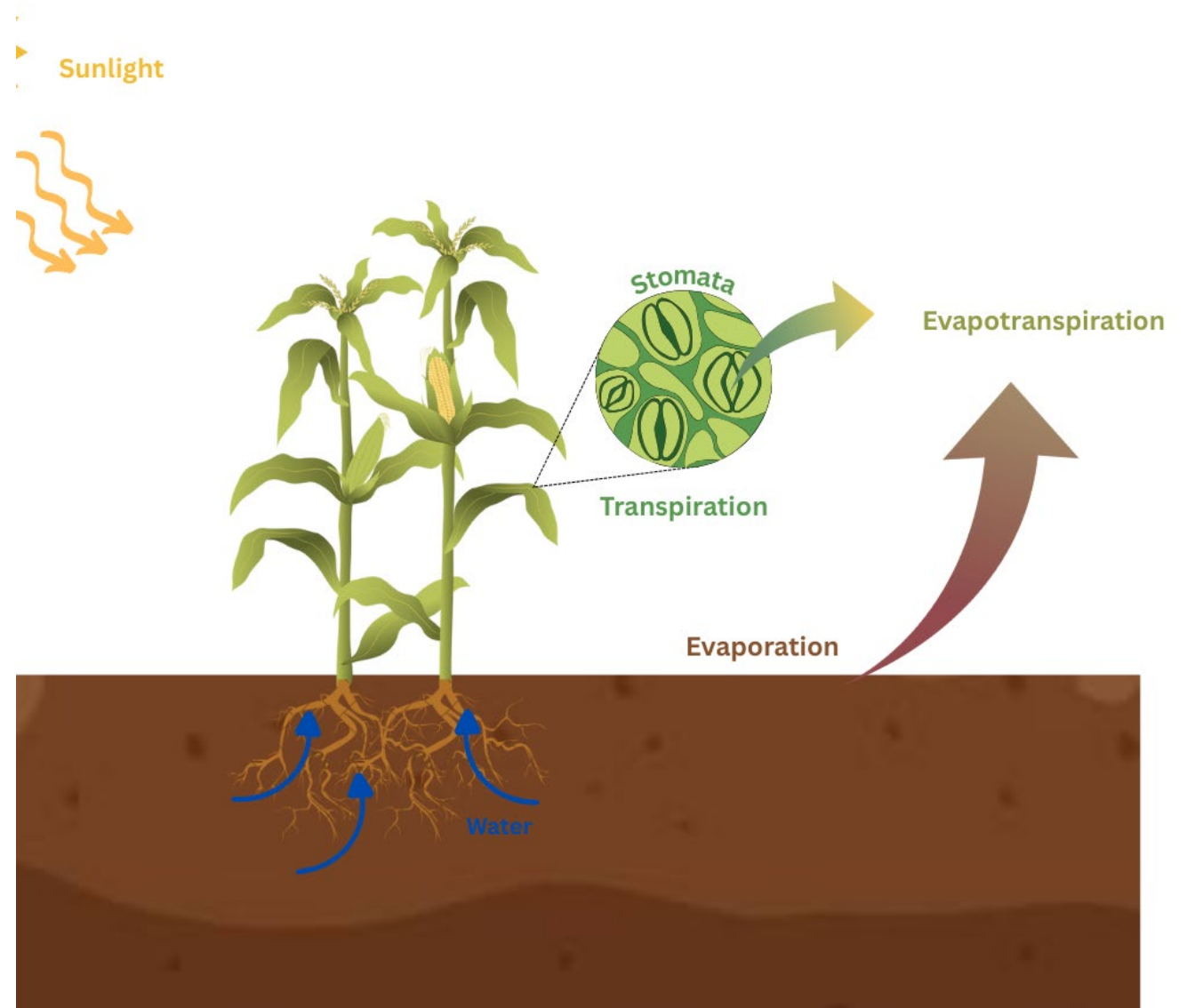
2. Runoff



Surface Water Runoff

When rain falls on a natural landscape, several things can happen to it.

3. Evapotranspiration



Surface Water Runoff

When rain falls on a natural landscape, several things can happen to it.

4. Storage

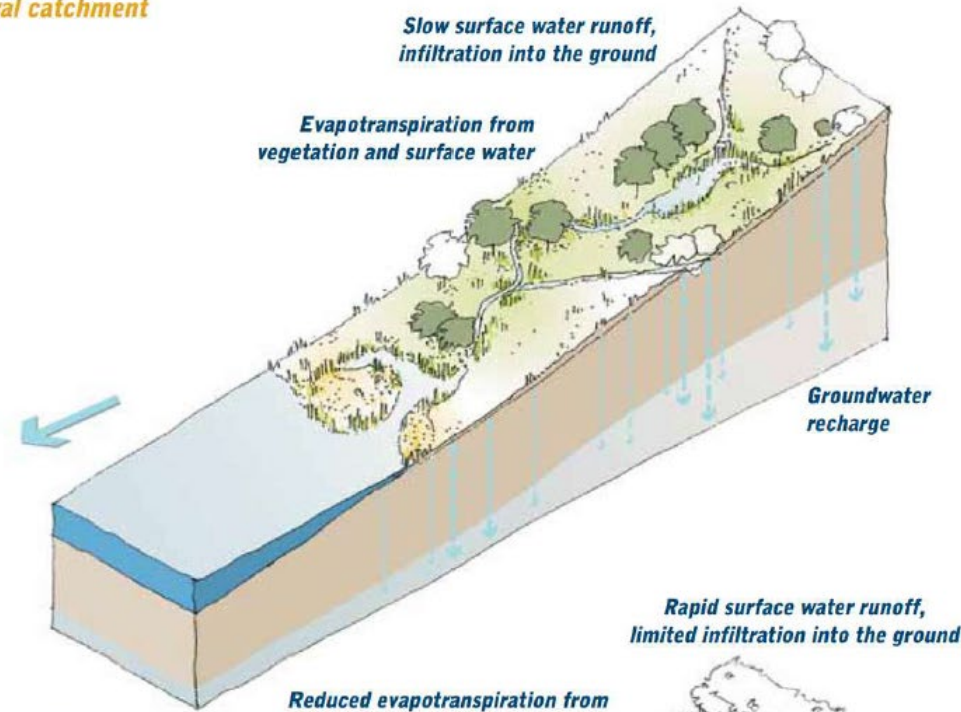


Surface Water Runoff

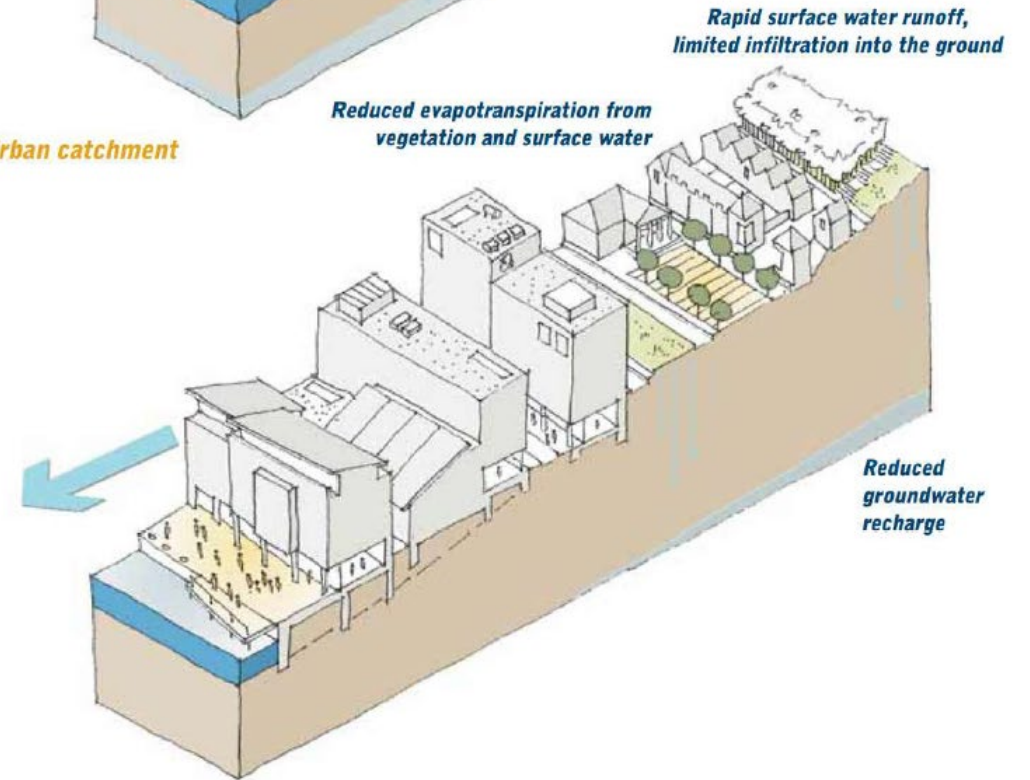
In urban areas, there tends to be less permeable ground available for infiltration and less vegetation for evapotranspiration.

When rain falls on impermeable surfaces, much more of it turns into surface water runoff.

Natural catchment



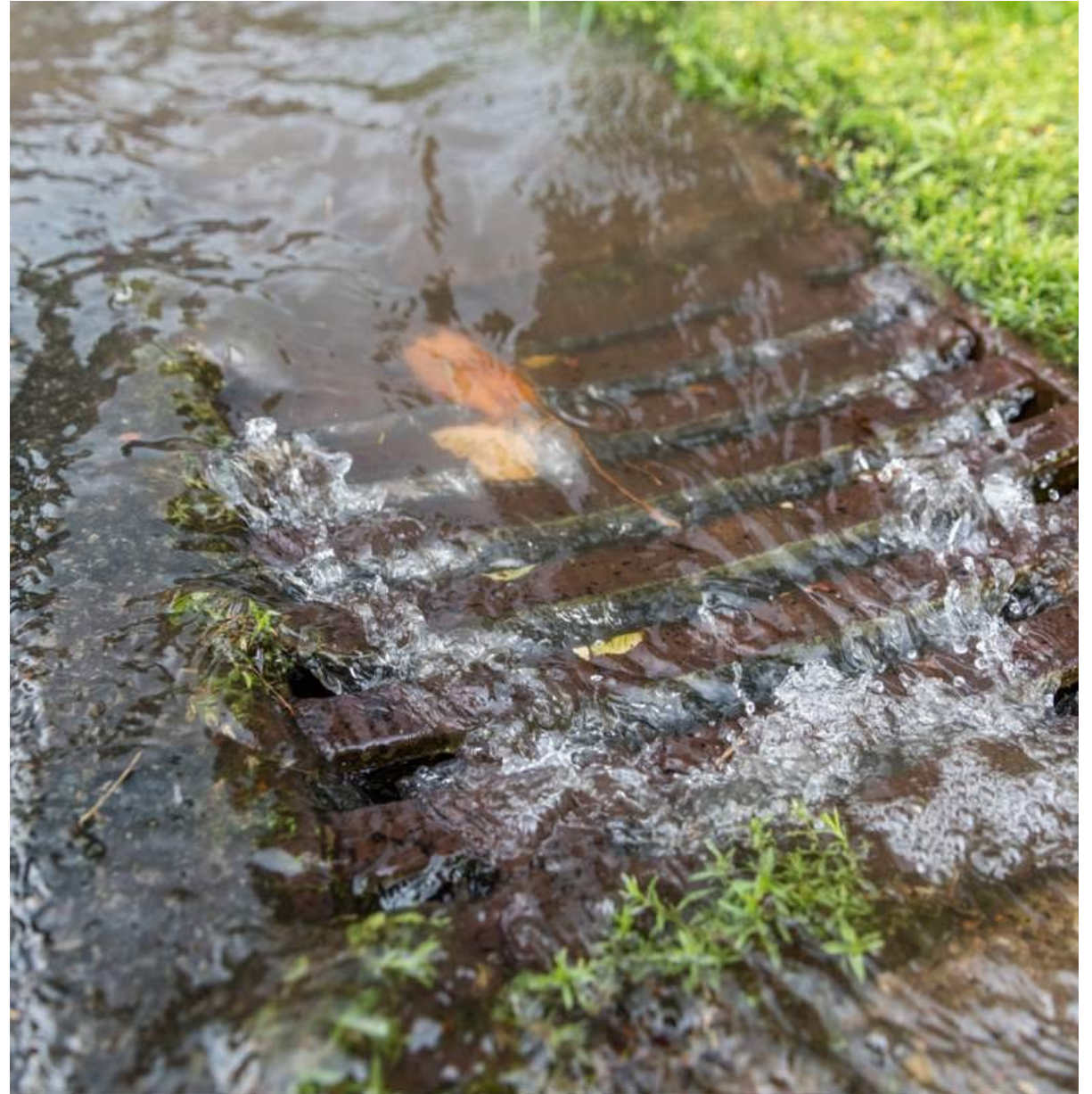
Urban catchment

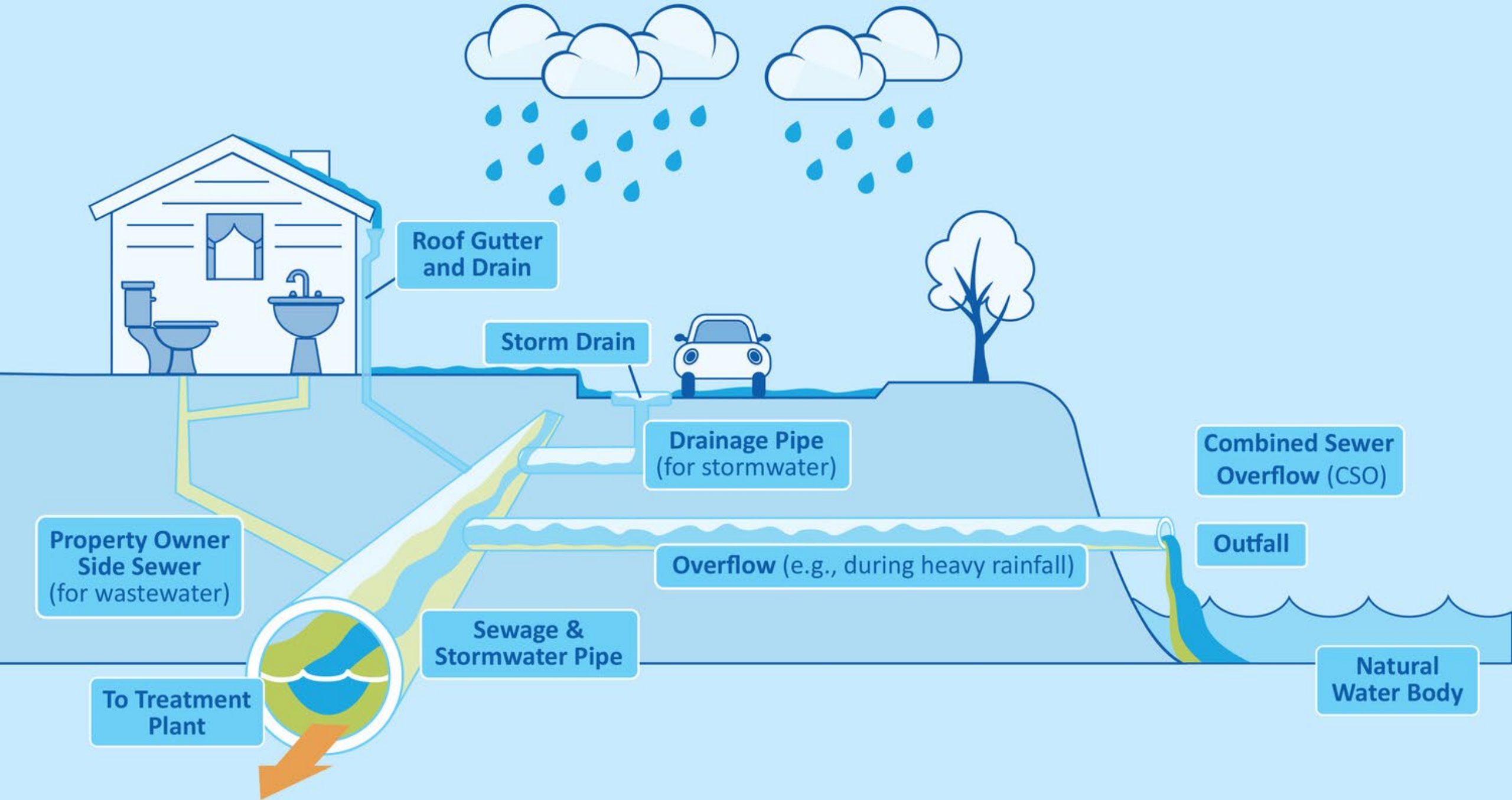


Traditional Drainage

Surface water drainage has traditionally been designed using underground pipes.

However, many older surface water systems drain to combined sewers which were not designed to accommodate today's volume of rainwater.





Anglian Water fined £500k for sewage discharge in Essex river

26th November

South West Water told to deal with waste water discharges

Wild swimmers are getting sick from sewage, campaigners say

🕒 24 November

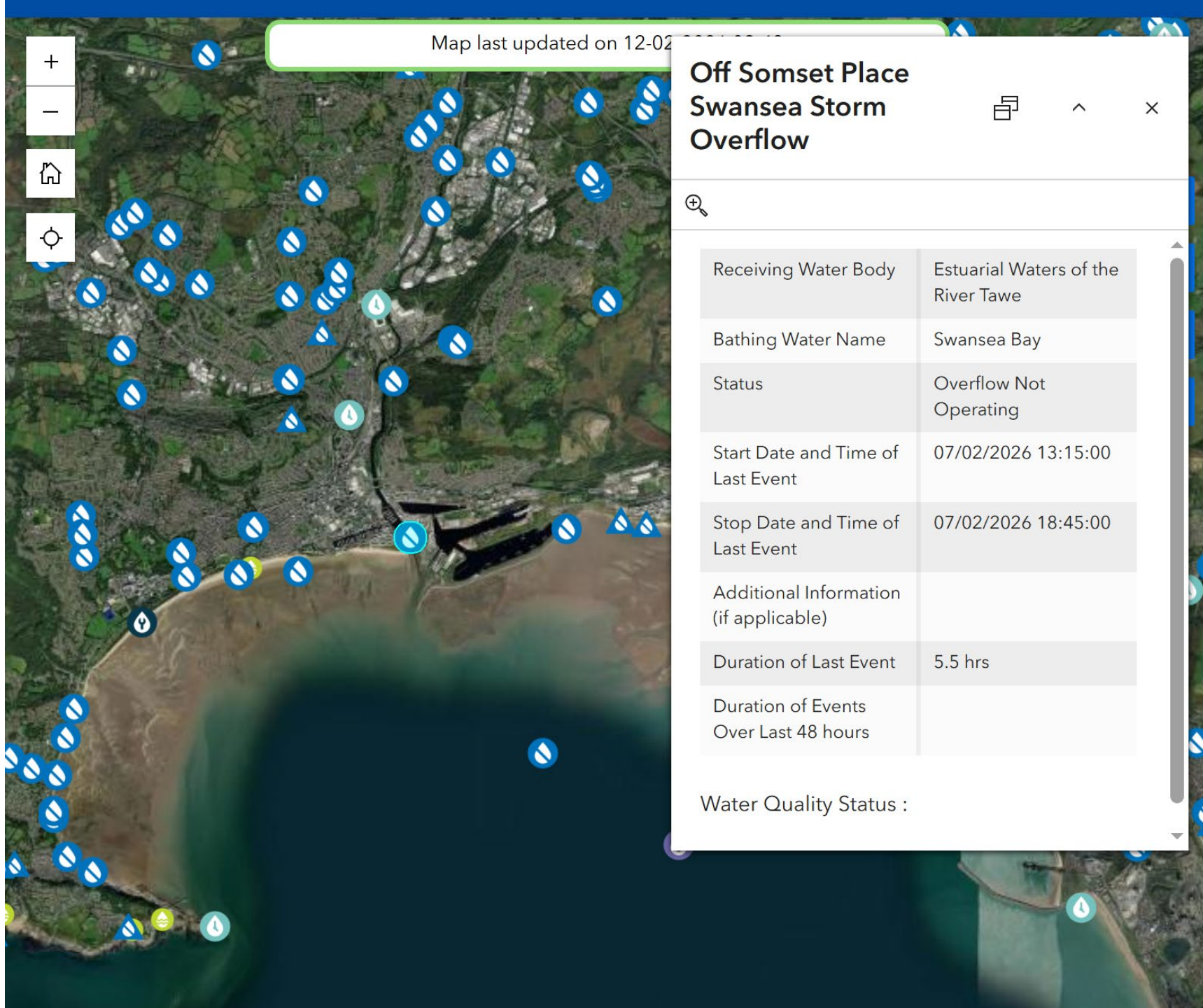
ENVIRONMENT

Half fall ill after surfing or swimming in British water

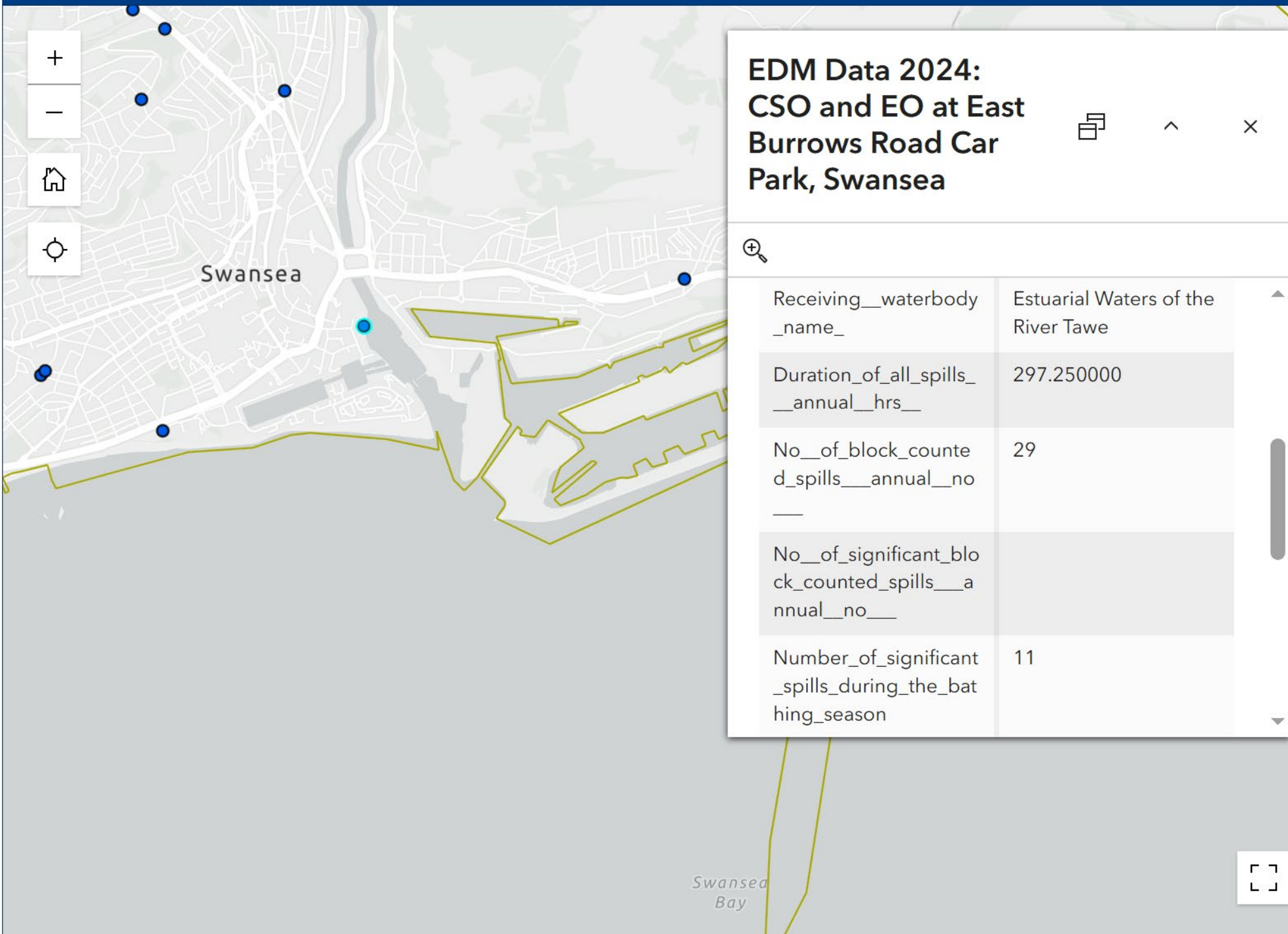
Southern Water 'dumps sewage 493 times in eight days at bathing beaches'

Campaigners condemning 'environmental vandalism' say equivalent of five months of discharges made so far in November

<https://corporate.dwrcymru.com/en/community/environment/storm-overflow-map>



<https://corporate.dwr.cymru.com/en/community/environment/event-duration-monitoring>



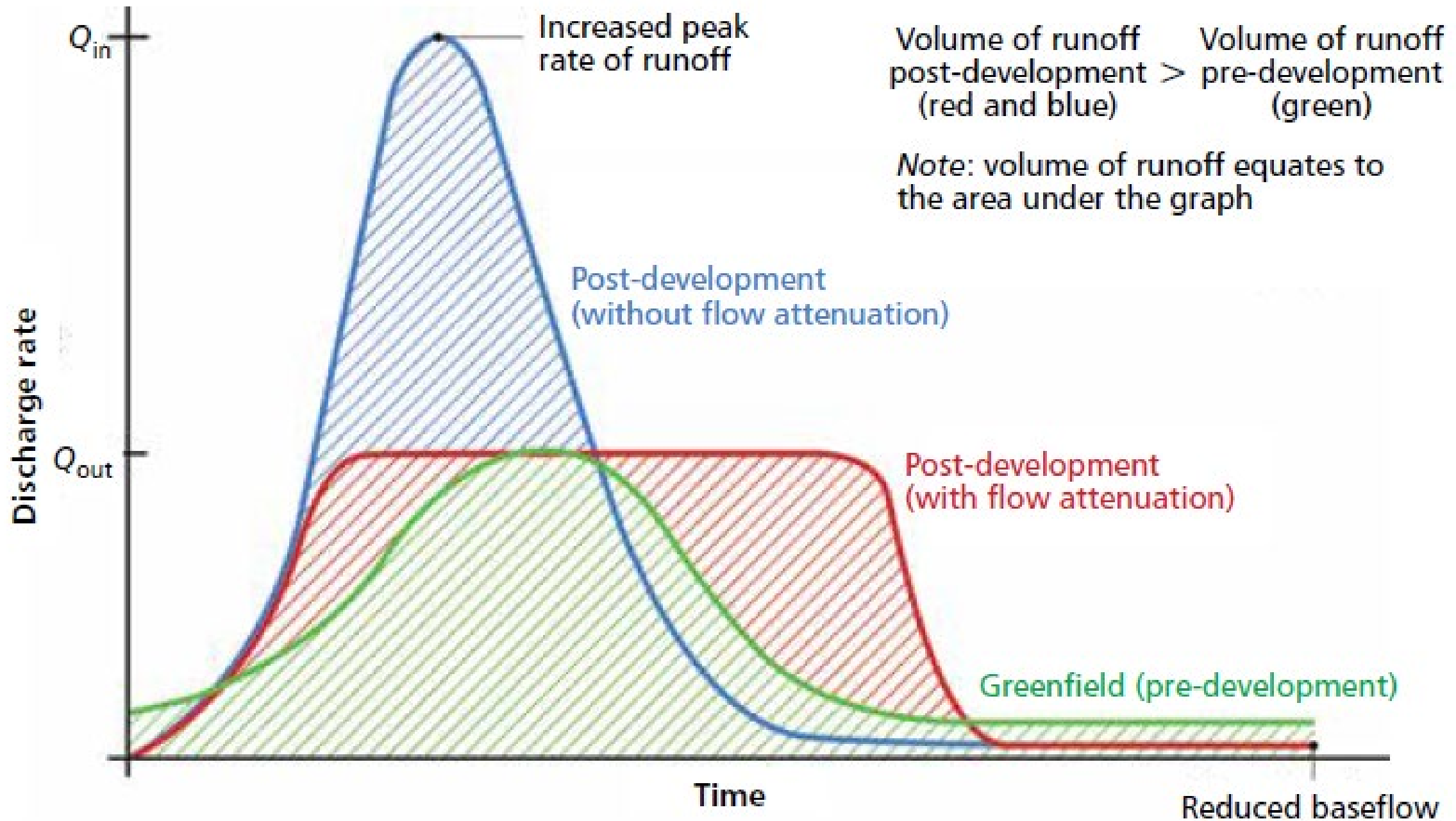
Principle of SUDS

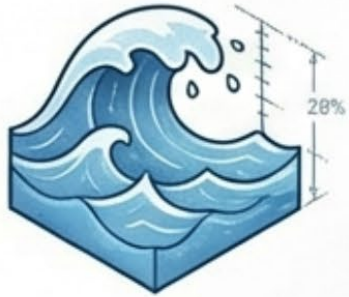
SUDS is about managing runoff.

When rainfall occurs faster than water can infiltrate into the ground it becomes surface runoff.

The aim of SUDS is to return the post-development runoff, infiltration and evapotranspiration to as near natural conditions as possible,







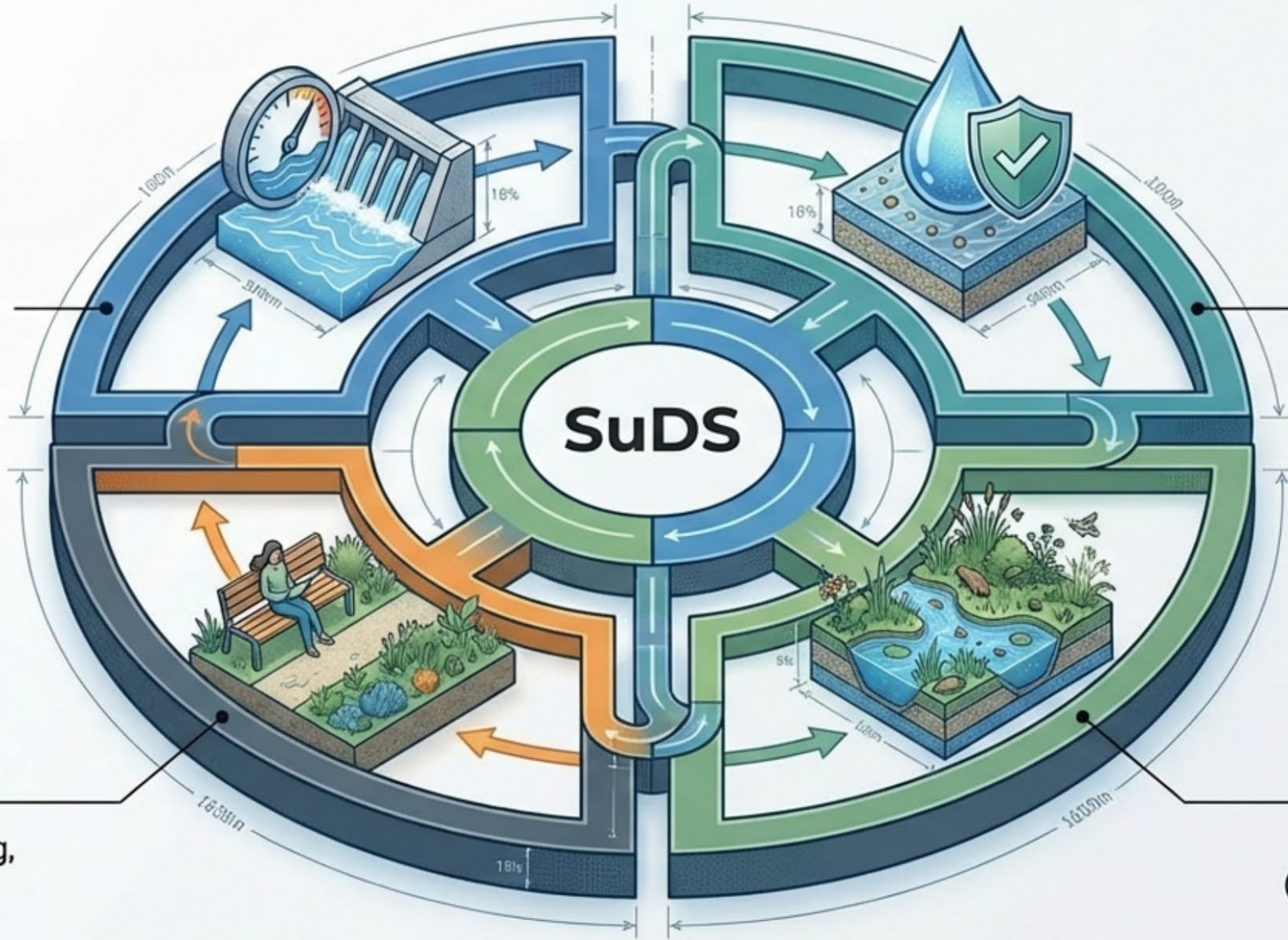
Water Quantity
Managing flow rates and volume to prevent flooding.



Water Quality
Filtration of pollutants—the key to nutrient neutrality.



Biodiversity
Creating habitats (wetlands, green roofs) for wildlife.



Amenities
Recreation, wellbeing, and aesthetic value for residents.

Water Quantity

- SUDS help manage surface water runoff by mimicking natural drainage processes.
- Instead of water flowing rapidly into sewers and rivers, SUDS slow down and control water movement, reducing the risk of overwhelming drainage systems.

Water Quantity



Water Quality

- Urban runoff often contains pollutants such as oils, heavy metals, and chemicals from roads and industrial areas.
- SUDS systems filter and break down contaminants before the water reaches rivers, lakes, or groundwater supplies.

Water Quality



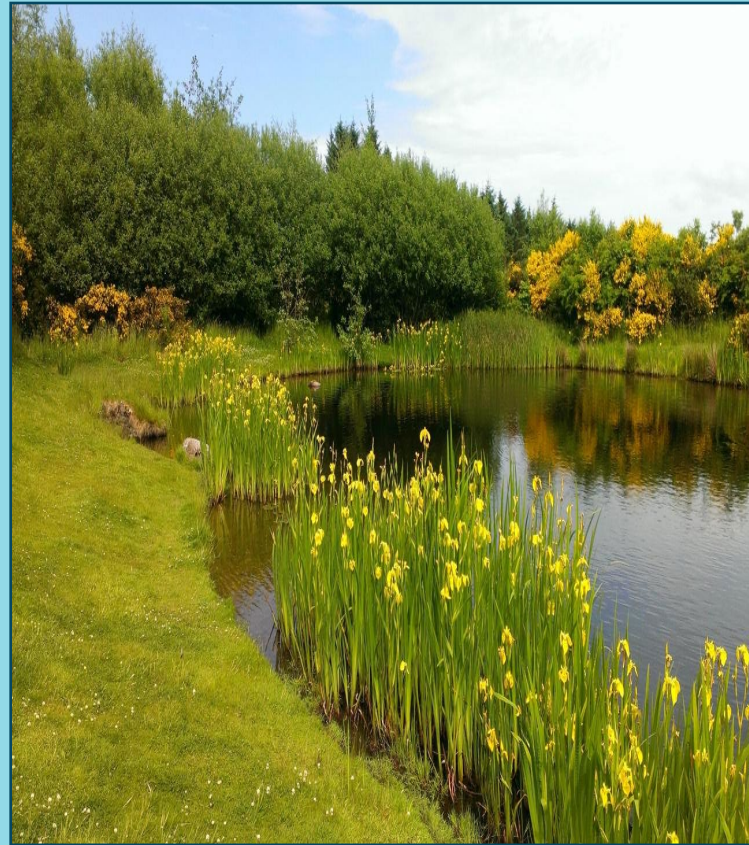
Biodiversity

- By incorporating green infrastructure, SUDS provide new habitats for plants, insects, birds, and aquatic life.
- These features enhance biodiversity in urban areas, which often suffer from habitat loss due to development.

Amenity

- SUDS contribute to more attractive and enjoyable urban environments by integrating greenery and water features into the landscape.
- Green infrastructure has been shown to reduce stress, improve mental health, and increase social interaction in communities.

Amenity



How construction planning affects SUDS?

Construction planning has a big impact on SUDS (Sustainable Urban Drainage Systems) because SUDS must be designed, protected, and built correctly to work properly long-term.

Sustainable Drainage: The Power of Site Integration



Strategic Space Allocation

Dedicate sufficient area for swales, ponds, rain gardens, and permeable paving.

Optimized Natural Flow

Position features at precise levels and gradients to facilitate gravity-based water movement.

Multi-Functional Landscaping

Seamlessly blend drainage infrastructure into public spaces and site greenery.

PROACTIVE INTEGRATION (The "Good Planning" Path)



EARLY SITE INTEGRATION

REACTIVE DESIGN (The "Poor Planning" Path)



Spatial Scarcity

Failing to reserve land, leaving no footprint available for drainage features.

Forced Redesigns

Ignoring SUDS early on necessitates expensive and disruptive last-minute site changes.

Performance Failure

Inadequate planning results in poor drainage and systemic site performance issues.

Common Construction Failures

Heavy Machinery Compaction

Large equipment compresses soil, making it significantly less permeable to water.

Drainage Pattern Disturbance

Unplanned site activities disrupt the land's natural ability to channel water.

Improper Topsoil Management

Mishandling or removing topsoil incorrectly prevents natural infiltration from occurring.

Reduced Soil Infiltration

Compacted ground loses its capacity to absorb and filter rainwater.

Increased Surface Runoff

Water that cannot soak into the ground creates hazardous surface flooding.

Total System Failure

Damaged soil prevents SUDS from functioning according to their engineering design.

The Impact on SUDS Performance



THE RISKS OF EARLY INSTALLATION

BEST PRACTICES FOR PHASING



Sediment and Debris Infiltration

Systems built too early often fill with mud and construction runoff.



Pre-Handover Blockages

Infrastructure may become blocked and non-functional before the project is even finished.



Optimize Installation Timing

Coordinate SUDS construction with final site surfacing to minimize exposure.



Deploy Temporary Safeguards

Use physical barriers to protect drainage areas during active building phases.



Final Inspection & Cleaning

Thoroughly clean and inspect all infrastructure before the final handover.

Drainage Material Selection: Planning for System Longevity

STRATEGIC MATERIAL DECISIONS (The Right Path)

Permeable Surface Prioritization

Opt for permeable surfaces over impermeable ones to facilitate natural water drainage.



Precision Component Selection

Integrate proper aggregates, filter materials, and flow controls into the design.



Optimized Pipe Sizing

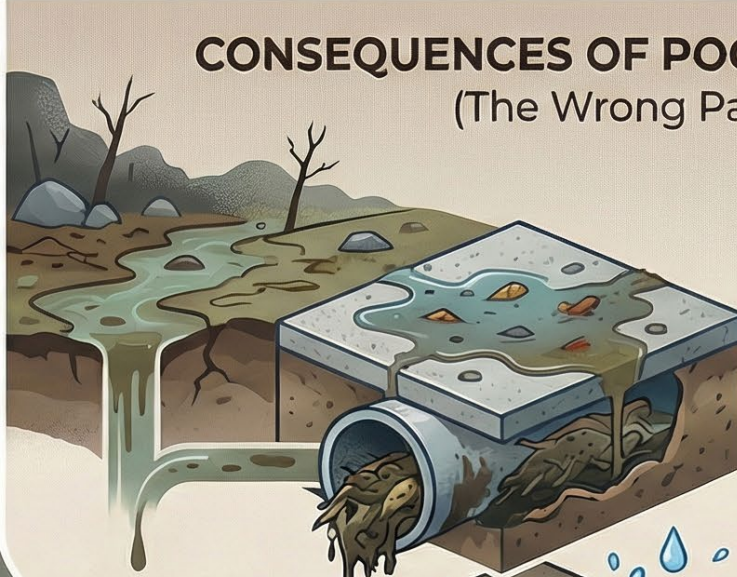
Ensure pipe sizes are calculated to handle specific volume and flow requirements.



CONSEQUENCES OF POOR SELECTION (The Wrong Path)

Systemic Clogging

Incorrect filter or aggregate choices lead to debris buildup and blockages.



Reduced Infiltration Capacity

Improper materials prevent water from effectively entering the drainage system.



Shortened System Lifespan

Material errors lead to premature structural degradation and replacement costs.



SUDS Compliance: Standards and Risks

COMPLIANCE OBJECTIVES

Flood Risk Control

SUDS must effectively manage water volume to mitigate local flooding.

Water Quality Improvement

Systems are required to treat and enhance the quality of runoff water.

Biodiversity Protection

Design standards prioritize the preservation of local plant and animal life.

RISKS OF POOR PLANNING

Regulatory Breaches

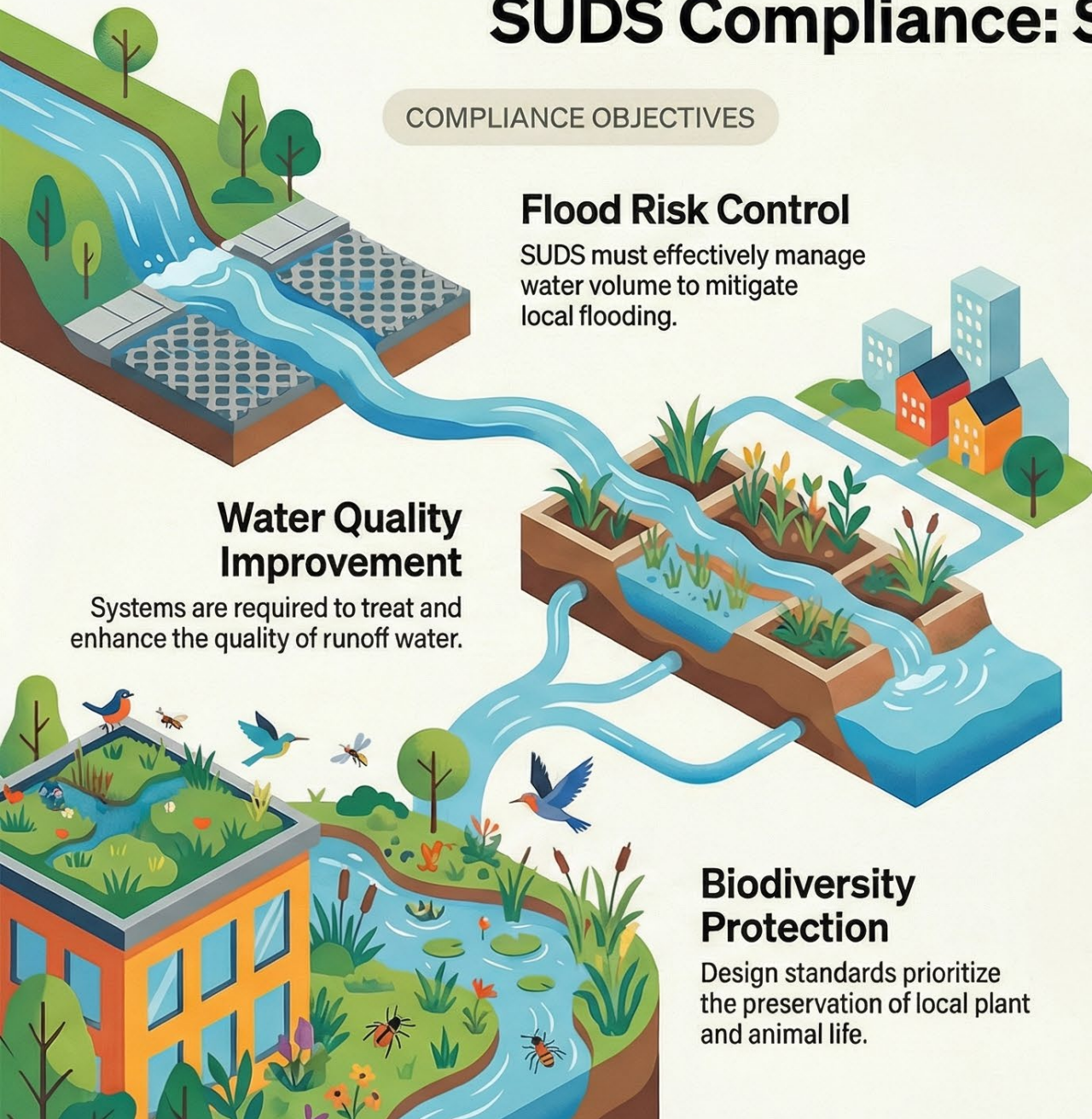
Inadequate designs may violate local drainage regulations and legal standards.

Planning Approval Failure

Projects may be rejected for failing to meet specific planning conditions.

Increased Downstream Flooding

Poorly planned systems often shift flood risks to neighboring communities.



SUDS Preservation: The Pillars of Maintenance Planning

Establish Safe Access:
Designate secure entry points for maintenance crews and equipment during the planning phase.



Define Ownership Responsibilities: Assign clear legal and operational accountability for the system's long-term upkeep.



STRATEGIC PLANNING REQUIREMENTS

Long-Term Inspection Plans: Create a formal schedule for recurring site assessments to ensure continued performance.



Rapid Loss of Effectiveness: SUDS systems fail to manage water runoff efficiently if maintenance is ignored.



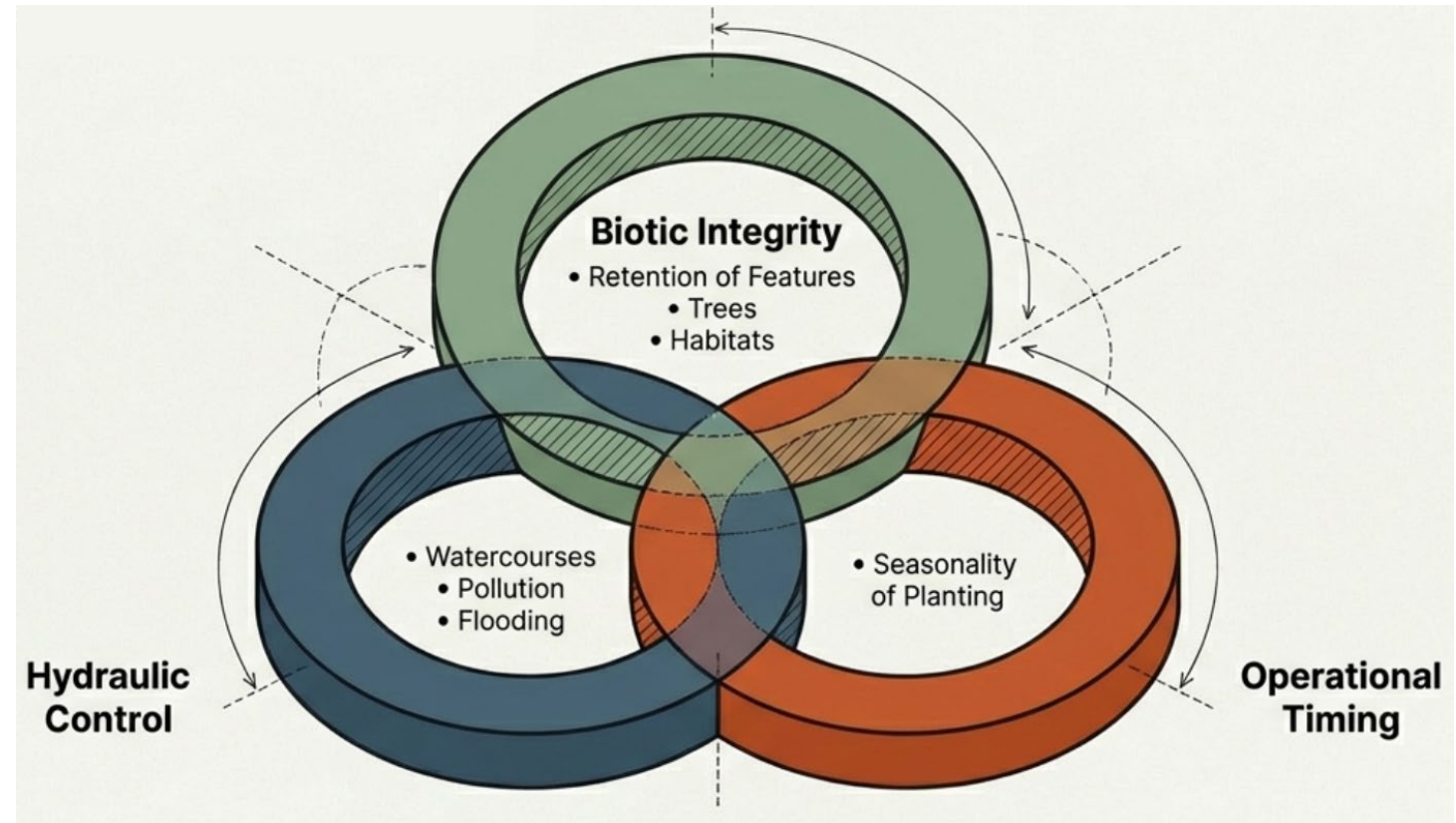
THE CONSEQUENCES OF NEGLECT

Physical Blockages and Overgrowth: Ponds and swales become obstructed by debris or unmanaged vegetation, leading to system failure.



How construction planning affects SUDS?

Environmental issues both on- and off-site can add further legislative and practical constraints so must be considered during the planning of SUDS construction





How SUDS affects construction planning?

Construction of traditional drainage follows well defined procedures.

It is usually constructed early in the construction process before superstructures are built.

This can therefore be used to help drainage on the site during construction.

How SUDS affects construction planning?

- For SUDS that are surface components, the levels, slopes and soil structure are crucial for their performance.
- Although SUDS can be installed early in a construction programme, they may have exposed surfaces, materials and vegetation that are prone to clogging by mud and silt.



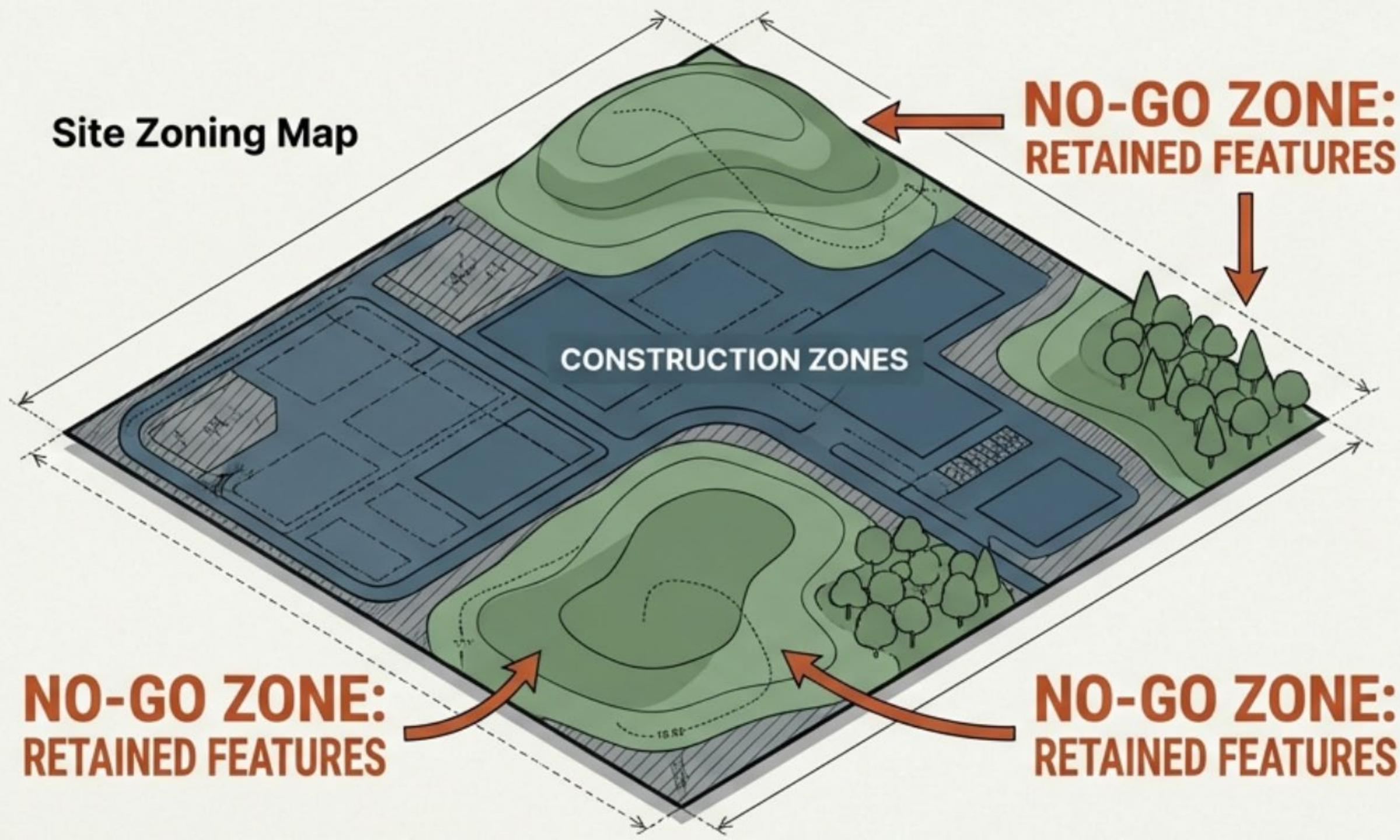


How SUDS affects construction planning?

SUDS generally require the land they are constructed on to be isolated from the construction process to prevent damage.

Vegetated SUDS require the planting to be sufficiently established before being used.

Site Zoning Map



Biotic Integrity



Hydraulic Control



Operational Timing



☐ Retention of Features mapped?

☐ Maintenance of Watercourses planned?

☐ Seasonality of Planting in schedule?

☐ Trees / Habitats fenced

☐ Prevention of Pollution (silt/chemical)?

☐ Prevention of Downstream Flooding calculated?

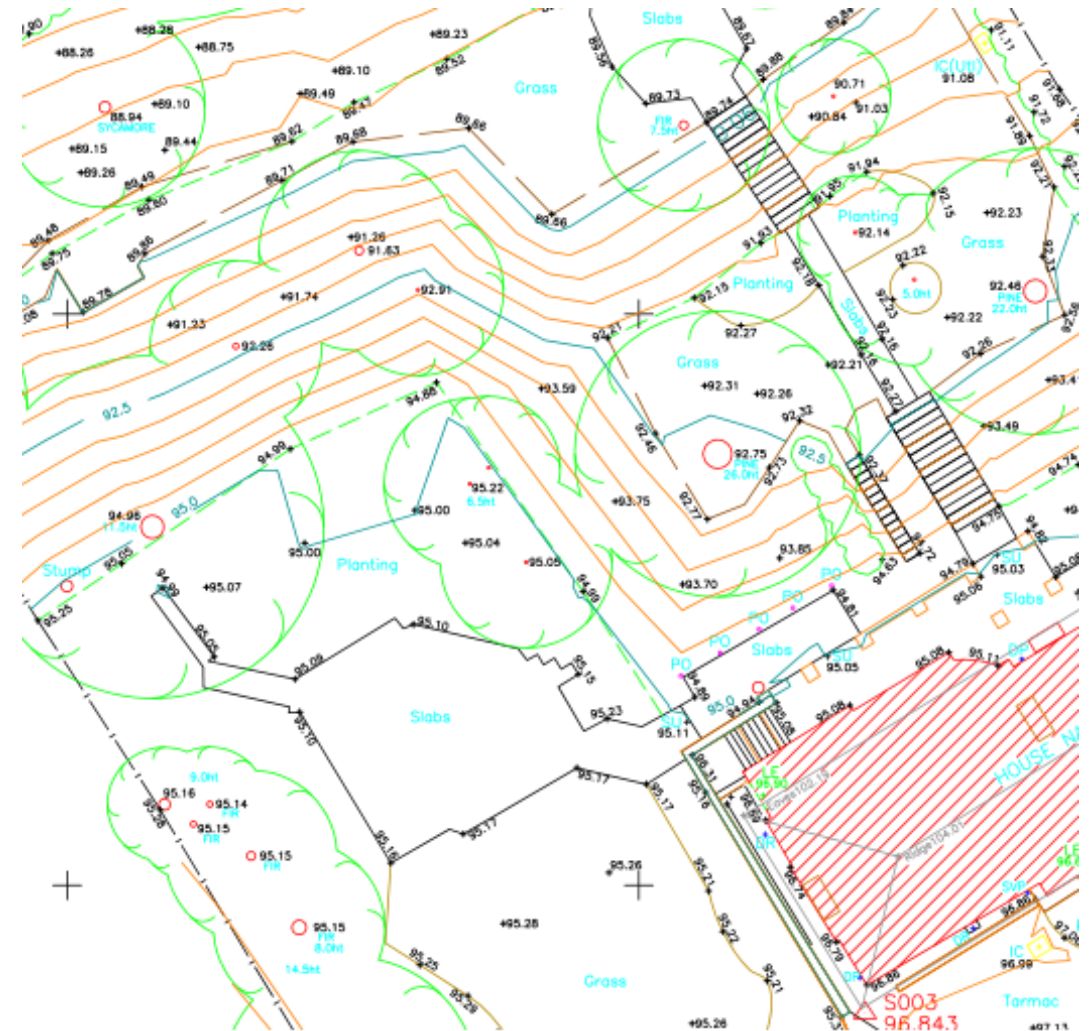
Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

Pre-construction

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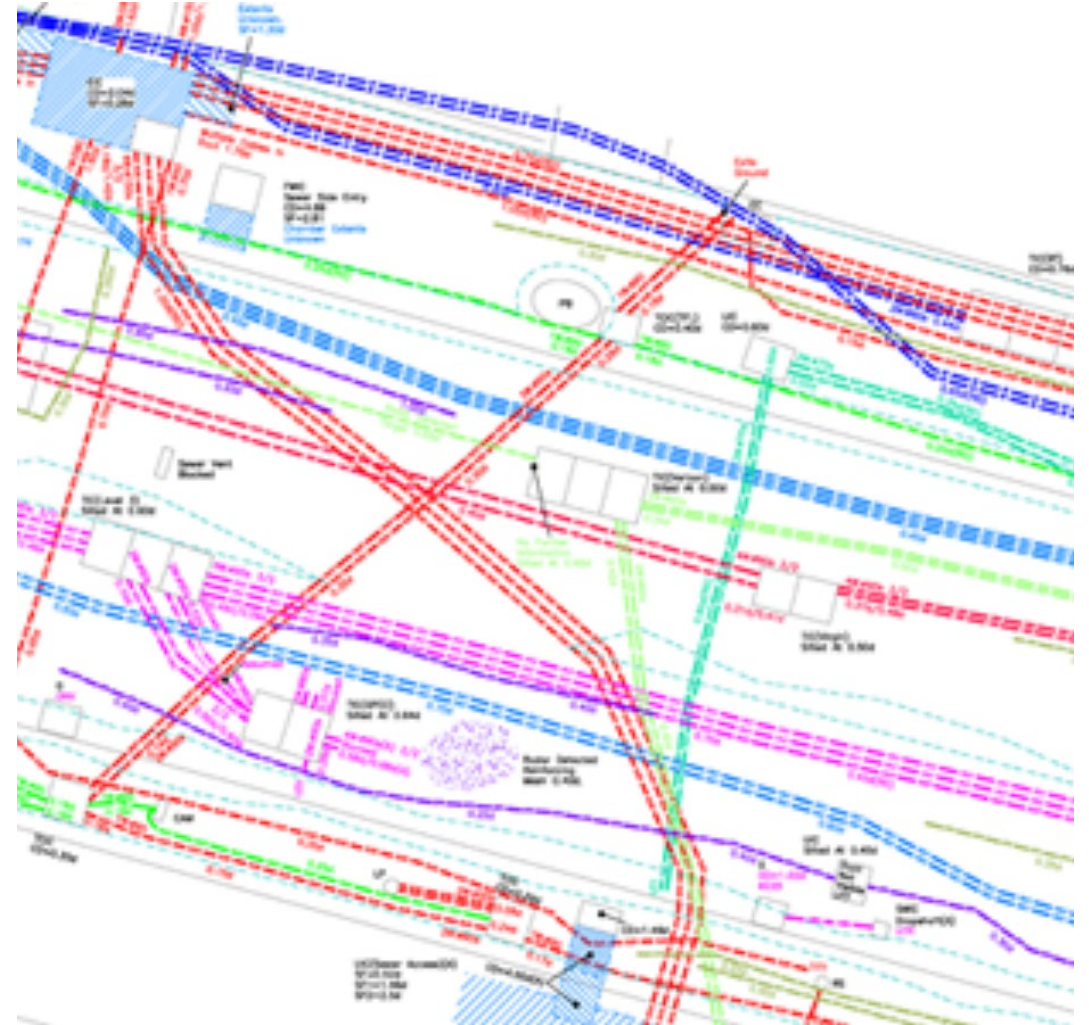
- Full topographic survey



Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

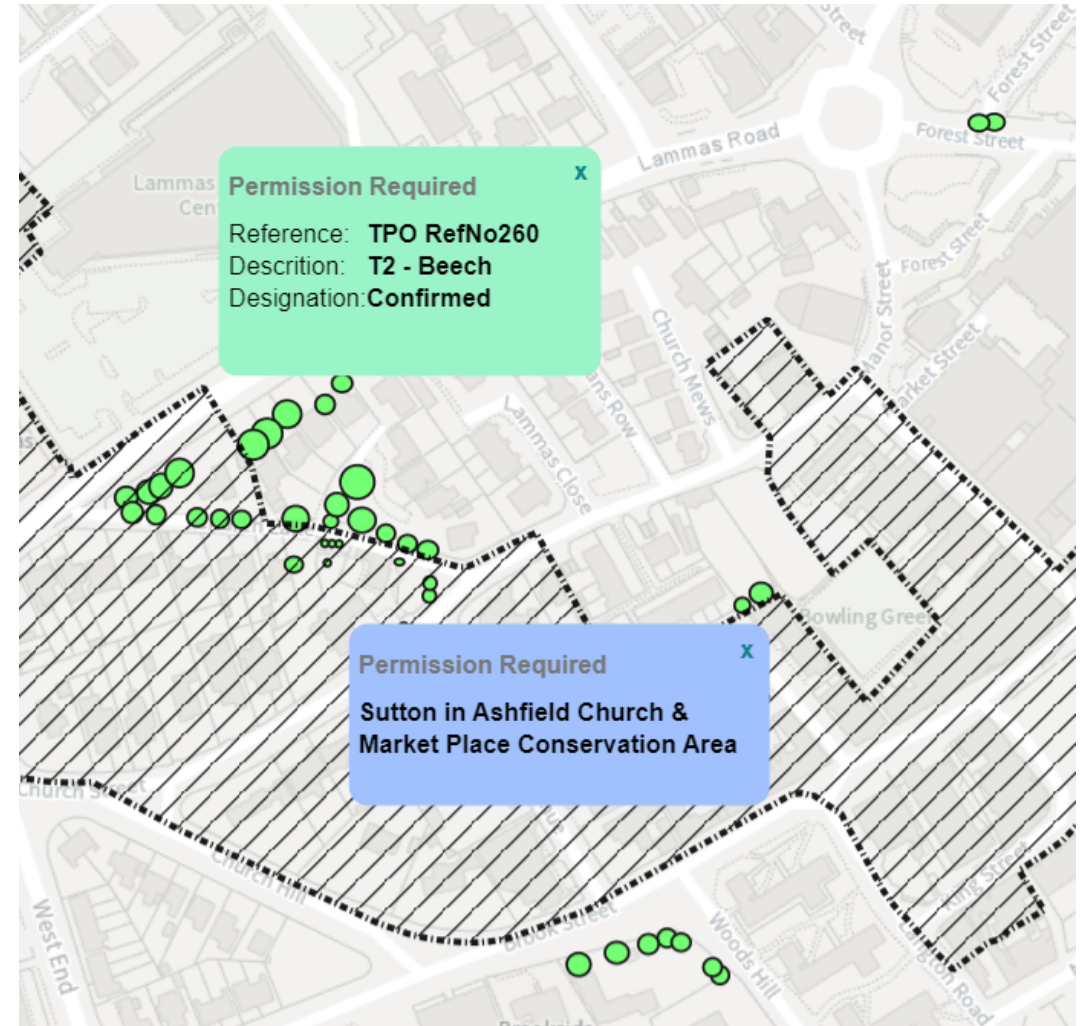
- Services information



Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

- Protected features



Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

- Drainage information



Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

- Higher adjacent land



Pre-construction

Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

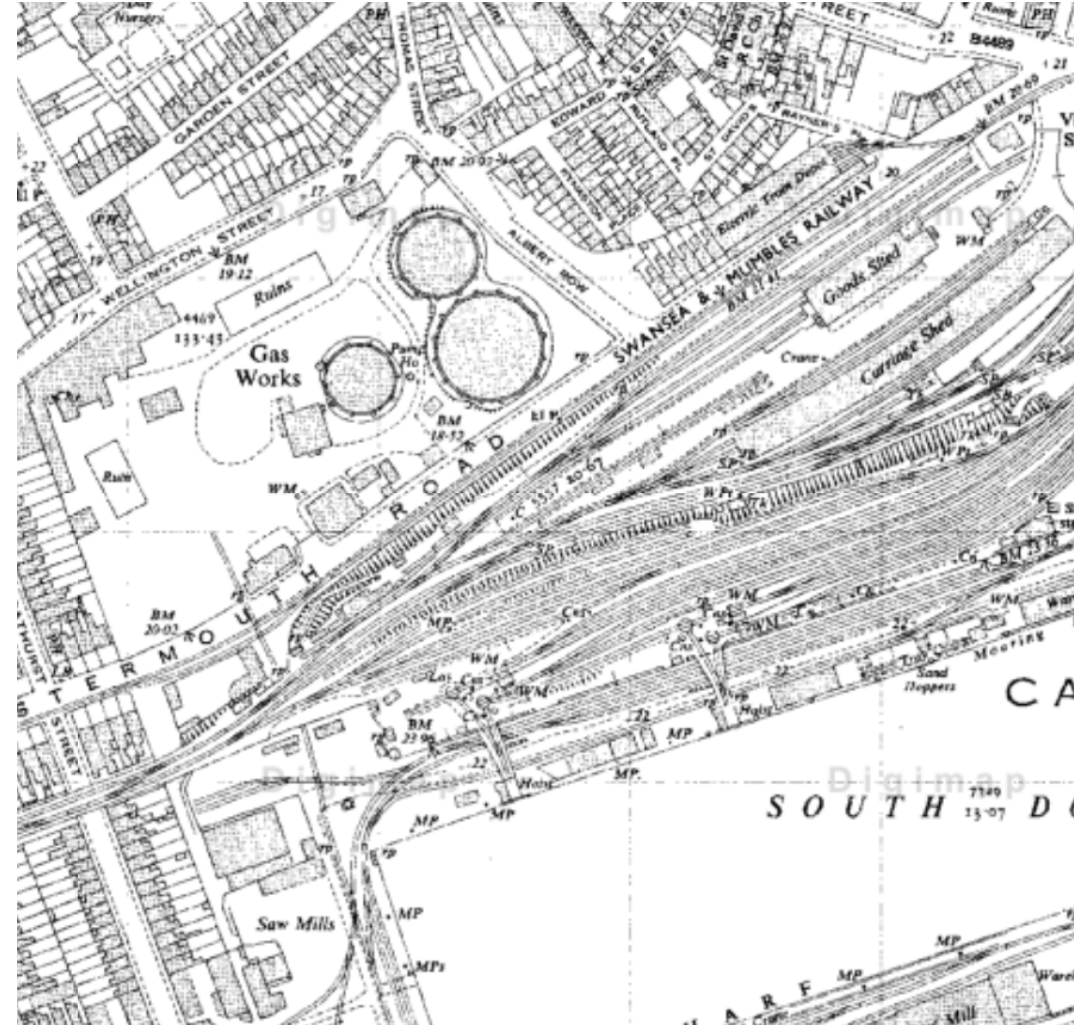
- Infiltration information



Pre-construction

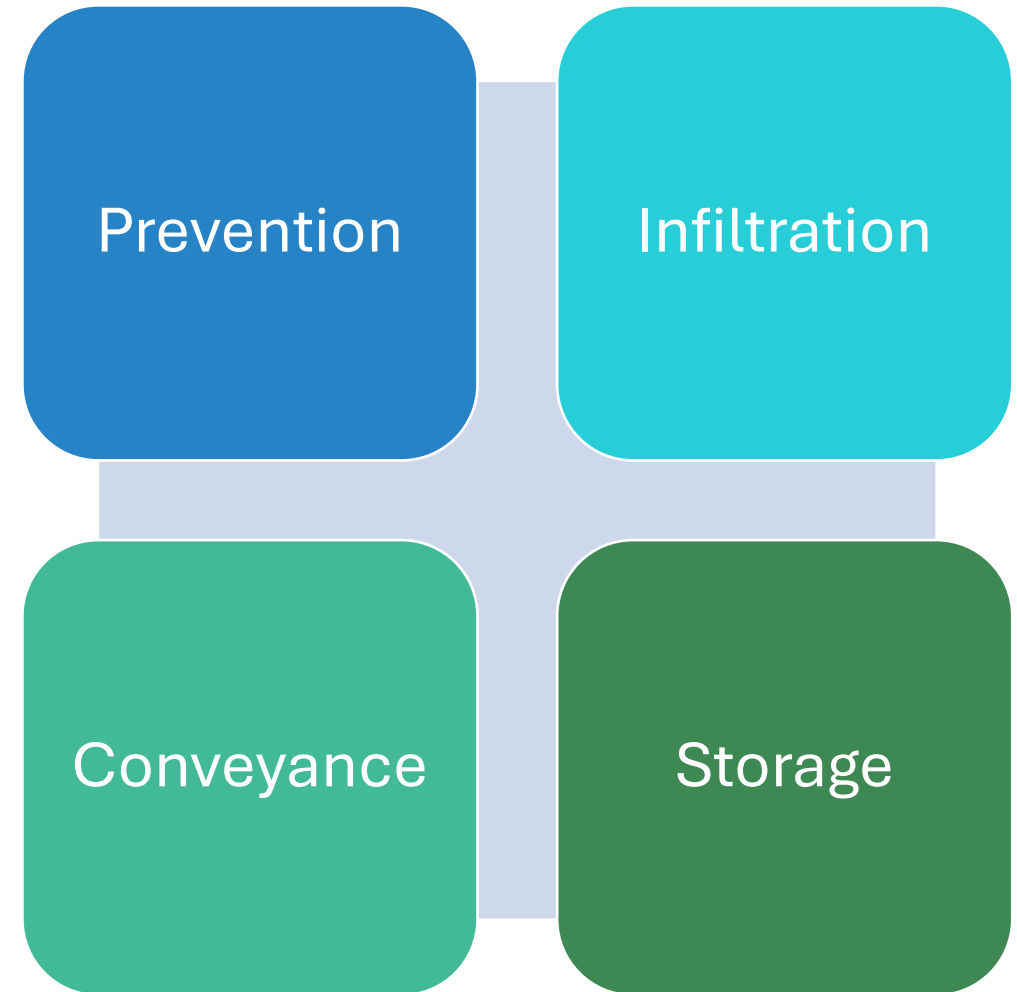
Before work starts, it is important to have a full understanding of the site in its predevelopment condition, what needs to be constructed and how it will be built.

- Historic Information



Designing SUDS

Based on site characteristics and project goals, SUDS components can be selected. These typically fall into four categories:



Living Roofs

Living roofs (often referred to as 'green' or 'brown' roofs) are rooftops planted with vegetation and provide habitat for insects and birds.

They can be used to reduce the volume and rate of runoff. There are two main types:

Living Roofs

Intensive living roofs: a deep layer of soil (up to 1.5 m) to support a variety of plants such as flowers and shrubs but requiring regular maintenance.



Living Roofs

Extensive living roofs: lightweight, often with shallower growing material, requiring little maintenance (e.g. mosses, sedums, grasses, succulents and herbs).

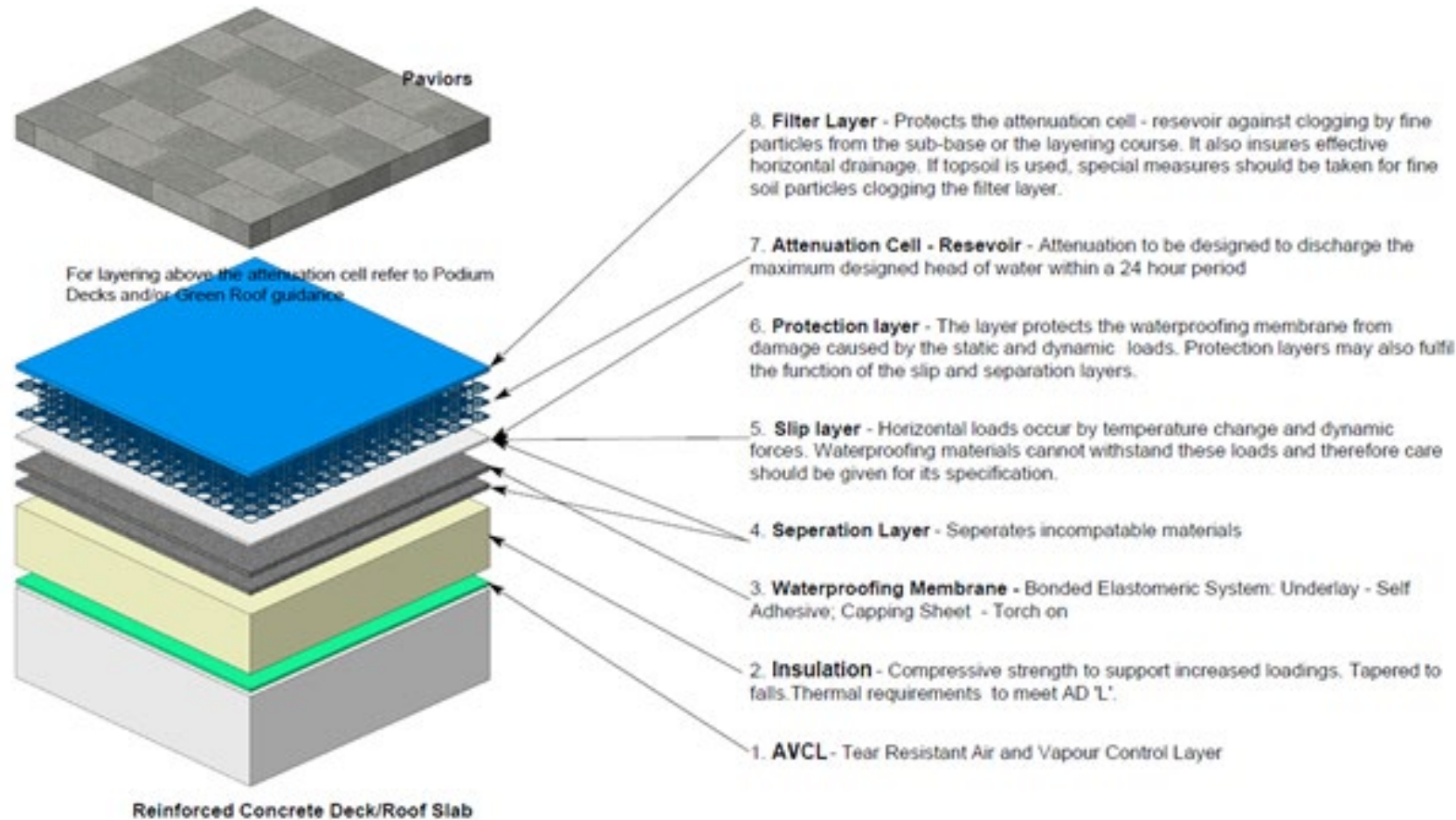


Living Roofs

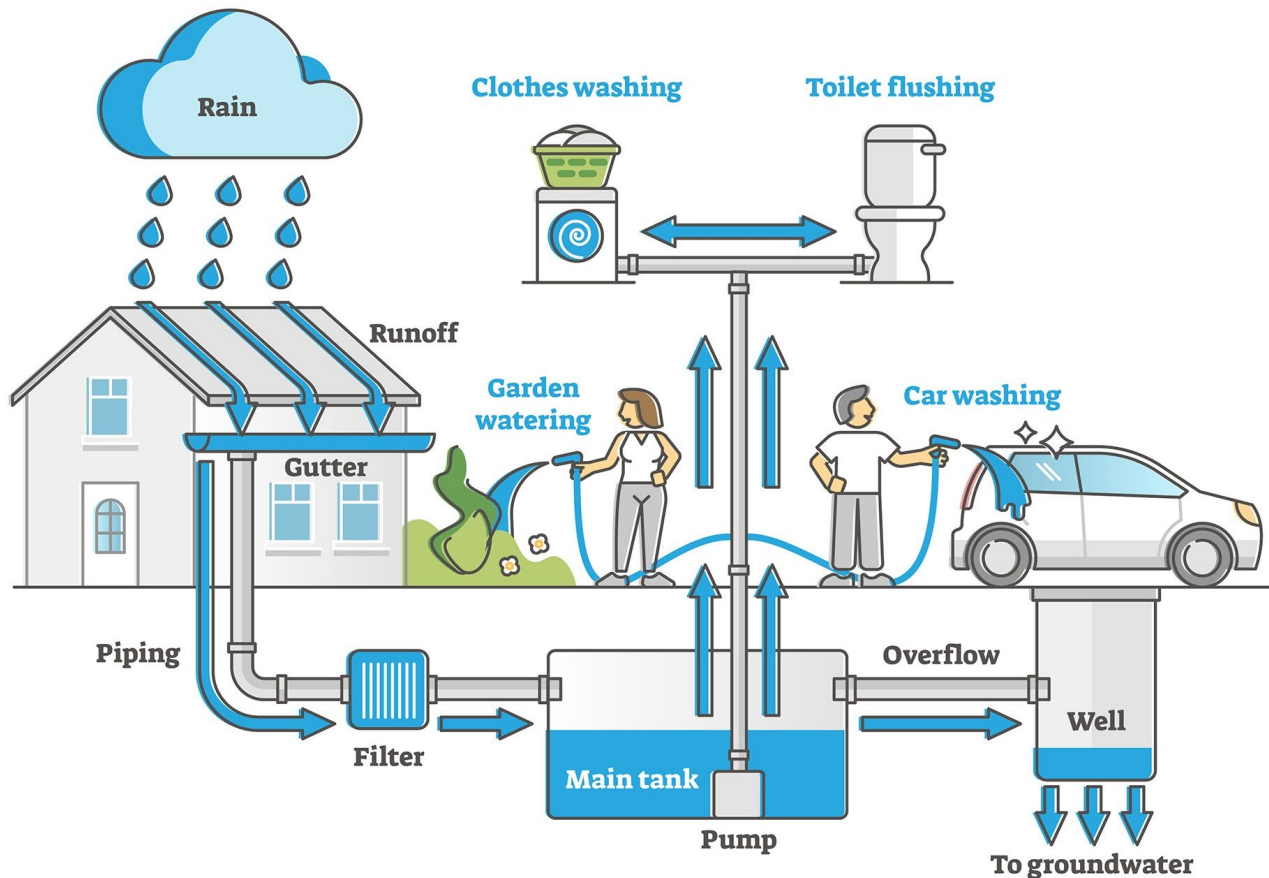
Roof type	Advantages	Disadvantages
Intensive (deep soil, irrigation system, more favourable conditions for plants)	Allows greater plants/habitat diversity Good insulation properties Simulates wildlife garden Diverse utilisation of roof	Heavy Requires irrigation and drainage Higher cost
Extensive (thin soil, little or no irrigation, stressful conditions for plants)	Lightweight Suitable for large areas and 0–30° slope Low maintenance More 'natural' Often does not require irrigation and drainage	Limited choice of plants Usually no access for recreation

Living Roofs

Blue roofs are specifically designed to provide attenuation of stormwater by allowing water to be held on the roof for a defined period, before slowly releasing the water into the drainage system.



Rainwater Harvesting



Rainwater harvesting is the collection of rainwater for use on site.

Water for use is normally collected from roofs, and other impermeable areas.

The water is collected in a tank, treated where necessary and then used as a supply of water.

Permeable Pavements



a Block permeable paving



b Porous asphalt



c Porous concrete



d Resin bound aggregate



e Reinforced grass

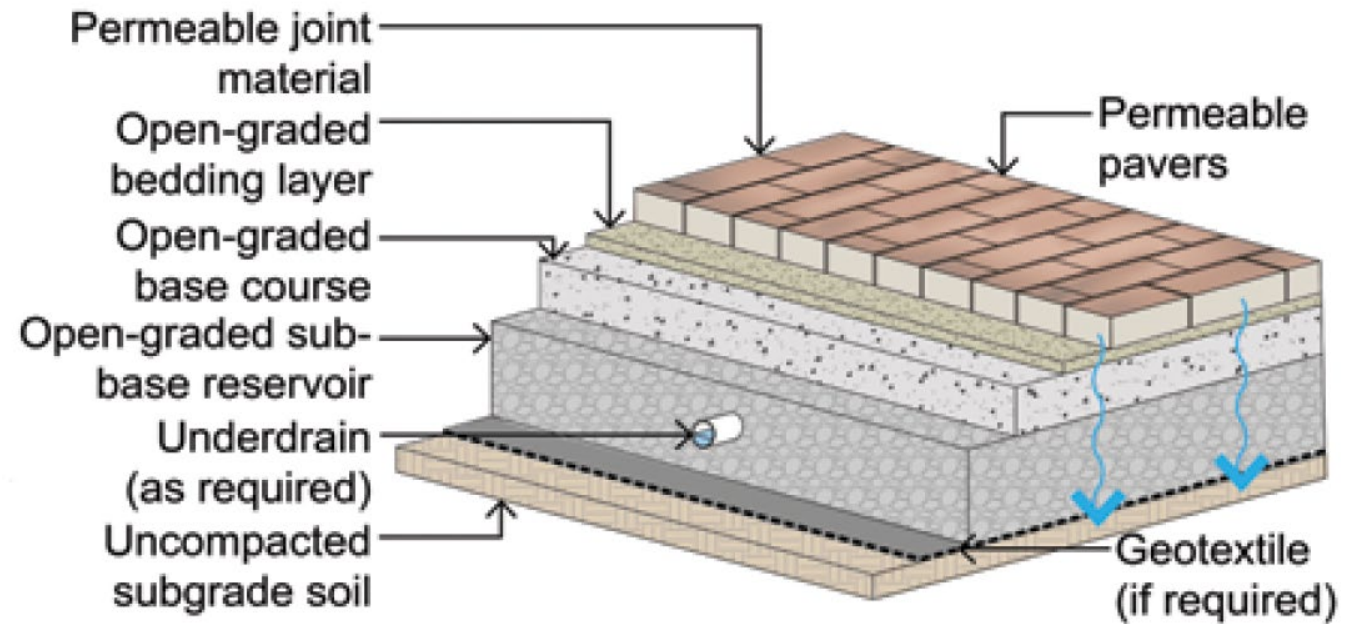
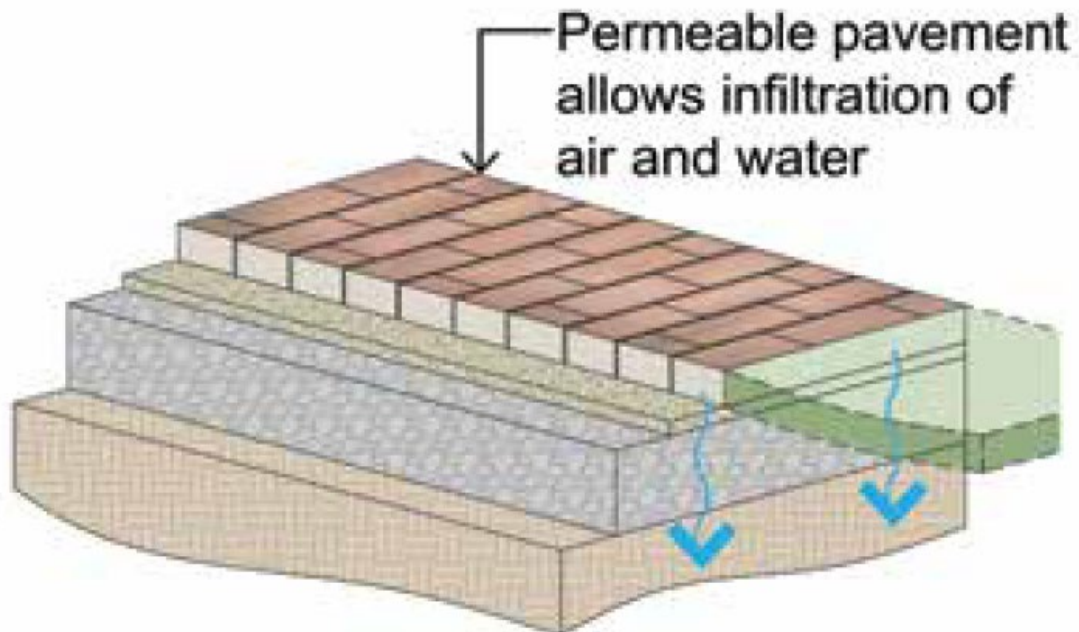


f Loose laid gravel

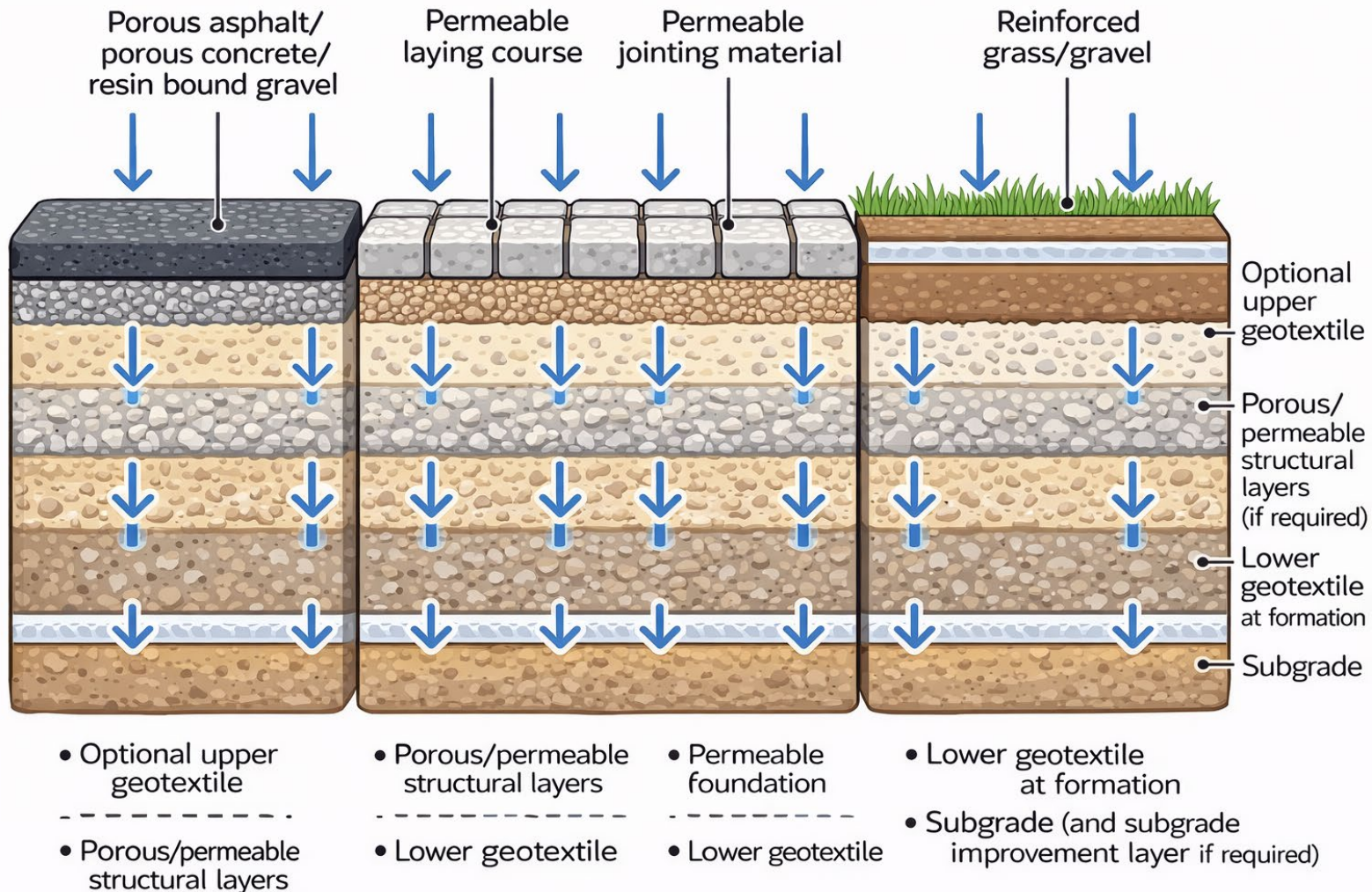
Permeable pavements is different to normal paving by allowing water to soak through gaps to the subsurface below.

The water can either soak into the ground or can be collected by collected in perforated pipes.

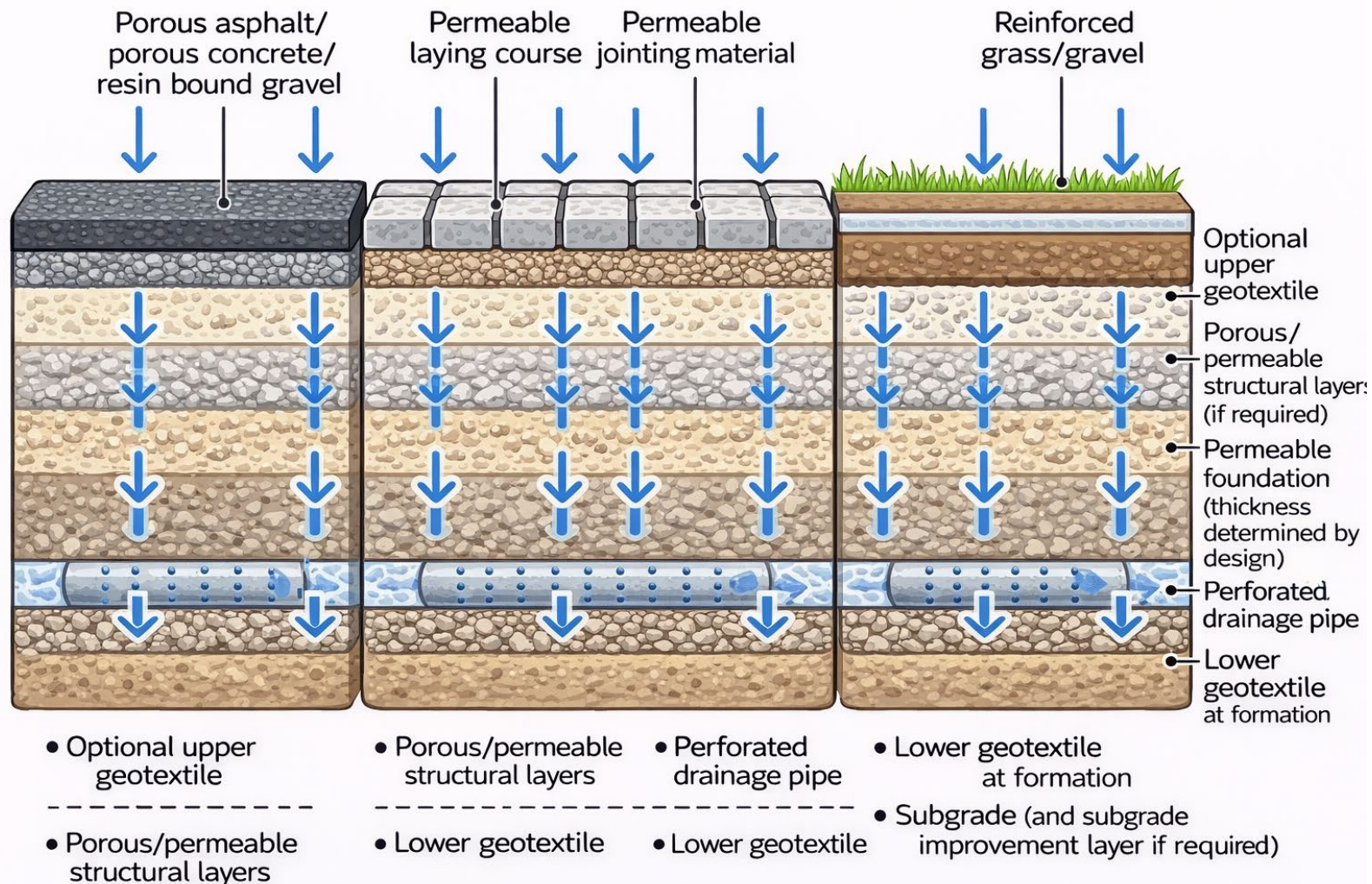
Permeable Pavements



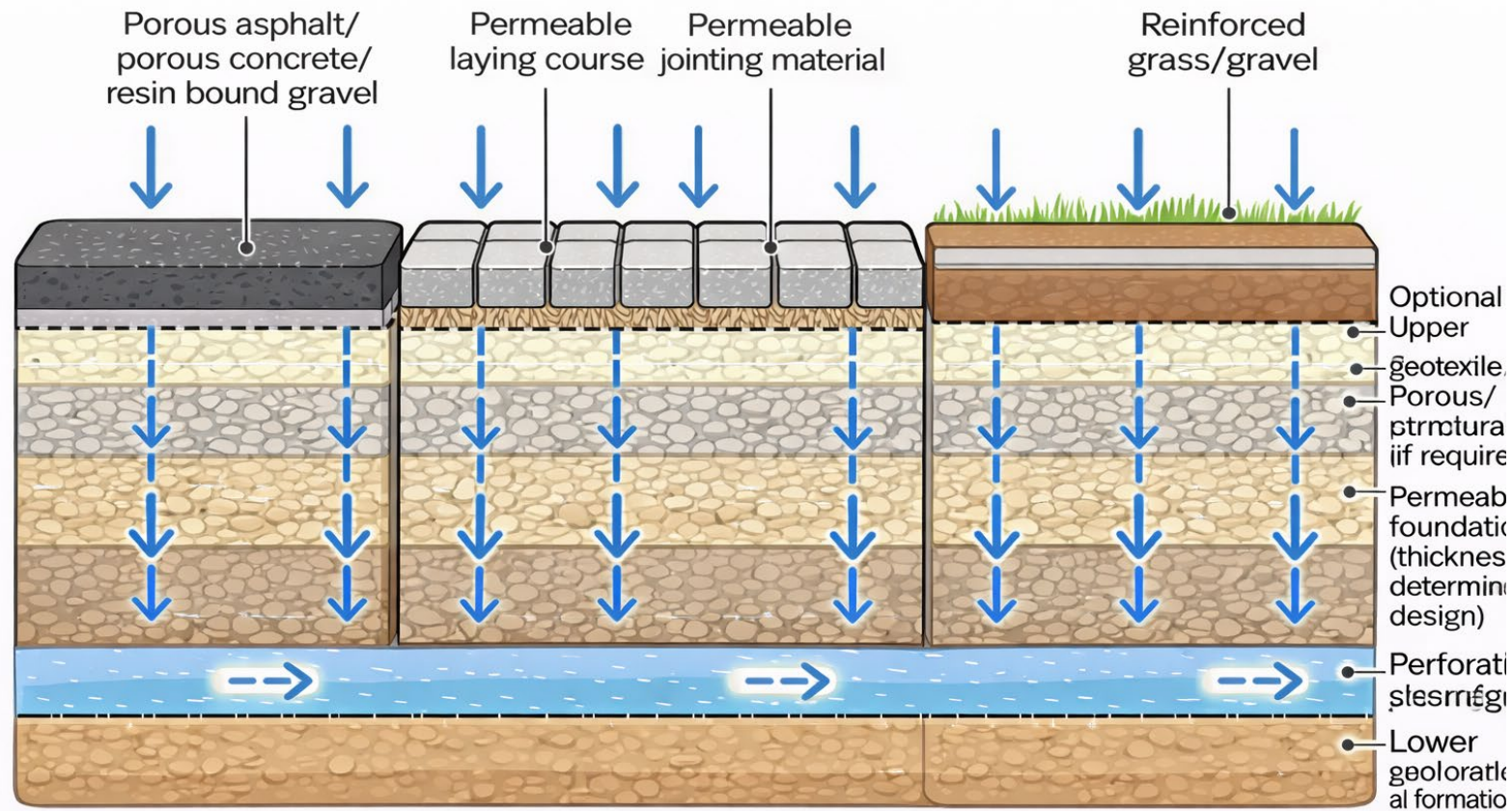
Permeable Pavements



Permeable Pavements



Permeable Pavements



- Optional upper geotextile

- Porous/permeable structural layers

- Impermeable flexible membrane at formation
- Subgrade (and subgrade layer if required)

Permeable Pavements

Ground characteristics		Type A: total infiltration	Type B: partial infiltration	Type C: no infiltration
Permeability of subgrade defined by coefficient of permeability k (m/s)	1×10^{-6} to 1×10^{-3}	✓	✓	✓
	1×10^{-8} to 1×10^{-6}	✗	✓	✓
	1×10^{-10} to 1×10^{-8}	✗	✗ (1)	✓
Highest expected water level within 1000 mm of formation level		✗	✗	✓
Pollutants present in subgrade		✗	✗	✓

Permeable Pavements

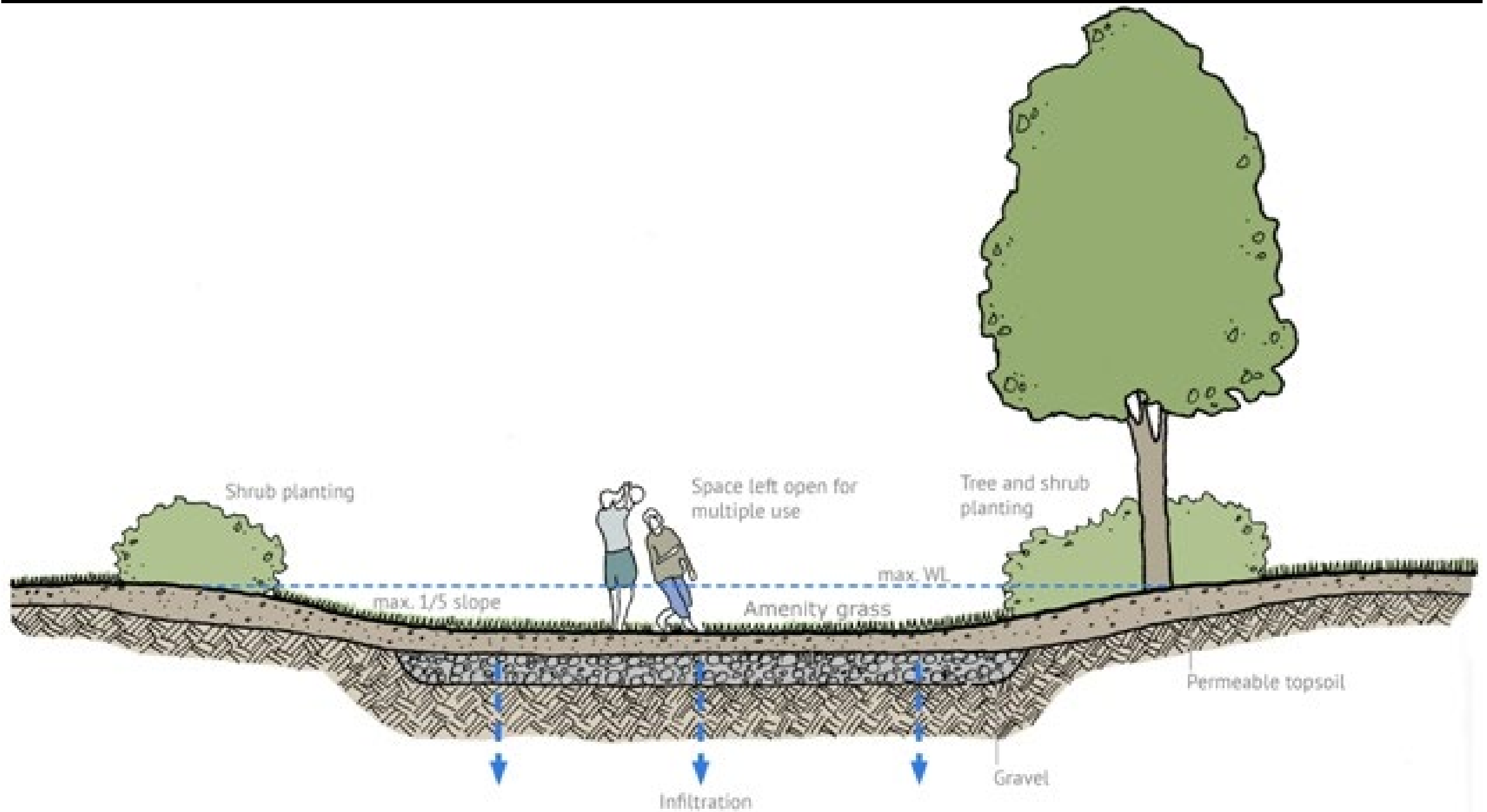
Typical Values of Coefficient of Permeability, K

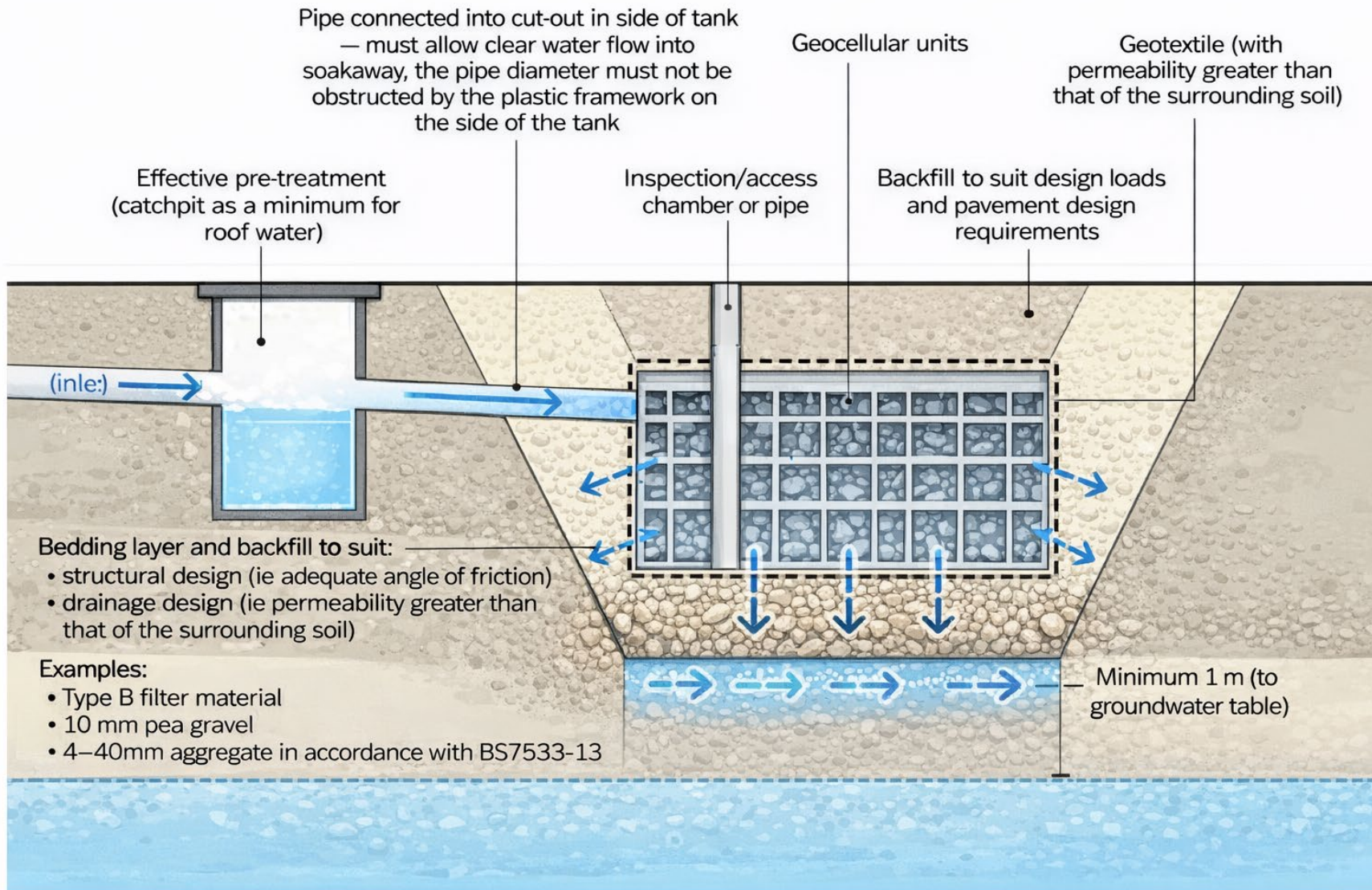
S. No	Soil type	Coefficient of Permeability, K	Drainage properties
1	Clean Gravel	10^{+1} to 10^{+2}	Very Good
2	Medium and Coarse sands	10^{-2} to 10^{+1}	Good
3	Loose Silt, Fine sands	10^{-4} to 10^{-2}	Fair
4	Dense Silt, Clayey Silts	10^{-5} to 10^{-4}	Poor
5	Silty clay, Clay	10^{-8} to 10^{-5}	Very Poor

Soakaways and Infiltration Systems



Infiltration components are used to capture surface water runoff and allow it to infiltrate (soak) and filter through to the subsoil layer, before returning it to the water table below.

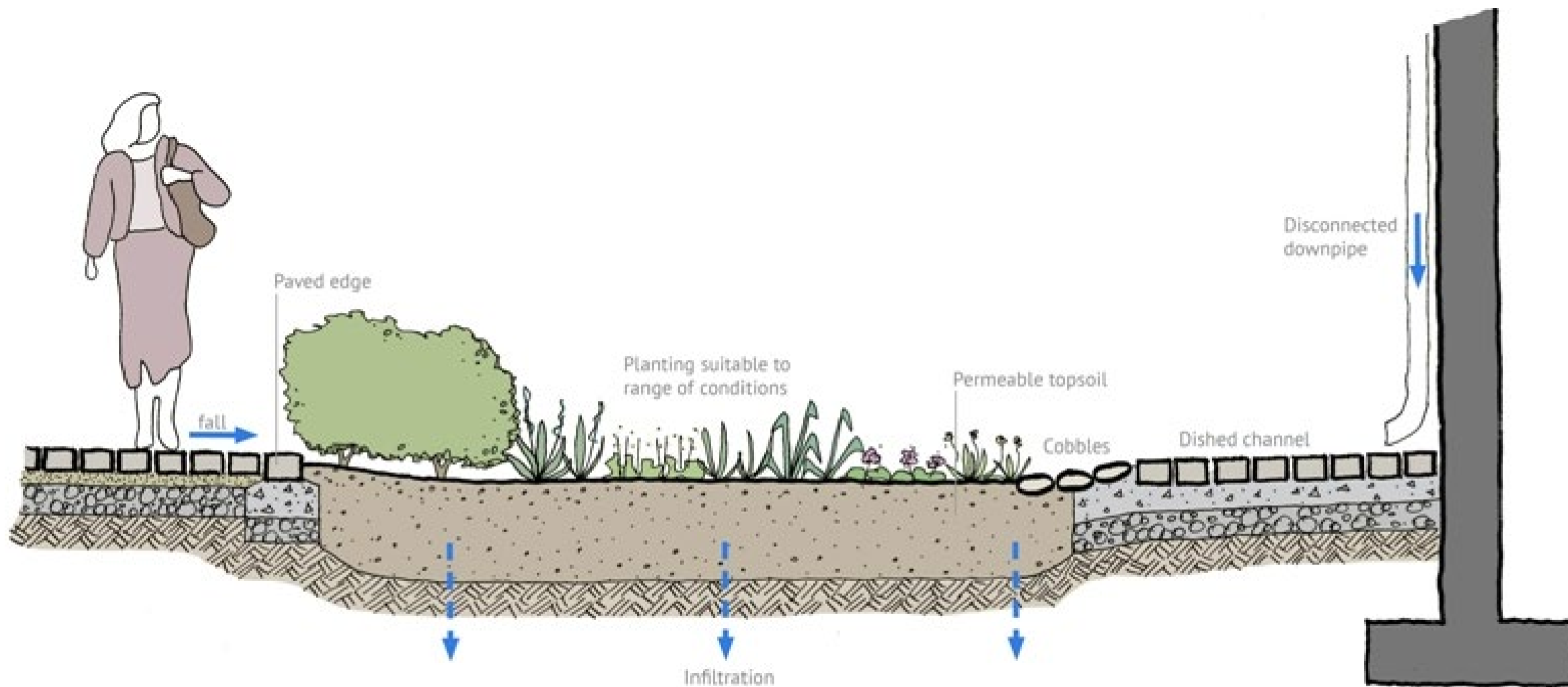




Rain Gardens



A rain garden is a shallow, landscaped depression designed to capture, slow, and filter rainwater runoff from roofs, driveways, roads, and other hard surfaces.

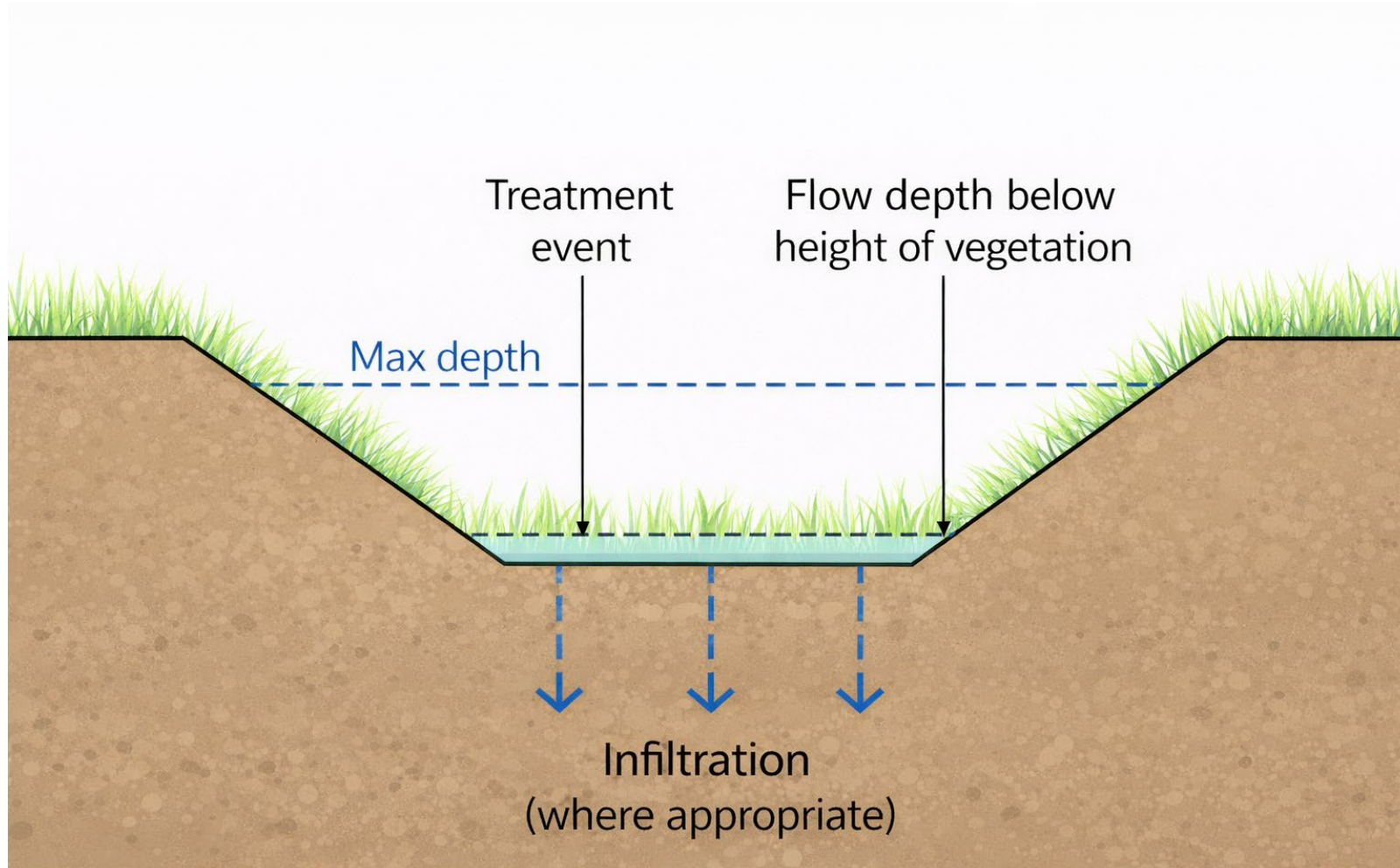


Swales



Swales are shallow, flat bottomed, vegetated open channels designed to convey, treat and often attenuate surface water runoff.

Swales



Swales



(courtesy Iilman Young)



(courtesy Essex County Council)



(courtesy Iilman Young)



(courtesy Terra Firma)



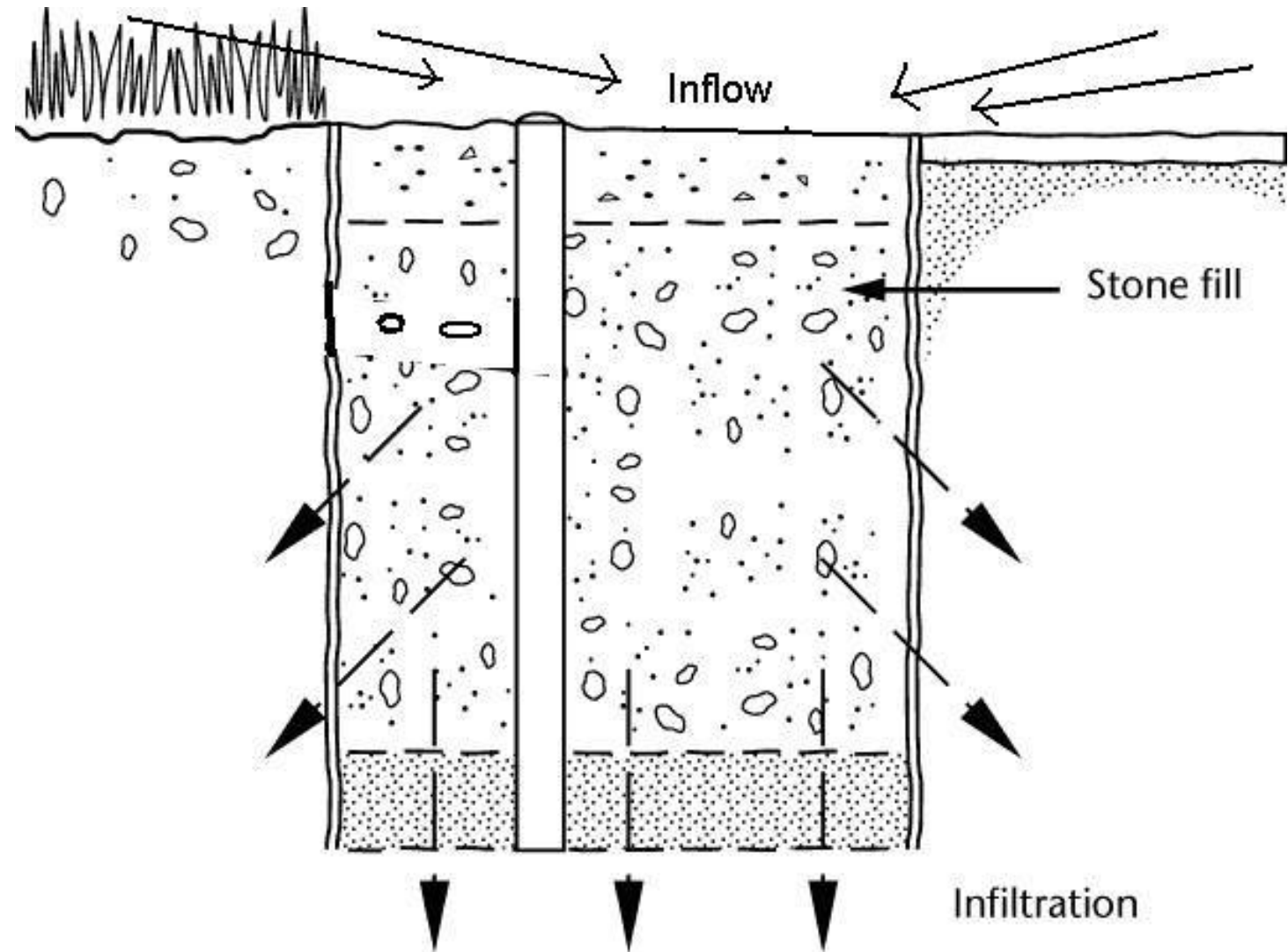
(courtesy Simon Bunn)

Filter Drains



A filter drain is a trench-based drainage system, typically filled with gravel or other porous materials, and equipped with perforated pipes that help collect, filter, and redirect surface water runoff.

Filter Drains

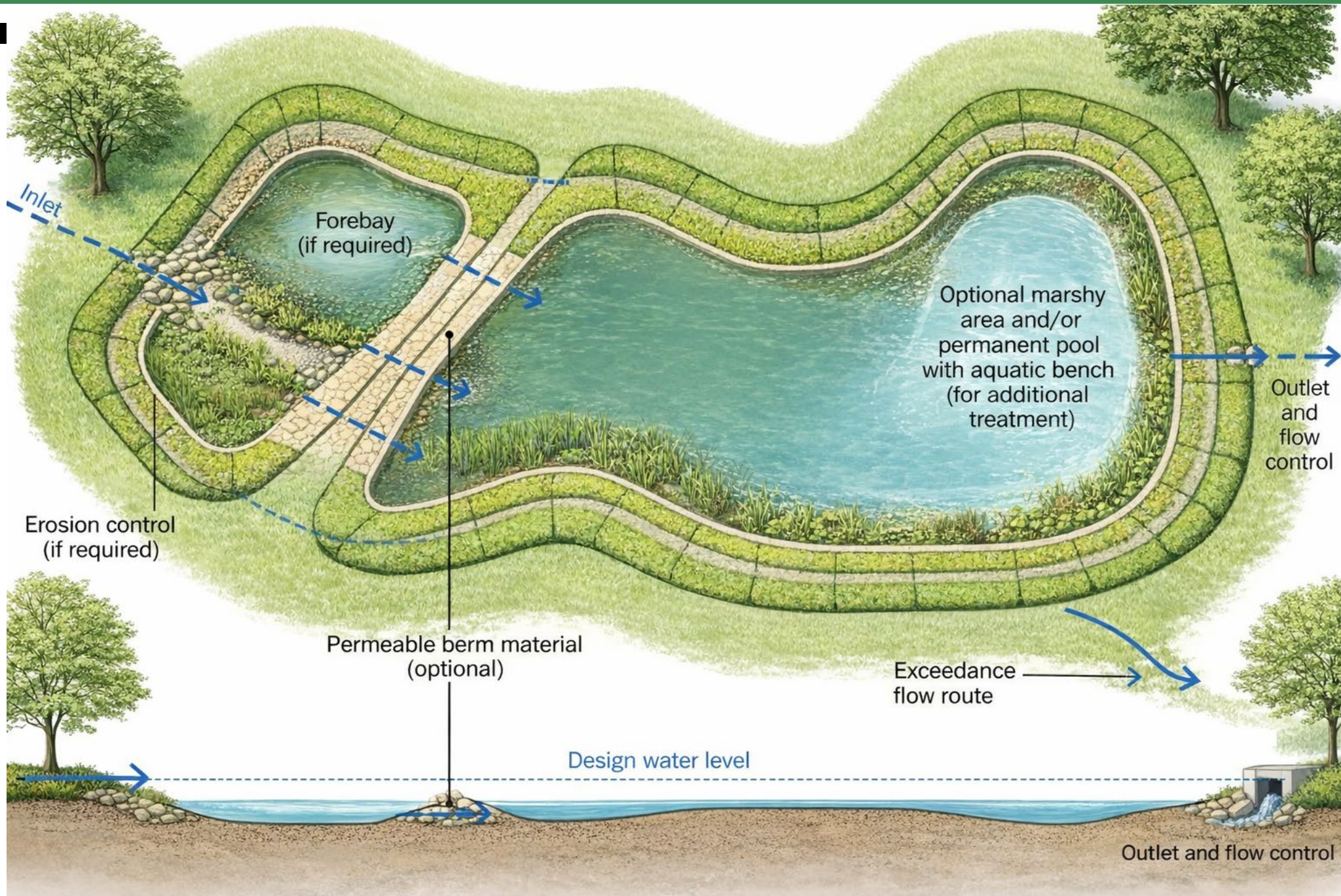


Detention Basins



A detention basin is a type of stormwater management facility designed to temporarily store and control the release of stormwater runoff.

A detention basin only holds water for a short period (typically a few hours) before it is gradually released to prevent flooding and erosion downstream.





Retention Basins



A retention basin is a type of stormwater management facility designed to temporarily store and manage excess stormwater.

It holds water for an extended period, allowing it to slowly release or infiltrate into the ground, reducing flood risk and improving water quality.

Wetlands



Ponds and wetlands are features with a permanent pool of water that provide both attenuation and treatment of surface water runoff.



Technique	Best For	Water Quantity	Water Quality	Biodiversity	Amenity	Cost	Maintenance
Green Roofs	Urban Areas	Medium	Medium	High	Medium	High	Medium
Rainwater Harvesting	Residential & Commercial	Low	High	Low	Low	Medium	Low
Permeable Pavements	Roads / Car Parking	High	Medium	Low	Low	Medium	Low
Soakaways	Gardens & Small Sites	Medium	Medium	Low	Low	Low	Medium
Infiltration Systems	Roadsides & Car Parking	High	Medium	Low	Low	Medium	Mediun
Swales	Roadsides & Car Parking	High	Medium	Medium	Medium	Low	Low
Rain Gardens	Urban Areas	Medium	High	High	High	Medium	Medium
Retention Basins	Large Scale Projects	High	High	High	High	High	High
Constructed Wetlands	Large Scale Projects	High	High	High	High	High	High

		Development settings		
		<i>High density</i>	<i>Medium density</i>	<i>Low density</i>
<i>Most suitable SuDS components</i>	Integrated buildings	- green roofs - rainwater harvesting.	- green roofs - rainwater harvesting.	- green roofs - rainwater harvesting.
	Streetscapes	- permeable paving - road-side bioretention components.	- road-side swales - permeable paving - road-side bioretention components - filter strips.	- road-side swales - permeable paving - road-side bioretention.
	Public realm and open space	- permeable paving and underground storage - rills and channels - hardscape pools - micro-wetlands or bioretention components in squares, courtyards or hard paved spaces.	- micro-wetlands or bioretention components in squares, courtyards or hard paved spaces - open space integrated ponds and wetlands.	- ponds and wetlands - swales.

Key

- 1 Urban square with permeable paving
- 2 Retention pond with integrated seating
- 3 Rill within pedestrianised shopping street
- 4 Brown roofs within town centre
- 5 Rain garden/planted bioretention element
- 6 Green roofs
- 7 Roof gardens
- 8 Permeable paving within street
- 9 Bioretention tree pits within square

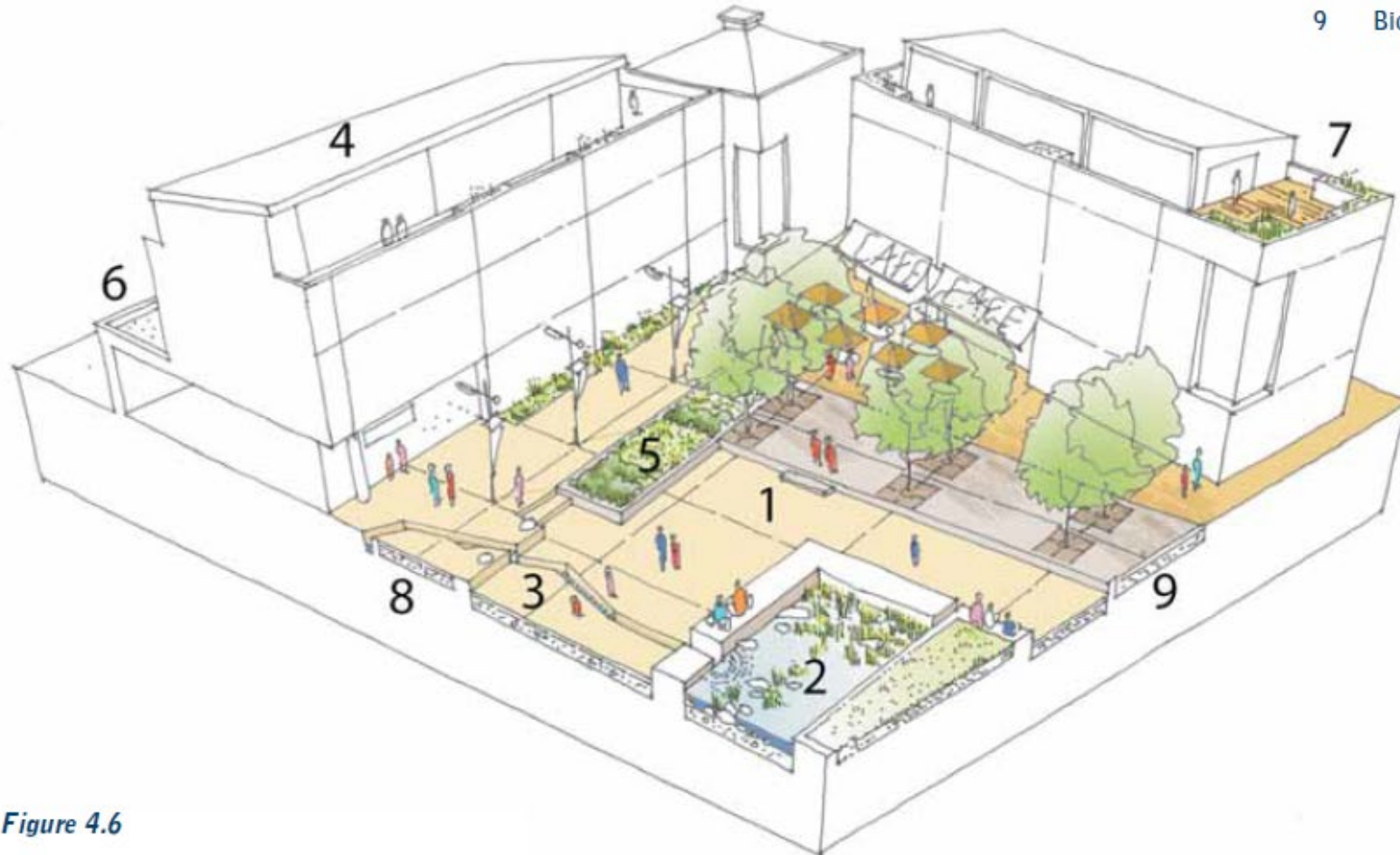
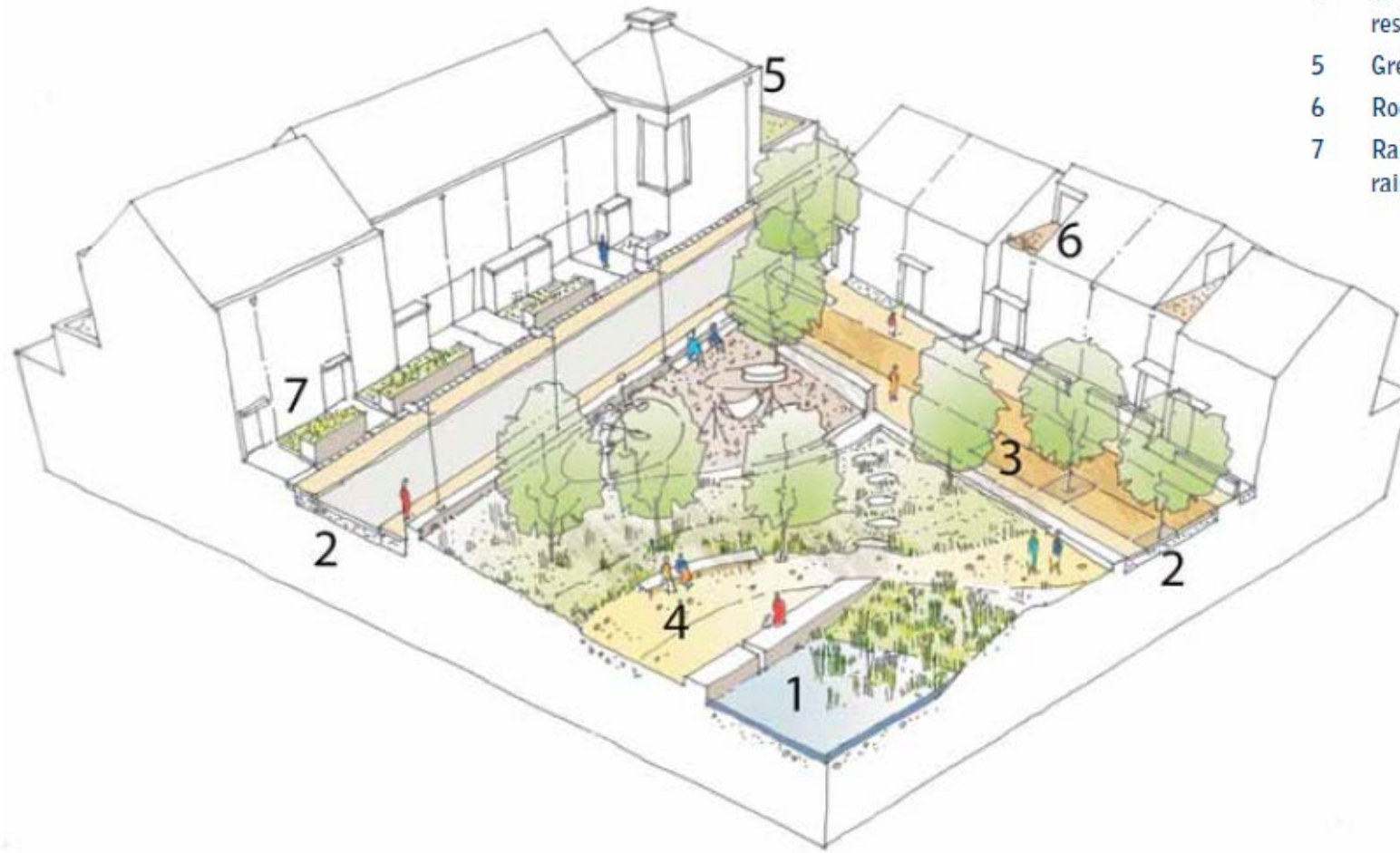


Figure 4.6

SuDS in a high density development setting

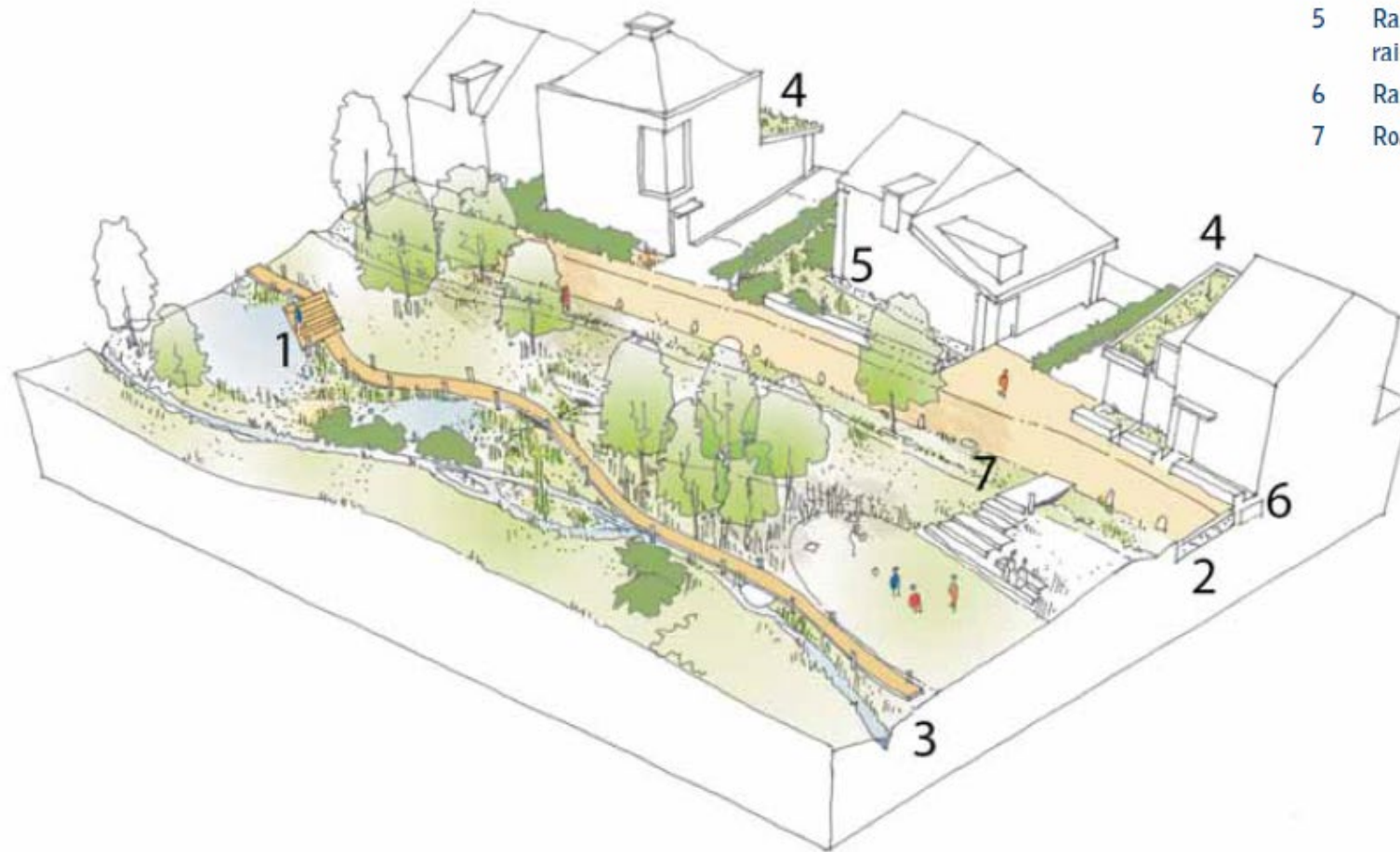


Key

- 1 Filter strip and retention pond within residential square
- 2 Permeable paving within residential street/mews
- 3 Roadside bioretention tree pits
- 4 Gravel/permeable surfaces within residential square
- 5 Green roofs
- 6 Roof gardens
- 7 Rainwater collection from roofs in front rain gardens/ water butts

Figure 4.7

SuDS in a medium density development setting

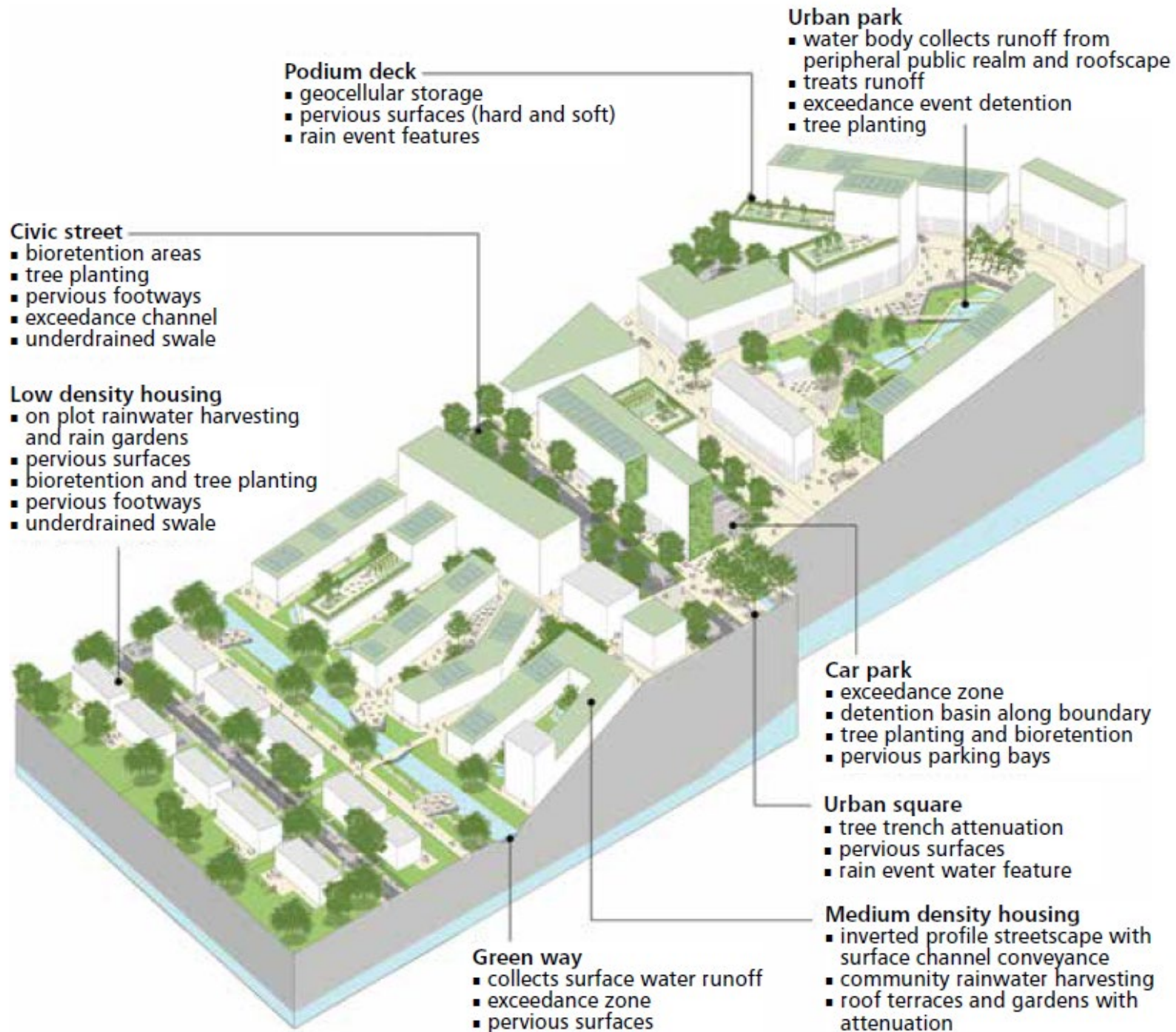


Key

- 1 Wetland areas within large open space
- 2 Permeable paving within residential street/ mews
- 3 Natural waterway
- 4 Green roofs
- 5 Rainwater collection from roofs in front rain gardens/water butts
- 6 Rainwater harvesting
- 7 Roadside swale

Figure 4.8

SuDS in a low density development setting



Nutrient Neutrality

Plans for 50 affordable homes close to a special conservation area have been put on hold over concerns about water quality.

Swansea council had been due to determine the application for Penyrheol, near the Loughor Estuary, which is part of a special area of conservation (SAC), but Natural Resources Wales (NRW) issued advice about the effects of nutrient pollution on SACs.



**Housing project halted over
pollution concerns**

Nutrient Neutrality



Nutrient Neutrality is the requirement that new developments cause no net increase in **Phosphorus (P)** or **Nitrogen (N)** entering protected water bodies.

Nutrient Neutrality



Applies to any development resulting in a **net increase in population** served by a wastewater system, specifically **overnight accommodation**.

Nutrient Neutrality

Does the proposal
involve overnight
accommodation?



Does it increase
population served
by wastewater?



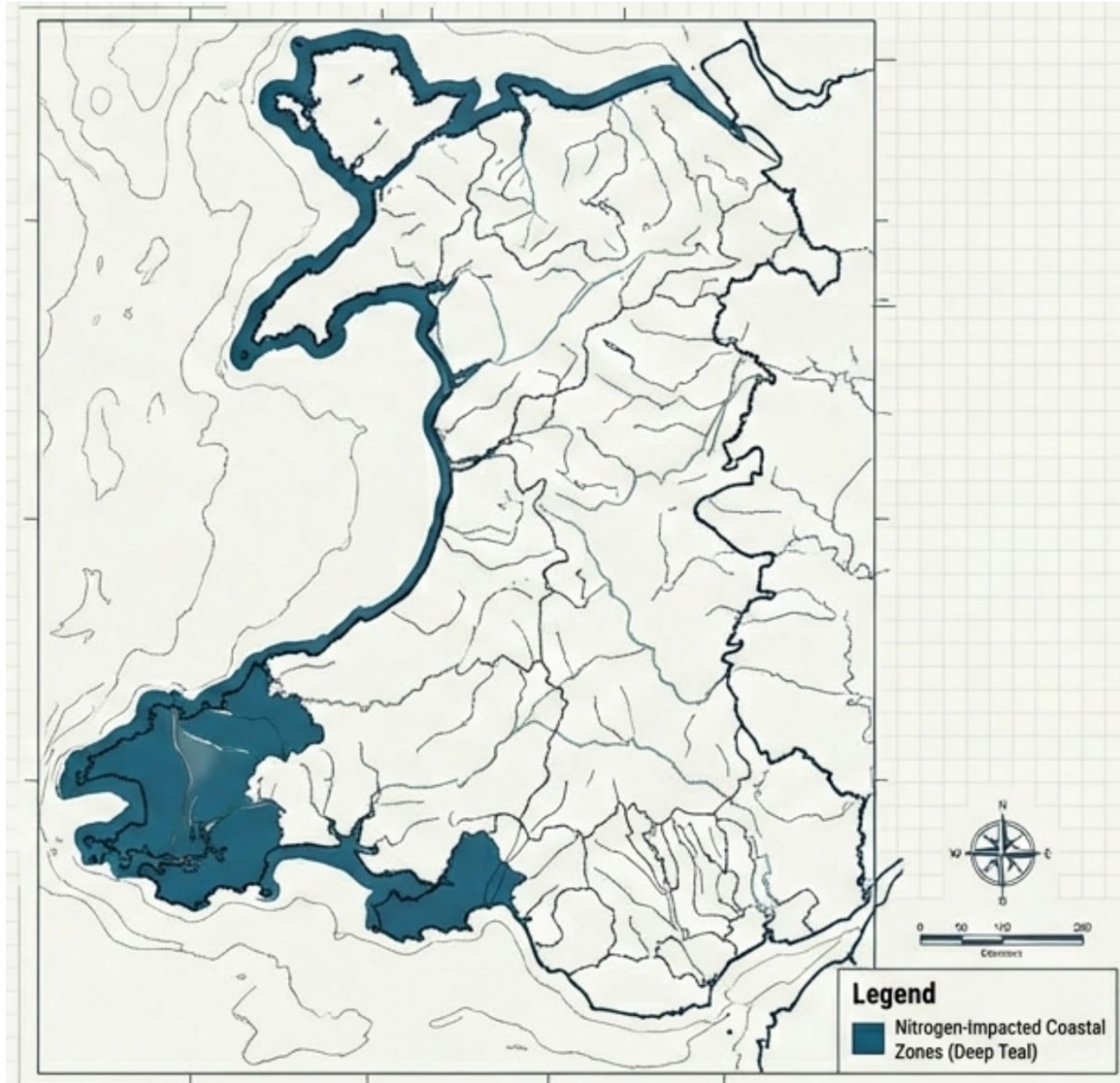
Nutrient Neutrality
Applies

Nutrient neutrality is applicable in Wales to developments with nutrient discharges into affected designated sites.

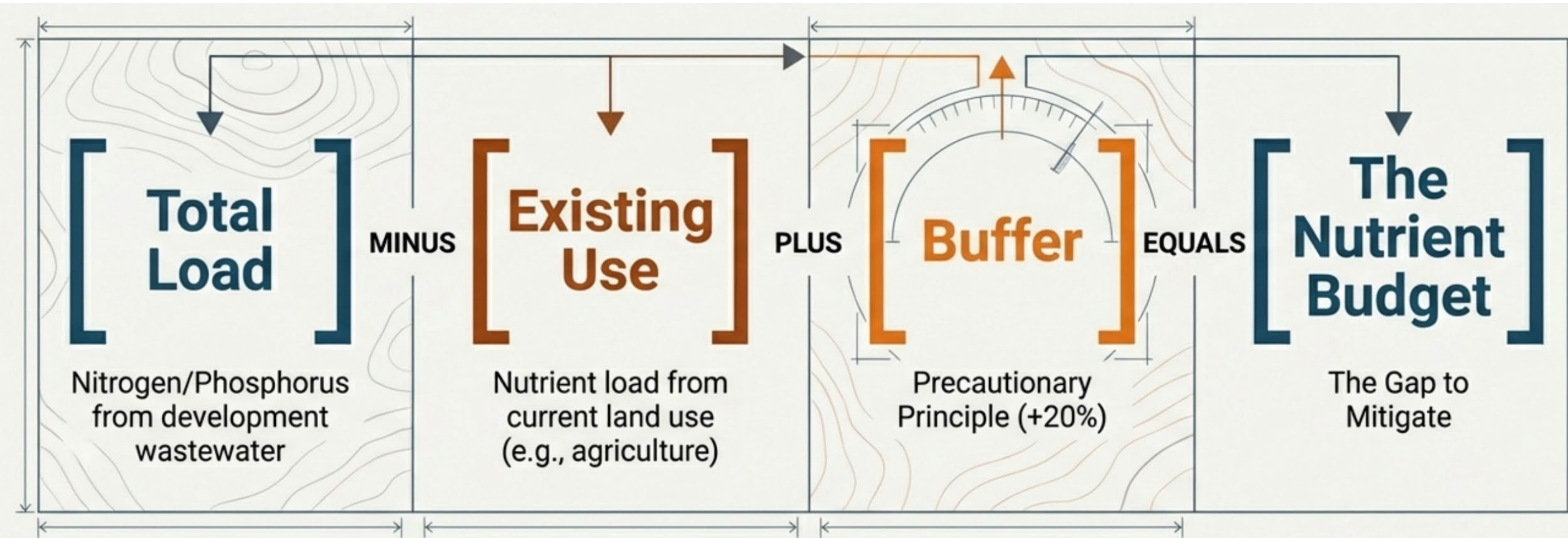


Nutrient Neutrality

Nutrient neutrality is applicable in Wales to developments with nutrient discharges into affected designated sites.



Nutrient Budget

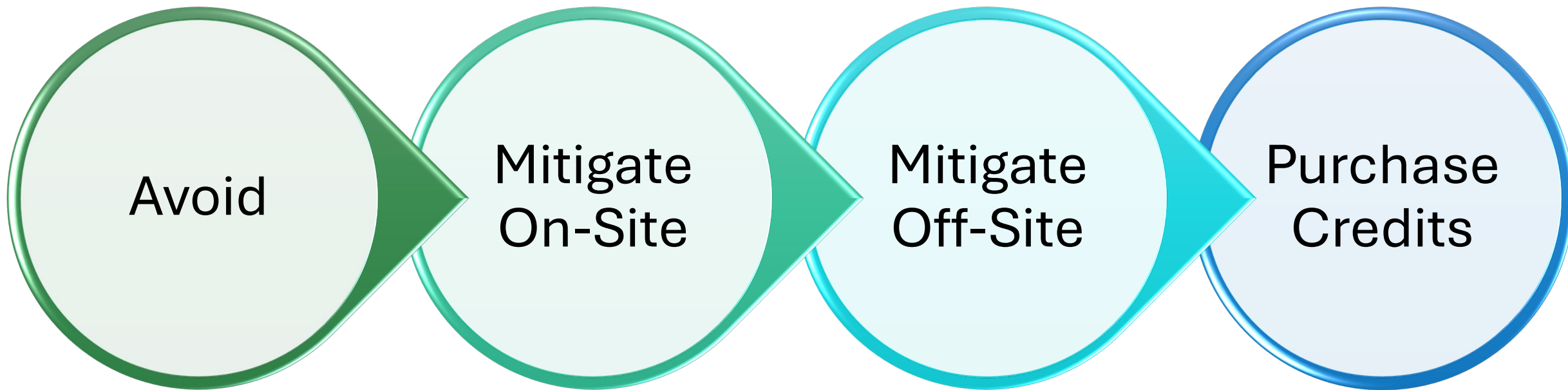


Neutrality in Perpetuity

To achieve neutrality, the nutrient load created by new occupants must be offset.

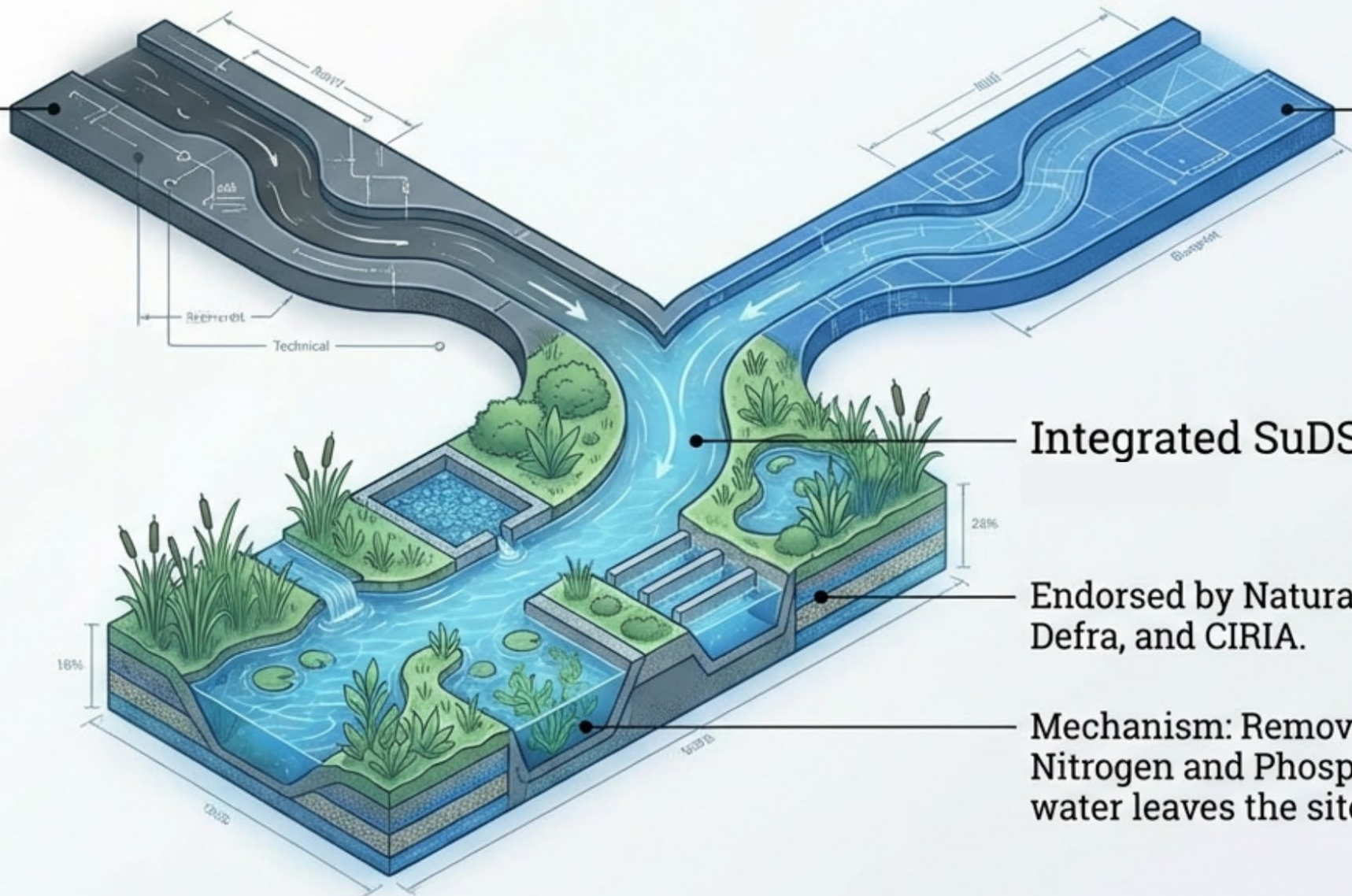
Mitigation measures must be legally secured for the lifetime of the development, typically defined as 80-125 years,

Mitigation Hierarchy



Nutrient
Neutrality Rules

Flood Risk
Mandate

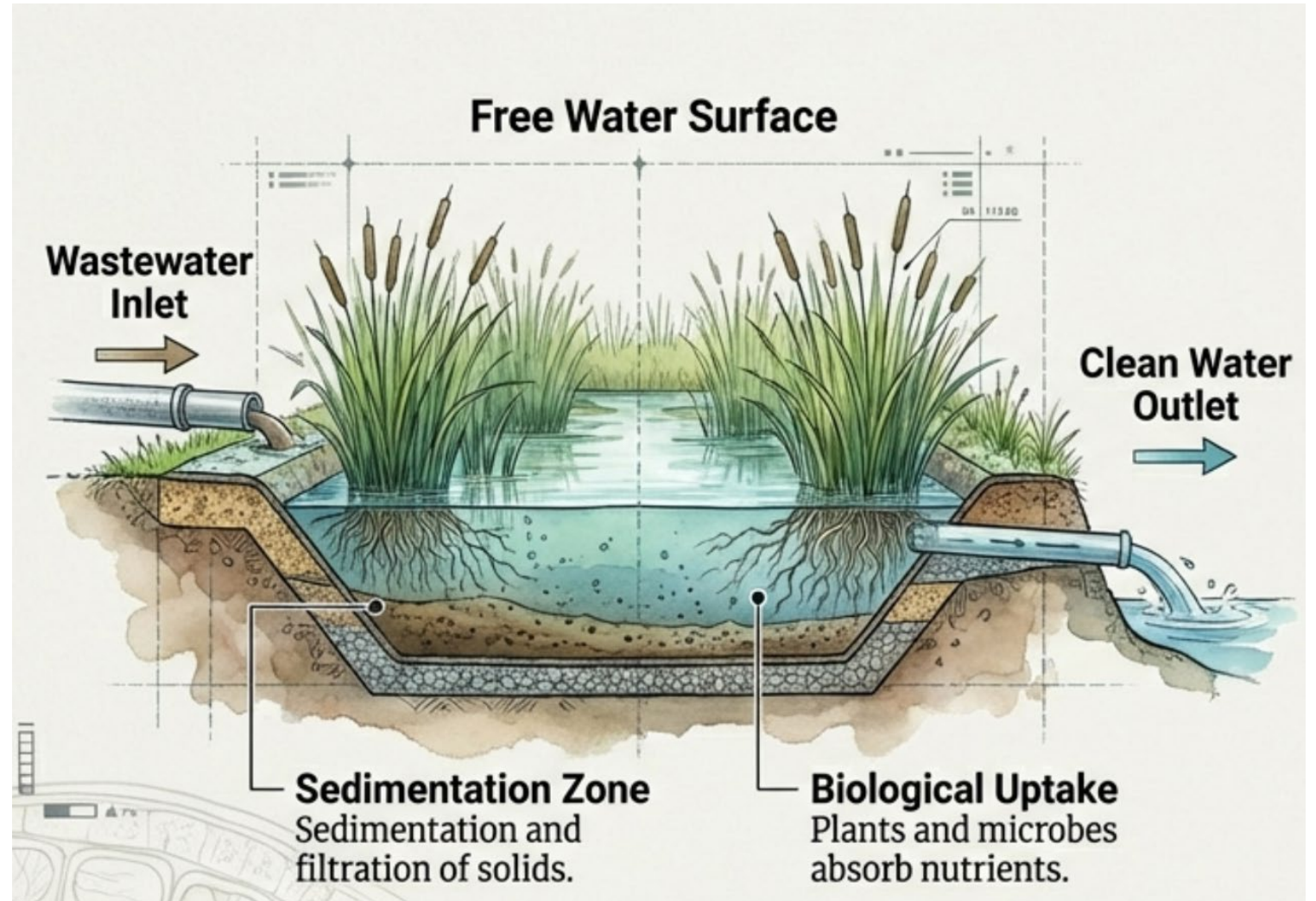


Integrated SuDS Strategy

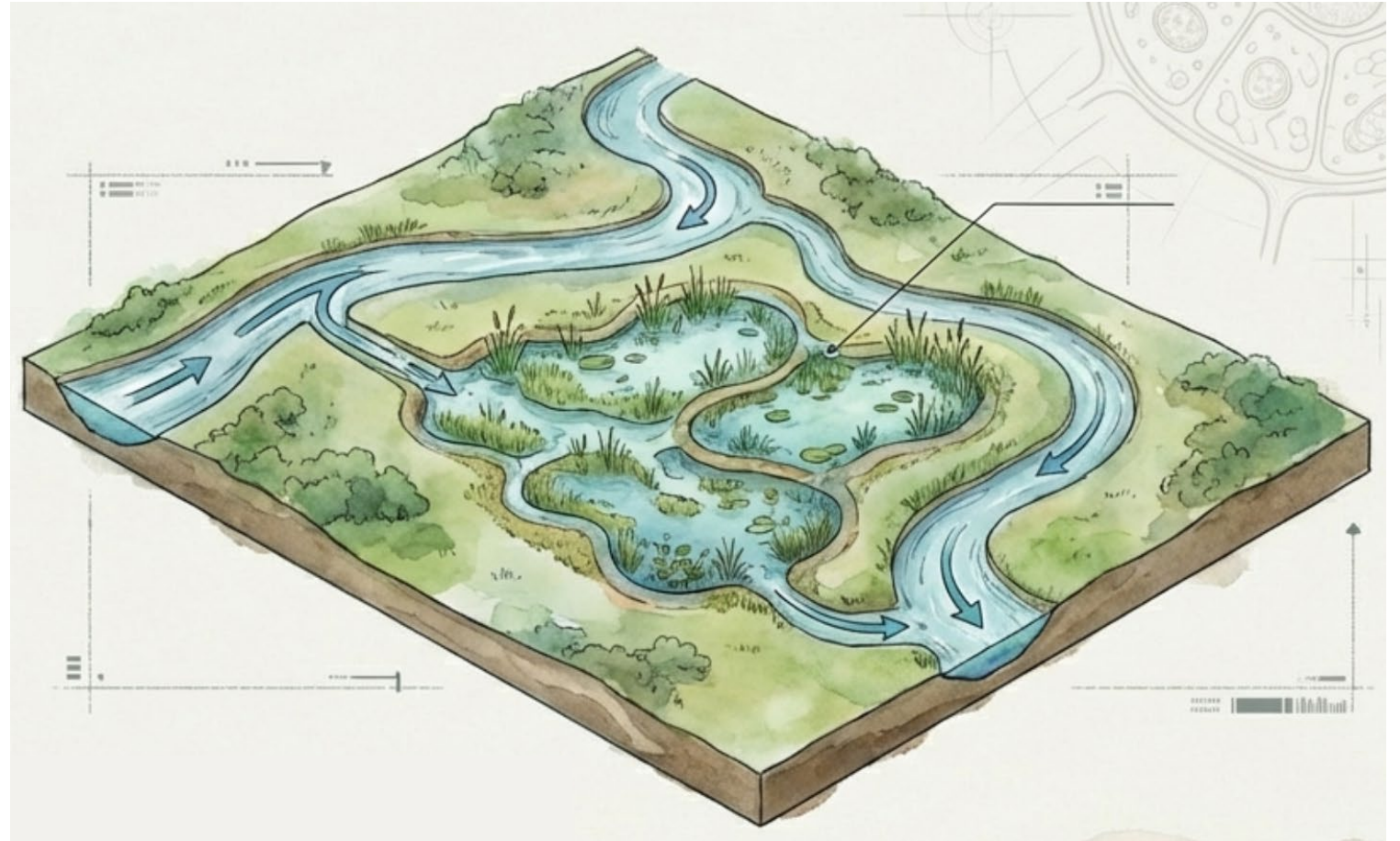
Endorsed by Natural England,
Defra, and CIRIA.

Mechanism: Removal of
Nitrogen and Phosphates before
water leaves the site.

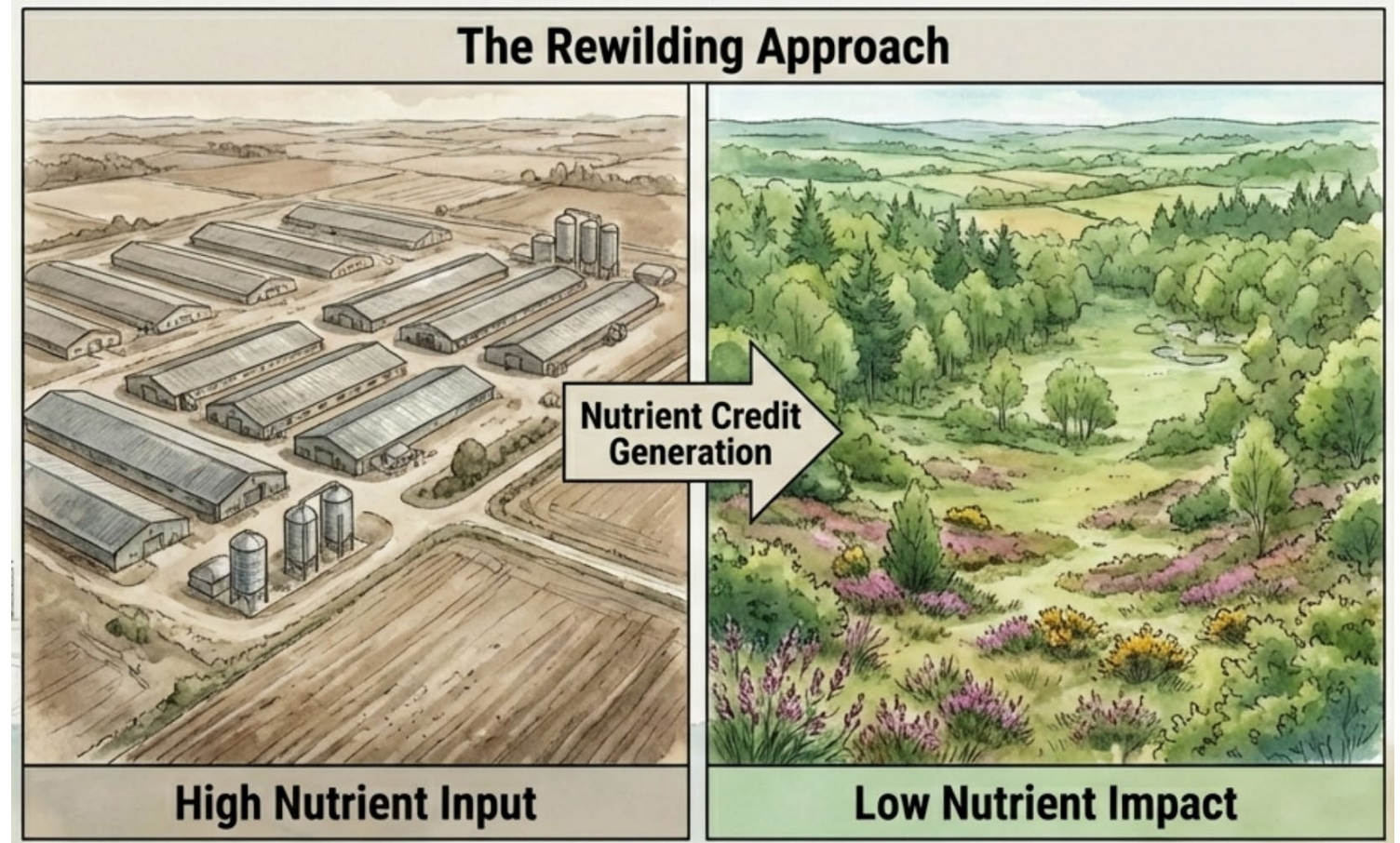
Constructed Wetlands



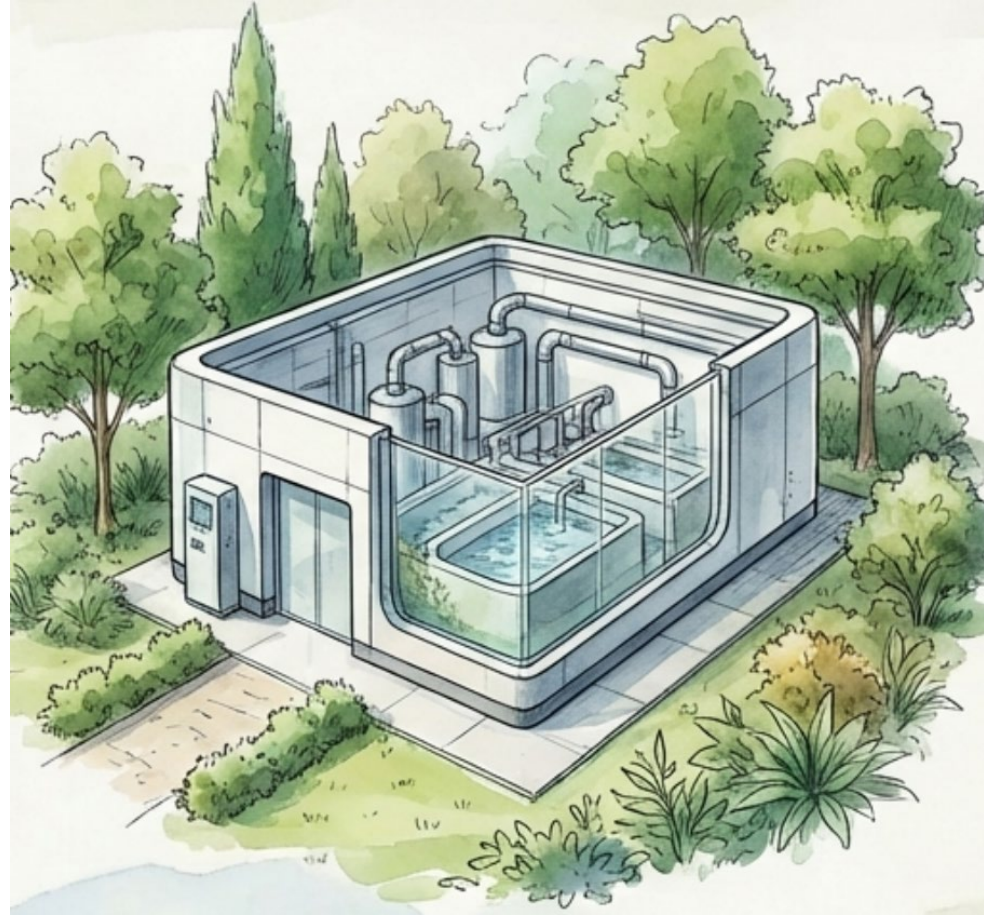
Integrated Constructed Wetlands



Rewilding



New Treatment Facilities



Time Lag Challenge

