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Biodiversity in new housing developments:

creating wildlife-friendly communities

rspb giving nature a home

NHBC FOUNDATION

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creating wildlife-friendly communities

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NHBC Foundation

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Disclaimer

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The NHBC Foundation

The NHBC Foundation, established in 2006, provides high quality research and practical guidance to support the house-building industry as it addresses the challenges of delivering 21st century new homes. To date we have published over 80 reports on a wide variety of topics, including the sustainability agenda, homeowner issues and risk management.

The NHBC Foundation is also involved in a programme of positive engagement with the government, academics and other key stakeholders, focusing on current and pressing issues relevant to house building.

To find out more about the NHBC Foundation, please visit **www.nhbcfoundation.org**. If you have feedback or suggestions for new areas of research, please contact **info@nhbcfoundation.org**.

NHBC is the standard-setting body and leading warranty and insurance provider for new homes in the UK, providing risk management services to the house-building and wider construction industry. All profits are reinvested in research and work to improve the construction standard of new homes for the benefit of homeowners. NHBC is independent of the government and builders. To find out more about NHBC, please visit **www.nhbc.co.uk**.

Barratt Homes, Kingsbrook, Aylesbury

CEO Forewords

RSPB

"Building sustainable communities is essential as we transition to a better future, and the protection and enhancement of biodiversity are crucial components of the sustainability agenda.

It is becoming increasingly apparent that small tweaks to the way we do things will not be enough to reverse the double threat of climate change and biodiversity loss. We will need to rethink radically the way we do things – environmental protection will need to be placed at the centre of all decision-making. And all of society – national and local government, businesses and communities will need to play their parts.

But for now, we must take steps in this direction, to minimise impact, to create more than we damage. If all developments were to apply the recommendations made in this guide, we would move a considerable way towards being on the right track.

The housebuilding industry is uniquely placed in having an opportunity to create not just houses, but new, sustainable communities, where people thrive alongside wildlife. We know now that people benefit immensely from the interactions with nature that we used to take so much for granted – our health and wellbeing are enhanced through contact with nature, and where better to experience this than right outside our homes?

This guide is a great introduction to the principles and practicalities of creating wildlife-friendly communities and a great addition to the sustainable housing toolkit. I hope that the industry will embrace it and help to drive positive change."

Beccy Speight,
RSPB CEO

Barratt Developments Plc

"At Barratt, we are committed to building high quality homes and communities where people want to live. As part of this, we think it's vital that we do what we can to protect the natural environment and encourage nature to thrive.

Wildlife in the UK is undergoing rapid change, with 58% of species having declined in abundance since 1970, and 15% of species at risk of extinction from Great Britain. Such changes can have far-reaching ecological impacts and represent a loss of our shared natural heritage.

Living amongst nature has proven benefits for people's physical and mental wellbeing and is a key factor in the creation of healthy, happy communities. We believe that installing wildlife-friendly elements and contributing to biodiversity should be central components of new housing development.

Our partnership with the RSPB has enabled us to drive up biodiversity standards on our developments and to lead the industry in supporting and protecting nature. Our collaborative efforts have led to the creation of best practice guidance that can be used on new housing developments across our business and the wider industry.

This helpful guide is a further example of the work we are doing and contains a range of changes that housebuilders can make that can have huge positive impacts on wildlife and on people's quality of life. "

David Thomas,
Barratt Developments Plc CEO

Contents

1 Introduction

This guide is for anyone with a professional interest in urban planning, housebuilding, green and blue infrastructure or urban biodiversity. It sets out approaches to design and development that work with nature to deliver multiple benefits – for people and wildlife. Biodiversity should be considered at every stage of planning and development, and beyond, and this guide will accompany that process.

There is an emerging climate, ecological and public health crisis. At the same time, the need for a significant increase in new homes is recognised in government policy. Therefore, we need to ensure that housing developments are sustainably built, have a positive impact on wildlife and adopt measures, nature-based solutions, that will help us withstand climate impacts, as part of the transition to a sustainable future.

Much of the focus on 'sustainable housing' has been and remains in reducing carbon emissions, however, appropriately designed and implemented green infrastructure has an important but not yet properly understood role in responding to this crisis, through both reducing the impacts of climate on us at a local scale, and helping to absorb carbon from the atmosphere. Between public greenspace and gardens this could be at a very significant scale if opportunities are properly realised.

This guide demonstrates how housing developments can deliver these opportunities; it starts with design concepts, moving into practical solutions, and illustrating them with case studies of good practice. It promotes a shift in design ethos, placing ecosystems at the centre of the process.

It also shows how opportunities can be realised to enhance and protect biodiversity in built development greenspace, whilst at the same time helping deliver public benefits. The combination of nature and public benefits creates desirable place making, with improved health and wellbeing of those who live there. Biodiverse SuDS, nature-orientated landscaping and features for wildlife (including buildings), improved climate resilience and connecting people with nature all form this approach, which is practical, achievable and is arguably cost neutral.

This guide should be considered in conjunction with NHBC Standards and all relevant statutory requirements to ensure that as well as delivering on biodiversity the homes are sustainable, for example when building near trees NHBC Standards Chapter 4.2 should be referenced – this gives guidance on technical requirements when building near trees, hedgerows and shrubs, particularly in shrinkable soils.

1.1 Why should the housing development sector work with nature?

Nature is in trouble; a keynote research report, The State of Nature 2019[1] identifies that 58% of UK species have declined since 1970 (and nature had already been depleted by this point). Urbanisation is identified as one of the key pressures driving biodiversity loss. However, there is realistic potential for development to contribute to nature's recovery.

Meanwhile, as well as impacting on people, climate change affects wildlife globally and locally.[2] There is, therefore, an imperative for housing or any other development to mitigate these impacts. This can be done by designing in adaptation, capacity and resilience to minimise the impact on communities and wildlife of extreme weather events, at the same time as minimising its contribution to climate heating emissions.

The National Planning Policy Framework (NPPF)[3] states that "Plans should take a proactive approach to mitigating and adapting to climate change, taking into account the long-term implications for flood risk, biodiversity and landscapes, and the risk of overheating from rising temperatures". Well-designed landscapes will do this at the same time as providing opportunities for wildlife.

Nature has a role in helping deliver on this imperative. Working with nature to help resolve environmental challenges isn't especially new but it is gaining more credence as evidence of the effectiveness of these so-called nature-based solutions grows. All aspects of nature contribute, from wetlands absorbing and slowing run-off to trees shading and storing carbon. This role is potentially powerful, particularly when it can have several benefits at once, and it has developing traction with government.

1.2 Place-making:

Nature adds character and quality of place and helps improve the liveability of that place.

Existing natural features retained within the development footprint, be they veteran trees, old hedgerows, or ponds provide a context and character for the development. Incorporating them into the landscape scheme ensures continuity of that character. At the same time, doing so ensures more opportunities for wildlife than if starting from scratch, and provides enjoyable recreational space, through which the value of homes can be increased.

Barratt Homes, Kingsbrook, Aylesbury

Figure 1 Advantages of working with nature

1.3 Implementation costs:

There is no particular reason why it should be more expensive to implement a more ecological approach to greenspace than conventional practice. Working with nature could generate cost savings; for example retaining exiting features reduces the need for groundworks, or the use of nutrient poor soils reduce the requirement for intensive management.

Examples of potential cost savings:

- retaining soils and adapting planting / seed mixes to suit them rather than importing soil should cause fewer plant failures and reduce soil handling
- Sustainable Drainage Systems (SuDS) that use soft landscape features have lower installation and maintenance costs than hard engineered solutions
- locally adapted native species are more durable, so have lower long-term maintenance costs.

However, there may be additional costs to factor during the transition to this new approach; nurseries may need to charge more for native stock until supply and demand equalise. However, this is likely to be paid back through increasing the value/desirability of the houses.

1.4 Environmental drivers:

A nature-orientated approach to design will provide more environmental and societal benefits than standard approaches do. Nature-based solutions to environmental impacts can achieve several outcomes in one process, and so they generate multi-use spaces. Leafy green space with integrated SuDS will help to deal with flood risk, clean run-off water, take up carbon from the atmosphere, and reduce local temperatures, as well as filter pollutants. All of this is realised at the same time as being wildlife-friendly and providing enjoyable recreational spaces. The UK Green Building Council (UKGBC) has produced a report on nature-based solutions to the climate emergency.[4]

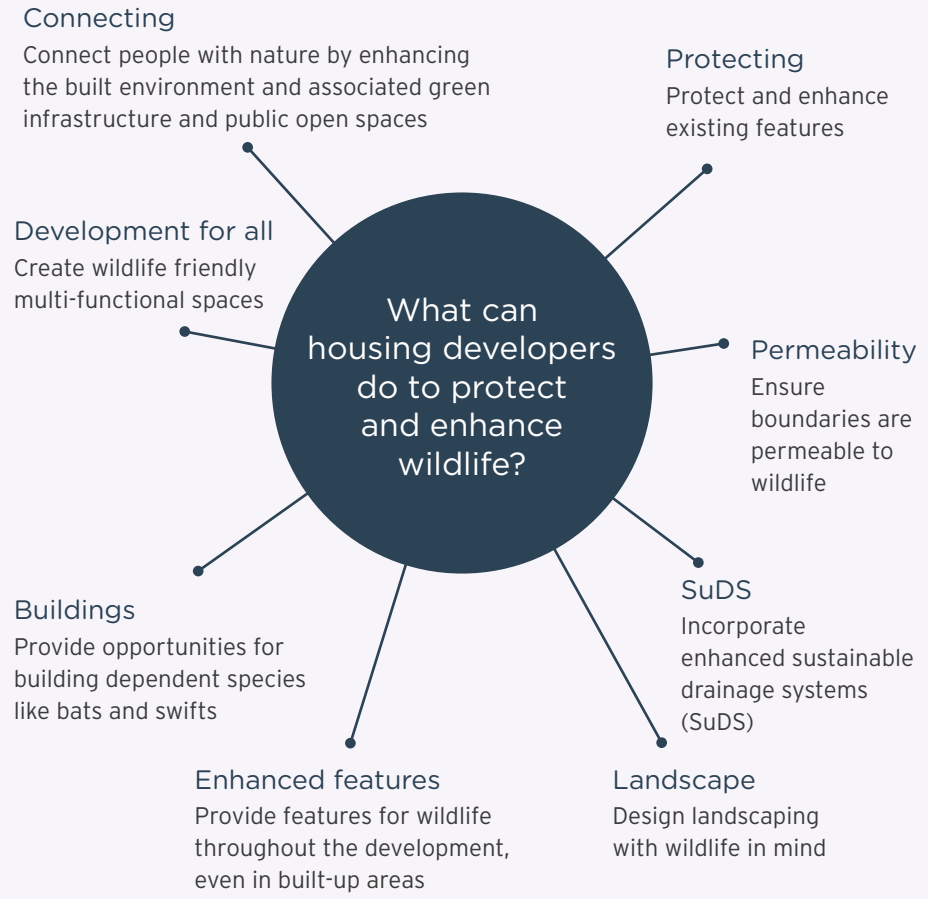


Figure 2 How housing developments help wildlife

1.5 Where is working with nature appropriate?

Any site, regardless of size or location has the potential to benefit nature, and to benefit from nature, through integrating space for nature via designs and layouts, from local plan development, through design to development.

Local plans and landscape designs that take account of existing habitats and priority species, and where relevant, connect these with the wider countryside, will help retain, and potentially increase, existing biodiversity value.

Developments on brownfield land which incorporate into their landscape designs elements of the specialised habitats that develop on formerly developed land once it is abandoned, have real potential to retain what are often now rare and specialised species characteristic of these sites.

Meanwhile, greenfield sites are often characterised by features such as hedgerows, mature trees, streams and ponds; these should be retained and used to inform both the layout of a site to accommodate them, and the design of the greenspace, which would use them as focal points. Existing connections between these features should be retained and new links created to provide so-called ecological networks.

The following table lists wildlife-friendly features and SuDS options covered in the text and their relevance to various sized developments.

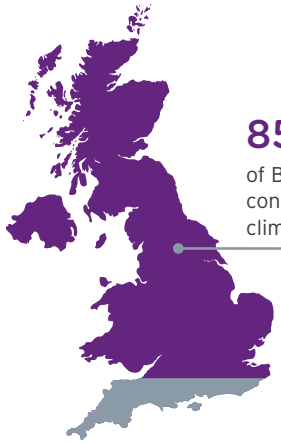
Features	<10 houses	11-100 houses	>100 houses	Urban	Rural	Greenfield	Brownfield
Hedges	Low	High	High	Medium	High	High	Low
Heritage boundary	Low	Medium	High	Low	High	High	Medium
Roadside landscaping	Low	High	High	Medium	High	High	Medium
Street trees	Low	High	High	High	High	High	High
Trees and shrubs	Medium	High	High	High	High	High	High
Wildflower grassland	Medium	High	High	Medium	High	High	High
Nest bricks	High	High	High	High	High	High	High
Bat roosts	High	High	High	Medium	High	High	High
Hedgehog highways	High	High	High	Medium	High	High	High
Hibernacula	Low	Medium	High	High	High	High	High
Green roofs & walls	Medium	High	High	High	High	High	High
Rain gardens	Medium	High	High	High	High	High	High
Detention basins	Low	High	High	Low	High	High	High
Balancing ponds	Low	High	High	Low	High	High	High
Bioretention beds	Low	High	High	High	High	High	High
Permeable surfaces	High	High	High	High	High	High	High
Suitability of feature to development size	Low		Medium		High		

Table 1 All sites, whatever their size or location are relevant to and will benefit from wildlife-friendly features and SuDS options

2 Benefits to people of wildlife-friendly developments

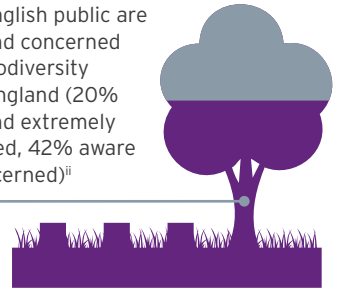
Housing developments are primarily to provide homes for people. It makes sense to create attractive, pleasant places for people to live, and providing opportunities for wildlife to live in the same space is part of this.

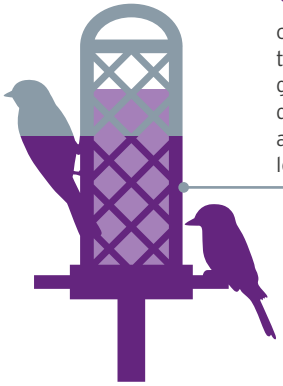
People value nature and are concerned about what is happening to the natural environment.[5, 6] There is a growing body of evidence that people appreciate and want to interact with nature near to their home.[7] Birds are a helpful surrogate for all wildlife. A YouGov survey undertaken on behalf of RSPB, found 87% of people agreed living close to spaces rich in wildlife and nature would be an advantage during the Coronavirus outbreak.[8] This means that wildlife-friendly aspects of a development, if well communicated, could help to market homes to new customers.



85% of Britons are concerned about climate change[i]

62% of the English public are aware and concerned about biodiversity loss in England (20% aware and extremely concerned, 42% aware and concerned)[ii]

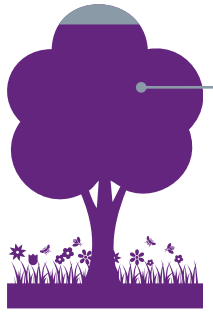




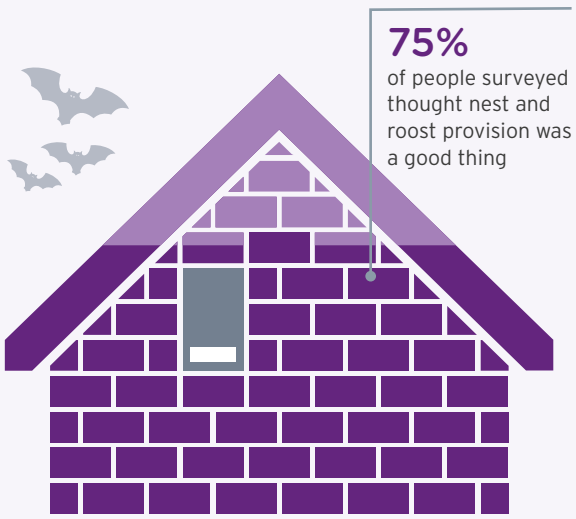
61% of the UK public feed the birds in their garden at some time during the year, and 52% do so at least weekly[iii]

67% of public have or would consider making significant changes to their own house or garden to support nature e.g. leaving part of their garden uncultivated to provide a habitat for wildlife[iv]

65% take visits to the natural environment at least once a week, up from 54% in 2009/10[v]



Having open green space close to home is important to **93%** of people[vi]



A recent study investigated householder attitudes toward nest and roost provision in new houses. 75% of people surveyed thought nest and roost provision was a good thing. 85% said their decision to buy a house was unlikely to be negatively affected by the presence of nest bricks while the remaining 15% thought it might increase the likelihood. 73% of people said they would recommend a house with one to a friend; nobody said they wouldn't. There were no discernible differences in the views of people of different wealth, age, gender or whether there were children in the house. Thus, the presence of such features is entirely compatible with the goals of housing developers.[9]

The greenspace within a development contributes to a positive impact on people's psychological and physical wellbeing. Wildlife-friendly greenspace, with colourful wildflowers, butterflies and an abundance of birdsong is thought to increase the benefit substantially. Access to biodiverse greenspace may therefore:

- Reduce stress, improve heart health, and reduce blood pressure[10]
- Create more peaceful neighbourhoods, improve people's mood and increase their motivation to higher levels of physical activity[11]
- Reduce the strength of ADHD symptoms in children[12]
- Improve people's happiness[13].

There are several ways that people can be encouraged to interact with the nature on their doorstep. Examples include:

- Interpretation: providing dynamic information about the nature in the development
- Engagement with schools on the development to support learning
- Community gardens, where the residents can decide how they want it to be, which in turn gives them a sense of ownership and value that can extend to other areas of the greenspace.

Nature as a motivation for moving house

The Barratt Developments plc Kingsbrook development in Aylesbury has been marketed as wildlife friendly, with integrated features to encourage biodiversity.

When residents were asked "what attracted you to live in Kingsbrook?" 43% of respondents mentioned an element of nature in their motivation to buy a property in this development. This included wildlife within the development, greenspace within the development and the easy links to the surrounding countryside.

Homes for nature as part of homes for people

54% of Kingsbrook residents with homes for nature on their properties (e.g. swift bricks, bat bricks, hedgehog highways) viewed them positively, no residents were negative about homes for nature. Residents considered integration of homes for nature as important for mitigating the effects of development, as a responsibility towards the environment and as an exciting opportunity to see wildlife in their gardens.

Public perceptions of wildlife-friendly development: residents of a new housing development at Kingsbrook, Aylesbury were asked what attracted them to and what they like about the development.

3 Managing Impacts of development on existing wildlife and their habitats, and means of remediation

The imperative to reverse biodiversity declines is clear. It is also essential that developments avoid impact on existing biodiversity wherever feasible, and to make good any adverse effects.

A sequential approach is needed to ensure wildlife objectives, and requirements, are properly and safely built into the planning and implementation of a development from the outset. The first stage prior to master planning and application for development permissions is to screen for the likely impacts of the development on biodiversity, and from that screening process to determine the need for example, further information, statutory consultation and a development of a Biodiversity Net Gain (BNG) assessment. These will then inform the master planning process, and not the other way around.

3.1 Ecological site assessment and net gain

This is the process of understanding the existing ecological value of a proposed development site, which is crucial to informing how negative impacts can be avoided or minimised, and for determining which features can be added to have the best impact for biodiversity. It effectively provides the baseline against which impacts and opportunities for remediation and net gain can be judged.

It is important that the assessment takes account of all key biodiversity features; providing a clear picture of the habitats present and their status, together with the priority species. This goes beyond those for which there is statutory protection and should consider those red listed by competent authorities.

Biodiversity Net Gain

This is a new concept that is already being applied in some areas and is expected to become mandatory, at least in England. It is a mechanism for ensuring that the impacts of a development on biodiversity are overall positive. It requires a minimum of 10% net gain for biodiversity against a baseline assessment. This is effectively achieved by habitat replacement and or enhancement to the tune of 110% of that lost or damaged.

A qualified ecologist will undertake a desk study and a Preliminary Ecological Assessment (PEA),[14] which will identify whether there is a need for specialist surveys. The data gathered will inform the mitigation hierarchy (see below), and to score features using Defra's Net Gain Biodiversity Metric Calculator to identify the scale of impact (damage or loss) and inform the scale at which measures will be needed to remediate and to ensure a net gain in the final development.

The greenspace within a development can be used to provide some of the remediation and or gain. Design should pay close attention to features that can suitably be created in the greenspace and then use the metric calculator to determine how many "credits" these are worth.

This will then identify whether sufficient credits are achieved within the development or whether there will be a need to go outside the site to 'offset' the shortfall. As offset credits owned by a landowner are likely to be tradeable, it is probable that optimising the credits that can be gained from greenspace enhancement for biodiversity within the development redline will be highly cost effective.

Biodiversity Net Gain (BGN) should be considered at the outset of planning a development as costs of implementation, including of any necessary offsetting, will need to be factored into budgets. Also, where offsets are required, the offset mechanism will need to be identified in order to demonstrate that net gain can be achieved. Meanwhile, the net gain measures will need to be maintained for at least 30 years following establishment and ideally in perpetuity.

There is a range of guidance on how to approach BNG. The Construction Industry Research and Information Association (CIRIA) published a good practice guide for development.[15] However, expert guidance will be essential to correctly interpreting the BNG mechanism at a site level.

3.2 The mitigation hierarchy

Avoid:

- Consider location of development before purchasing land – is there important habitat present? If so, look for an alternative site.
- Could damage to important habitats on site be avoided by considered layout, phasing, alternative technologies, reducing the scale of development?
- Avoiding impact should always be the most favoured approach. If unacceptable impact is unavoidable then development should not take place. In such cases it is unlikely that relying on further steps in this process will be possible.

Minimise:

- Can alternatives to the development's location, siting, scale, layout or phasing be used to minimise impact?
- Always make maximum effort to minimise impacts.

Rehabilitate:

- Where features of ecological value must be temporarily damaged or removed to allow the development to take place, and these impacts are deemed acceptable, every effort should be made to return these areas to as close to the original state as possible, or better.

Compensate/offset:

- Any residual negative impacts should be compensated for by the creation or enhancement of habitat.
- Preferably, this should take place on site or as close to site as possible and should be on a like-for-like basis, or better.

The mitigation hierarchy is a key tool in decision making in relation to potential biodiversity impacts caused by a development, and how they can be minimised. The mitigation hierarchy is a way of modelling the information gathered in the assessment to guide choices in planning the development. Avoidance is the key principle. Irreplaceable cannot be replaced, so must be avoided. For less critical habitats avoidance is the priority but the hierarchy shows the impact is minimised and or offset.

3.3 Master planning

The master plan uses desk studies and site surveys to analyse the opportunities, constraints and potential of a site or area for development. They are drawn up by or for a consortium of stakeholders, including the landowner, clients, businesses, the planning authority and local community representatives.

Outputs from the master plan show the layout of roads and transportation, housing including types and numbers. It also determines where community facilities, landscaping, and green spaces are located.

Master planning is the starting point for protecting and enhancing biodiversity, generating climate resilience and for integrating nature-based solutions. Existing landscape and ecological features, as well as historical and archaeological features are also encompassed.

Applying the hierarchical approach to conserving and mitigating a development's impact is crucial; informing the layout design to avoid impact on irreplaceable habitats, or fragmenting of valuable features, which could lead to biodiversity loss. It also guides the master planning process in how it will mitigate for any losses, and to consider opportunities for biodiversity enhancements.

3.4 Design

Development master plans should use BNG approaches including the mitigation hierarchy to ensure the development will avoid negative impacts on nature. Layouts need to be informed by ecological constraints and opportunities. All disciplines (urban planners, landscape architects and ecologists) need to be involved to identify the optimal design to deliver net gains.

The layout needs to take account of how spatially the net gain credits will be achieved in the development, and how these features will be integrated with other requirements, for example, recreational space and climate resilience.

Retained existing features that should be incorporated in the master plan are likely to include woods, copses, native feature trees, mature hedges, scrub, flower-rich grassland and water features including ponds and lakes. The net gain metric scores these by their distinctiveness (the better for biodiversity the more distinctive they are, so the higher their score in the metric). Some will be priority habitats as listed by the four devolved countries of the UK.

Connectivity of habitats is important in enabling wildlife to have safe passage into and through a site, during and after construction. Connectivity scoring is included in the net gain metric. Layout design at the master plan stage will ensure connectivity is built in.

Species are not part of the net gain metric; however protected species need to be considered; these usually need to be conserved in situ.[16]

3.5 Groundworks

Prior to commencing works, all mitigating measures for protected species will have been implemented according to advice and guidance from the ecologist and or relevant statutory authorities. This is in addition to the Construction Environmental Management Plan (CEMP)[17] which deals with other environmental matters.

Timing of works is important in avoiding adverse impacts. Plan to undertake operations at the appropriate times to avoid and minimise the impact construction activities may have on retained habitats and wildlife. Also, carefully plan spatial avoidance of wildlife features, including:

- providing and marking stand-off zones, using barrier fencing
- including a clearly marked map of features in the site's operational documentation, to include e.g. routes used by for example badgers
- providing clearly marked vehicle and pedestrian operator routes to avoid sensitive areas
- seek advice from a qualified ecologist to minimise impacts of compound security lighting which can otherwise cause disturbance to nocturnal wildlife.

Note: where statutorily protected species occur, information here does not replace the need for an approved mitigation plan.

3.6 Incorporating, enhancement and care for existing biodiversity features

Retained habitats, such as ponds, ditches, grasslands, copses and hedges need to be carefully incorporated into the masterplan, as well as the associated landscaping plans and maintenance schedules.

Depending on the condition of these habitat features, works may be needed to restore and improve their function for biodiversity, and to avoid or remediate any impacts of the building operations. This is best achieved through ecological and landscaping scopes of work, and by ecological method statements for contractors.

Key aspects of plans and method statements should:

- be developed involving a qualified ecologist, especially for specialised ecology and protected species
- provide a framework to ensure protected species are properly conserved
- include a monitoring plan to inform whether priority species are successfully accommodated
- include net gain obligations.

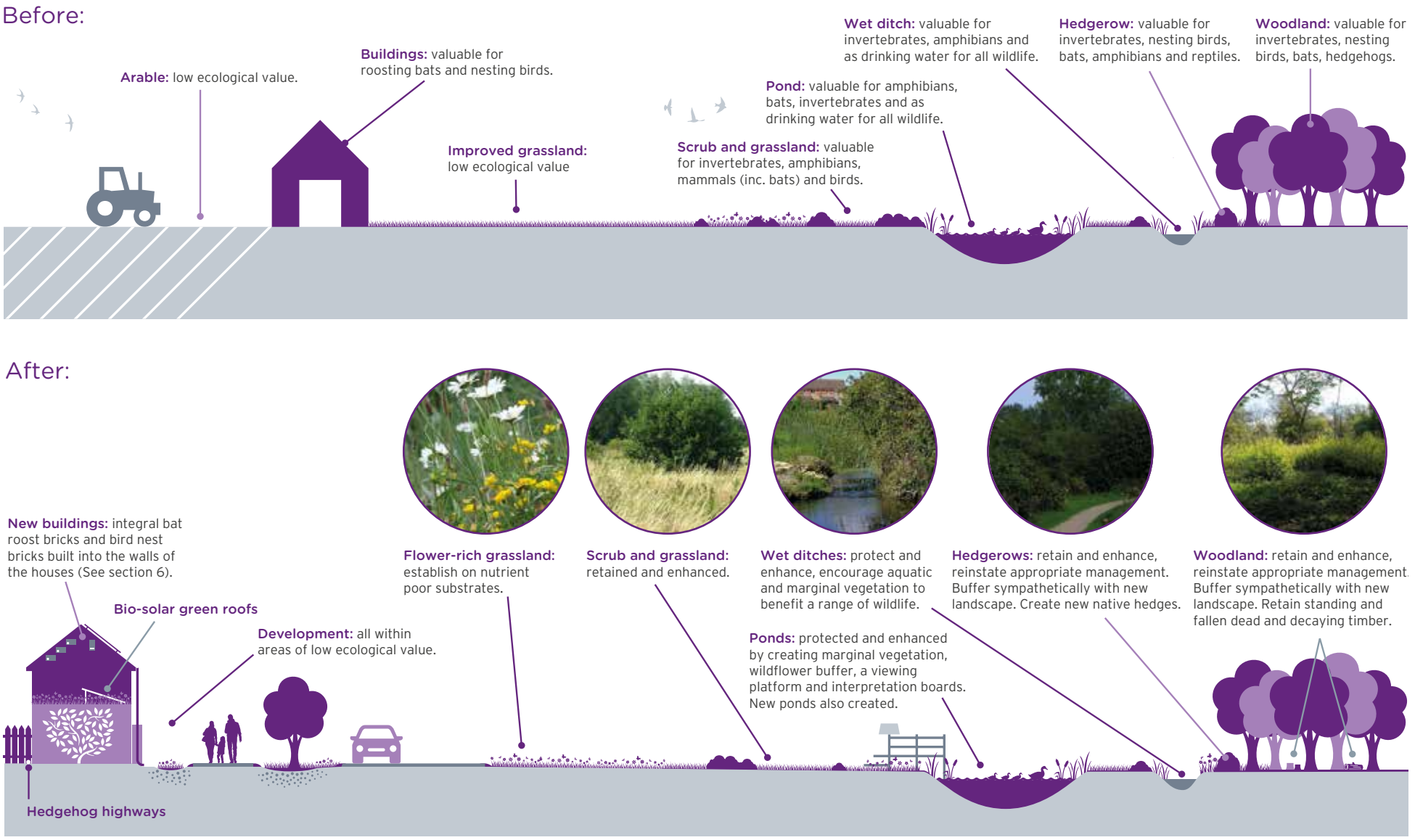


Figure 3 Protecting and enhancing features of ecological value (before and after)

4 Boundaries, buffers and connectivity

New boundary and buffer features, including hedgerows, drystone walls and verges should be designed to maximise wildlife value by forming connective corridors so that, as well as providing food and shelter, they enable wildlife to move to occupy new habitats. Meanwhile, vegetation contributes to climate resilience, especially when incorporated into SuDS.

4.1 Hedges

Hedges serve as an effective boundary function, but also have ecological benefits, particularly where the species choices are made carefully. They provide effective connectivity through a development, by creating corridors to the surroundings along which wildlife can safely travel.

Retained mature hedges and hedgerow trees are often the foundation on which to build an interlinking connective network of new planting. The master plan needs to incorporate and work around these and to buffer them.

Key actions for existing and new hedges include:

- identifying existing hedgerows in the landscape plan and indicating where new hedges are to go to provide connectivity
- remedial works to rejuvenate neglected hedges, including gapping up with additional plants
- providing buffer strips of wildflower grassland, cut every other year on rotations.

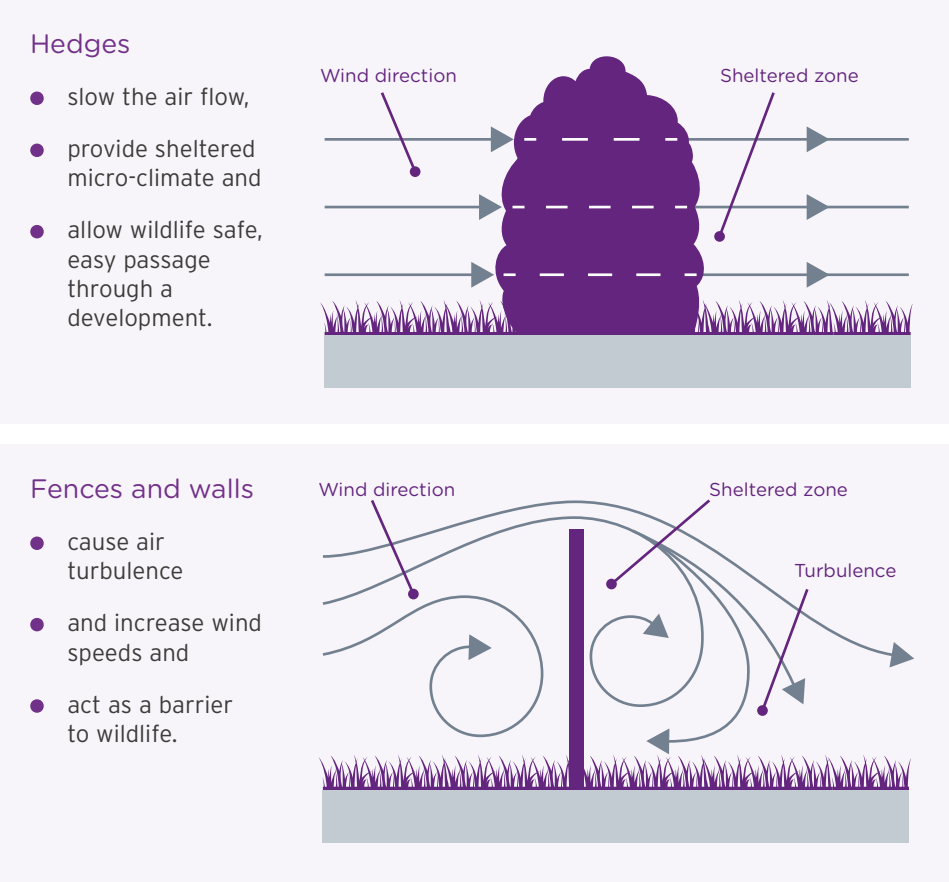


Figure 4 Airflow comparison between soft and hard boundary features.

New hedges are usually best when they comprise mixed native species. All native hedging species can be clipped to a formal shape if required. Choice and type of species (native/non-native) will be informed by:

- soil type
- species characteristic of the local landscape
- NHBC approved planting distances of trees and shrubs from footings.[18]

Native hedges are most beneficial to wildlife. They can be used in formal as well as informal settings. Most native species are not thorny should this be of concern in the proximity of high footfall (see table 2).

Non-native, usually single evergreen species hedges are often used in formal settings. Where this is necessary, wildlife value can be enhanced by using high nectar value species. Table 3 lists examples of non-native hedging species with good nectar.

Table 2 A selection of some native hedging shrubs and trees

Hedging shrubs	Trees
Hawthorn - Crataegus monogyna	Field maple - Acer campestre
Dogwood* - Cornus sanguinea	Silver birch - Betula pendula
Beech* - Fagus sylvatica	Hornbeam - Carpinus Betula
Wild privet* - Ligustrum vulgare	Crab apple - Malus sylvestris
Blackthorn - Prunus spinosa	Wild cherry - Prunus avium
Guelder rose* - Viburnum opulus	Rowan - Sorbus aucuparia

*non-thorny shrubs

Table 3 A selection of some **non-native** hedging shrubs and trees with a wildlife value

Hedging shrubs	Trees
Barberry spp - Berberis spp	Snowy mespil - Amalanchier lamarkii
Californian lilac - Ceanothus spp	Crab apple - Malus tschonoskii
Ebbinge's silverberry - Elaeagnus x ebbingei	Morello cherry - Prunus cerasus
Chilean gum box - Escallonia spp	Ornamental pear - Pyrus communis 'Chanticleer'
Lavender - Lavendula spp	Rowan - Sorbus 'Shearwater Seedling'
Laurel-leaved viburnum - Viburnum tinus	Swedish whitebeam - Sorbus intermedia

As well as the species composition, hedgerows are enhanced through:

- providing flower-rich grassland buffer strips to either side of the hedge, which are typically a sown grass and wildflower mix, 2+m wide. Buffer strips can be enhanced by:
- suitable cutting regimes, dependent on setting: informal areas should be cut in alternate years on rotation in early autumn, elsewhere 1-2 times a year in early spring and late summer. Avoid cutting too short (no less than 10cm) to retain cover for invertebrates in the thatch.

(Buffer strips protect the base of hedges from drying winds, retaining soil moisture and humidity beneath the hedge, and provide important habitat for butterflies and other insects to breed, and mammals, birds, reptiles, and amphibians to forage.)

- providing a diverse mix of nectar-rich herbaceous plants in formal settings where wildflower grass is not deemed appropriate. This will help provide some food and shelter for invertebrates
- planting well-spaced standard trees along their length. Larger, locally characteristic native trees are the best option. (see tables 2 & 3 for species of wildlife value that may be considered where appropriate). These should be:
- spaced to ensure sufficient distances between the tree canopies at maturity
- away from houses.

(In more formal settings appropriate native and non-native species can be used, with smaller trees being suited to areas close to buildings.)

A dense, mixed native hedge has high wildlife value

Dogwood is one of many suitable thornless native plants

Ceanothus and Viburnum tinus are formal hedgerow plants that are useful for pollinating insects

Figure 5 Good quality hedges provide food, shelter and safe breeding sites for wildlife

4.2 Fences and walls

Hard boundaries such as walls and fences form a barrier to ground dwelling animals such as hedgehogs, reptiles and amphibians, inhibiting their movement around a housing development. Creating small 13cm diameter or 13cm square holes in garden fences or walls allow them to pass between gardens. Avoid making holes that lead directly onto roads.

Figure 6 'Wildlife highways' can be created in garden fences and walls

Bee bricks

Boundary walls are suitable places to include bee bricks in a development; located in sheltered, sunny locations at various heights between 1m and 1.5m from the ground, and proximity to nectar-rich plants from which bees can forage.

4.3 Heritage boundaries

Dry stone walls are characteristic in parts of Britain. Existing, particularly old walls should be retained and where it is needed sympathetically repaired and even extended, or new ones created. They are valuable hibernacula for reptiles and amphibians and provide habitat for species of plant that are not readily found elsewhere, such as ferns, mosses, and lichens. A qualified ecologist will advise on the presence and implications of amphibians and reptiles, to ensure works avoid detrimental impact.

New walls incorporated into landscaping and restoration of old walls should provide opportunities for reptiles, amphibians and other wildlife through dry stone construction or through leaving loosely filled core accessible through gaps provided at various heights in the walls.

Figure 7 Dry stone walls provide a different dimension to wildlife habitat

4.4 Verges

Well landscaped and managed verges of the local street network contribute to connectivity for wildlife and provide space for improved biodiverse and climate resilient solutions.[19] Combined landscape and Sustainable Drainage Systems (SuDS) features ameliorate the effect of surface water flooding, urban heat and atmospheric pollution.

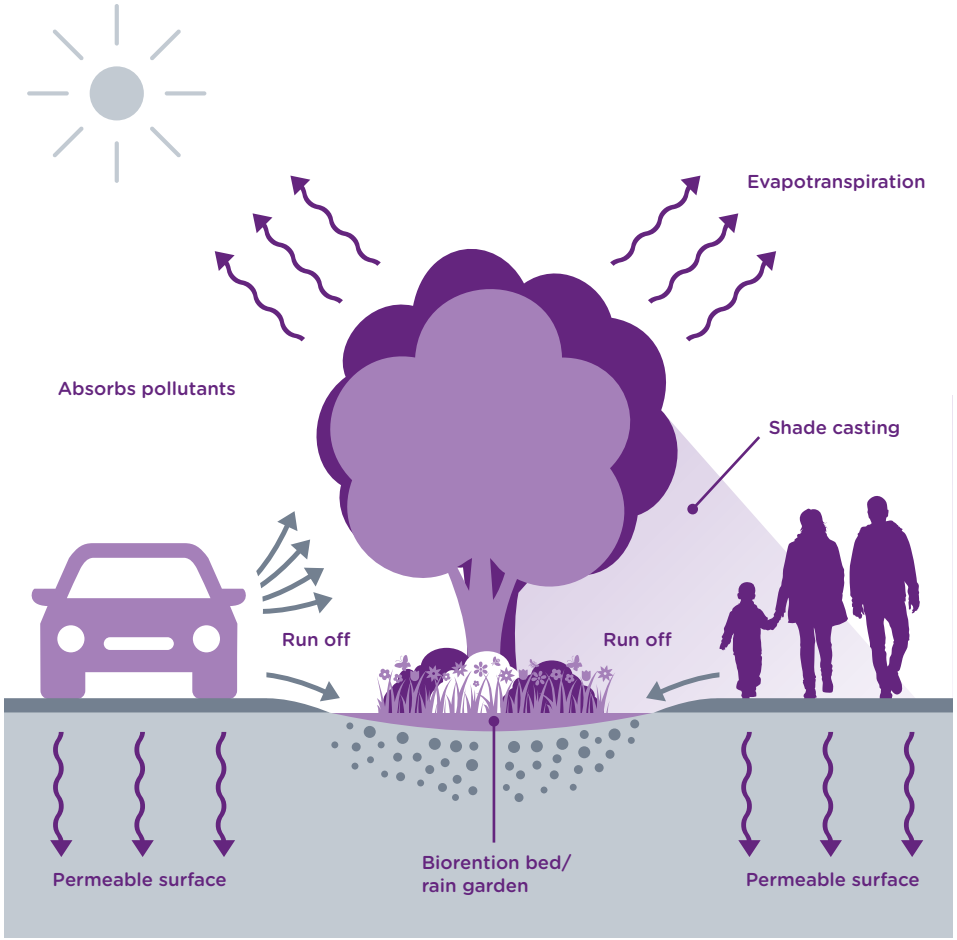


Figure 8 Schematic of a landscaped verge with SuDS features incorporated

Verge features that benefit wildlife include:

- a varied vegetation structure, including grasses, low herbaceous vegetation, shrubs and trees
- a continuity of vegetation cover, linking with other landscape features to provide safe connectivity, for example, hedgehogs to help them move through the development with minimal road crossing
- informal landscaping of grass and wildflower mixes appropriate to soil types and or conditions, with regularly mown areas adjacent to paths and roads, and more extensive mowing elsewhere.

Where shrubs are used, plant mixtures of native and non-native shrubs of wildlife value in informal irregular shrub beds.

4.5 Incorporating biodiverse SuDS into verges

The street network can help deliver multiple benefits. This includes dealing with run-off through combining planting schemes with SuDS features, particularly source control and conveyance.

Verge vegetation can act to:

- collect and treat run-off from roads and paths, filtering and breaking down pollutants
- help cool the local atmosphere on hot sunny days, reducing the temperature of hard surfaces
- absorb atmospheric pollutants and improve air quality, helping reduce heart and lung disease[20]
- provide shade for pedestrians and adjacent shops and buildings on hot days.

Figure 9 Trees provide partial shade along a flower rich verge. This verge could have been configured to take run-off water from the road.

Extending the life of street trees

Urban trees suffer stress from soil compaction, which limits root function and compromises a tree's establishment and life span. Street trees can cause road and path lift, damage to footings and services, all of which are cited as reasons not to plant trees near houses or roads.

Extensive tree pits and root barrier membranes will ensure long-term healthy tree growth, good soil aeration, avoidance of compaction and protection of surfaces and services. They also enable trees to be used in SuDS bioretention features, with run-off water providing irrigation and helping remove diffuse pollution contaminants in the run-off:

There are two commonly used tree pit techniques:

1 Rigid interconnecting polymer panels are assembled into crates, with integrated air chambers to help aerate soils. The roots of the planted tree are diverted downwards into the aerated soils.

2 A concrete planting chamber deflects tree roots into the surrounding substrate of structural soils - a crushed stone growing medium combined with charcoal-based soil improver and compost.

Root barrier systems are thick sheets of high-density polyethylene (HDPE) that block and divert roots into uncompacted soil profiles, away from paths, footings and utility services.

Figure 10 Root barriers prevent damage to paths and services by diverting root growth away from structures and services and into uncompacted soils.

5 Sustainable drainage and urban water catchment

Sustainable Drainage Systems (SuDS) mimic natural processes in managing rainfall using landscape form and vegetation such as trees, shrubs, flowering plants and grassland.

SuDS provide:

- flow control and limit volumes of surface water to reduce risks of downstream flooding
- improved water quality by trapping silts and reducing pollution of water courses and bodies
- groundwater recharge which helps maintain river flows and support wetlands
- increased evapotranspiration thereby helping climate regulation in urban areas
- increased opportunities for wetland wildlife in urban areas and links to the wider landscape
- help to well-being by increasing the amenity value of the public realm.

Source control is the most important stage of treatment for SuDS to realise their full nature and amenity value. Source control also provides additional wildlife enhancement opportunity.

Treatment	Purpose and feature	Scale of development
Source control	Controls rainfall close to where it lands, using green roofs and walls, rain gardens, bioretention beds and filter strips, permeable paving and incorporates rain-harvesting features such as water butts.	<10 to >100 houses
Site control	Controls run-off received from source control features, collected in hard or soft detention basins and balancing ponds, swales or other surface features.	>10 houses
Regional control	Controls and stores the clean run-off received from the site in detention basins and balancing ponds. Larger scale SuDS, collecting from multiple sites can provide more extensive wetland features. This is the final stage of treatment, so any discharge to adjacent water courses, via controlled outfalls, must not impact on water quality. Ideally it should improve stream quality.	>100 houses
Conveyance feature	Moves water between each treatment stage. This should be done using above-ground channels such as swales and rills to maximise filtration, wildlife value and people benefits.	>10 houses

Table 4 SuDS stages and the scale at which they apply Adapted from: A. Graham, J Day et al [21]

5.1 Bioretention beds and filter strips

Bioretention beds and filter strips manage run-off from paths and roads. Omitting kerbs or leaving gaps between kerb stones allows water to enter these features. With good landscape design, these can be attractive amenity assets that require minimal maintenance. They may be informally or formally landscaped to suit location, with native or non-native trees, shrubs, herbaceous plants and/or flowering lawns.

Removing kerbs makes it easier for wildlife such as amphibians and hedgehogs to escape the road. It also reduces a need for gully pot drains that otherwise act as preferential pathways through to other surface water features, including balancing ponds and waterways. Gully pots need maintaining, and the contents disposed of. They can also trap and kill wildlife, especially amphibians and small mammals.

Figure 11 Bioretention beds and filter strips slow and clean run-off from paths and roads

5.2 Conveyances

Swales lend perfectly to being incorporated into verge landscaping. Lowered kerbs allow run-off from paths and roads to flow over flower-rich filter strips into the swale. With minor modification, swales may be improved for invertebrates and amphibians by creating:

- an uneven bed
- small hollows to provide temporary pools
- check dams to slow water flows and around which can be planted marginal aquatic plants
- meanders, which further help to slow flows and create a naturalistic feel.

Where water needs to be conveyed across hard landscapes, rills or stone lined channels can add interest. These can be enhanced by planting wetland species around check dams or incorporating other design elements that can also be enhanced by planting.

Figure 12 Landscape options for swales and rills

5.3 Wetland features: Detention Basins, Balancing Ponds

Wetlands are important for wildlife. Meanwhile, as well as supporting plants and animals they help store and manage water and are a valuable recreational asset to communities. Existing wetlands, for example ponds, ditches and streams, should be retained in the master plan to form the basis around which to design the new landscape and to be incorporated into the surface water management plan.

The relationship between the SuDS network and the wetland should protect it from direct discharges of contaminated surface water run-off from the development. The long-term landscape and ecological management plan will identify any remedial work to restore and enhance their ecological value. This might include exposing culverted streams that pass through a site (see case study 9.9).

Pipe to balancing pond SuDS do not remove oils and heavy metals

Ponds and wetlands are not efficient at dealing with oils and heavy metals. Where they are fed directly from pipes conveying un-treated run-off from roofs, paths and roads they can contain elevated levels of oils, heavy metals and micro plastics in the water, which can impact on people and wildlife.[22, 23]

5.4 Detention basins

These are temporary water storage basins for use during flood events. They can provide both amenity and wildlife opportunities. As they remain dry most of the time, they can be integrated into wider greenspace and include, for example, use as play areas, as well as more dynamic landscaping that also benefits wildlife. The addition of wildflower grass, flower-rich herbaceous planting and high wildlife value trees and shrubs all provide food and shelter. A varied topography to the basin that includes humps and hollows post flooding, will hold patches of water and prolongs the draw down.

5.5 Balancing ponds

These are permanent water bodies within the boundary of a development. Where central in a development they can be hard landscaped, but these should always be enhanced with a range of aquatic plants to provide aquatic wildlife habitat and improve the aesthetics.

Soft landscaped balancing ponds are the most familiar SuDS feature. A good balancing pond will have:

- an irregular shape, to provide a greater length of valuable edge habitat for a given area
- a series of shelves at incremental depths and uneven bed topography
- appropriate trees and shrubs strategically planted around the pond, in clusters of irregular shape and size
- open margins to the waterbody, sown with flower-rich grassland mixes to suit the soil type and conditions
- some selective planting of marginal aquatics to give the pond a head start – other, locally native plants will soon quickly colonise.

Larger areas have greater opportunities for wetland features. Combining both detention basin and balancing pond can provide a functioning wetland with wet scrub, grassland, reed and marsh.

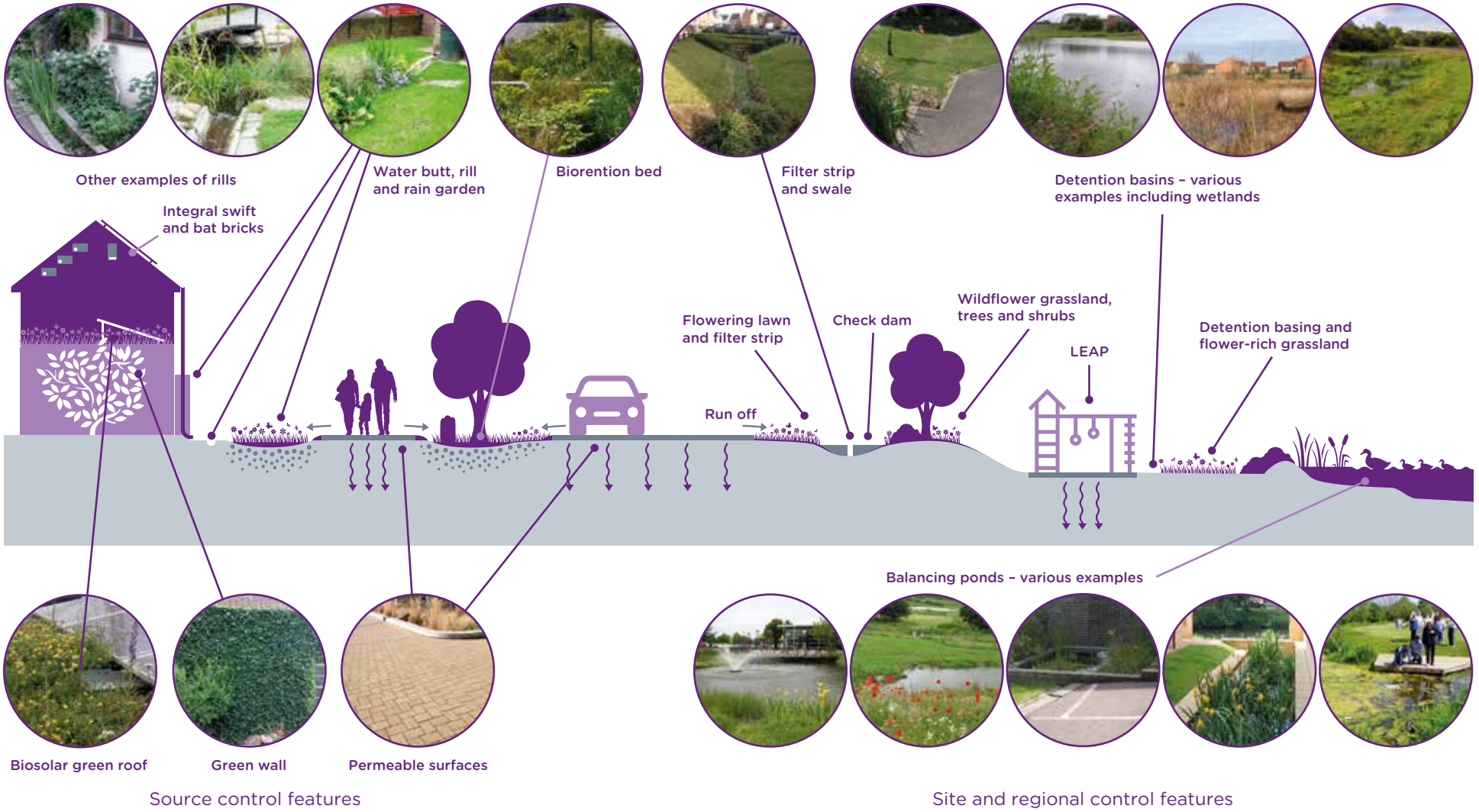


Figure 13 Wet features as part of a Sustainable Drainage System, integrated throughout a development

5.6 Rain gardens

These are shallow depressions with free-draining soil that slow and clean the run-off they receive from paved areas and roofs often via a water butt and downpipe. Following heavy rain, water will fill the depression and then slowly drain. They may hold water for no more than one or two days other than which they will be very dry. [24] They should be planted appropriately for the conditions, which are likely to include dry spells and short periods of temporary inundation. For wildlife benefit ensure that planting is nectar-rich and of benefit to pollinators.

Conventional excavated rain gardens need to be at least 5m from a house, with a shallow grass swale or stone rill providing the channel to carry water to it. With some creativity other elements can be incorporated such as rain chains and ponds and non-linear channels to convey the water. An alternative to the conventional excavated rain garden is a rainwater planter – a raised bed that provides the same attributes and can be adjacent to the house as there is no direct infiltration that could affect the building.

Figure 14 Conventional and raised planter rain gardens served by water from a downpipe

Permeable surfaces

Run-off generated by rainwater landing on hard surfaces filters through permeable joints or pores which have a treatment function that helps improve water quality for surface SuDS 'downstream'.

They are usually laid as block pavers, cellular concrete blocks or porous tarmac which allow water to drain through vertical gaps, or pores, into the roadbed beneath, which is constructed to enable the water to soakaway. This provides a first line of defence against diffuse pollution, and in dealing with run-off volumes. They are sometimes the only SuDS option in high density developments, although, as shown in the photograph they can be successfully combined with adjacent rain gardens.

6 Planting for wildlife and climate resilience

The careful use of planting in a landscape design creates opportunities to increase value for wildlife, and to buffer people from the effects of climate change, especially in urban areas. Well-designed landscapes will do this at the same time as providing opportunities for wildlife.

Trees improve the quality of life for communities and provide a wide range of benefits.[25] Research shows that where tree canopy cover is over 25% but open enough for people to feel safe (and not suppress the vegetation beneath), social deprivation and crime are lower, plot values are higher, and there are education and employment benefits.[26] Vegetation cover designed and provided for biodiversity provides these benefits.

Problem	Nature-based solution
Heat island effect	Vegetation cover and SuDS
Airborne pollution	Vegetation cover
Carbon emissions	Vegetation cover
Noise	Dense vegetation cover in strategic locations
Water run-off/localised flooding	Vegetation cover and SuDS
Soil erosion	Vegetation cover, less mowing and soil disturbance
Pollinator decline	Nectar-rich landscape with more deciduous and herbaceous plants and less evergreens with little or no nectar value
Habitat fragmentation	Maintain habitat continuity, retain and enhance existing landscape
Water pollution	SuDS source control, soft landscaped SuDS features

Table 5 Nature-based solutions help provide climate resilience

6.1 Topsoil and landscaping

Landscaping with wildlife in mind does not benefit from fertile topsoils, these can instead be used for areas such as allotments where it will be of value. Highly fertile soils promote rapid growth of a low diversity of aggressive herbs and grasses which compete with beneficial plants, require intensive maintenance, and thereby increase carbon emissions. Nutrient poor substrates, conversely, promote a more diverse vegetation community, supporting abundant and diverse populations of invertebrates and other wildlife, and need less maintenance.

6.2 Structural landscapes

Structural landscapes are the matrices of planting and physical structures in the greenspace, particularly in relation to access infrastructure, that include retained and created green corridors. These should use native plants to buffer and enhance existing and create new habitats. In other areas a diverse palette of deciduous and evergreen, native and non-native trees, shrubs and herbaceous plants will deliver structure and year-round food for wildlife.

Planting dense monoculture blocks of evergreens provides little structural diversity or feeding opportunities for wildlife. They may also be vulnerable to attack by plant pathogens, which are becoming more prevalent as the climate warms.

Except for perhaps high-profile areas, shrubs do not need planting at the densities often seen in conventional schemes. By spacing shrubs and underplanting with a mix of herbaceous plants and bulbs they provide nectar for pollinators and look attractive. See Resources – Landscape (Page 55), for a source of suitable plants.

Careful choice and use of herbaceous planting within shrub beds creates aesthetically pleasing displays for much of the year which are very good for wildlife. The underplanting with herbaceous plants helps suppress weeds, reduce erosion, and retain soil moisture.

Figure 15 Nectar rich shrubs and herbaceous plants are vital for pollinators as well as being aesthetically very attractive

Non-native plants

Native plants offer the best outcomes for wildlife. However, it is rarely realistic to adopt a purist approach to this in the built environment. Those non-native plants that pose little current threat to the environment can be used to benefit wildlife e.g. by prolonging the availability of nectar to insects.

However, many non-native species do have the potential to be invasive and around 60% of those known to damage the natural environment in the UK originate from the horticultural industry. These invasive non-native species (INNS) should be avoided in planting schemes.

Despite their value for nectar and berries, Buddleias and Cotoneasters are amongst several unsuitable invasive species. Meanwhile government agencies' horizon scanning has identified many other frequently used plants that will become invasive in the future, including common and Portuguese laurels.

For more information, see:

- Schedule 9, Section 14A (Part 2) of the Wildlife and Countryside Act 1981[27]
- Natural England report: Horizon-scanning for invasive non-native plants in Great Britain (NECR053).[28]

1. Naturalistic areas (Structural)

100% native trees, shrubs and herbaceous plants of UK provenance, characteristic of the area. Use to buffer and enhance existing landscape and in new landscape to create copses with shrubby and herbaceous understory and scrub-grassland mosaics.

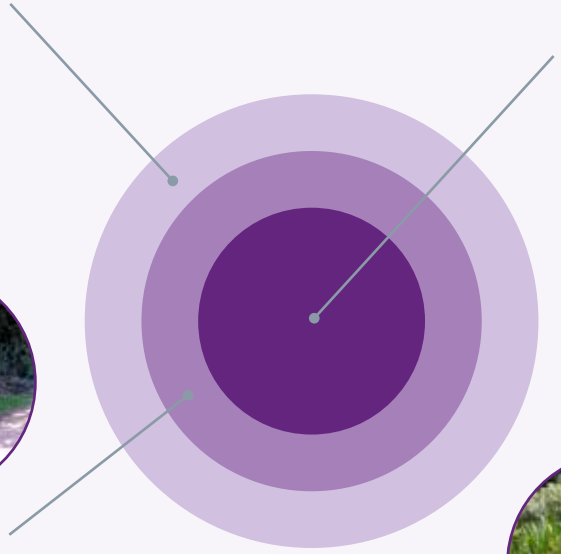
Applicable to: mitigation areas, green spaces and corridors around and through developments.

2. Informal areas (Structural-Residential)

Intermediate overlap between naturalistic and formal areas.

70% native species and 30% non-native trees and shrubs. Appropriate mixes of non-native species can add colour throughout the seasons. Shrub planting densities can be as low as 2/m^2, underplanting with native and non-native herbaceous plants and bulbs of known wildlife value.

Applicable to: high use public open spaces such as: pavilions, and other high profile amenity and community areas.



3. Formal areas (Residential)

A mix of native and non-native trees, shrubs and herbaceous plants and bulbs of high wildlife value. Ideally:

60% deciduous species (30% proportion non-native)
40% evergreen (5% proportion non-native)

Plus herbaceous plants and bulbs.

Applicable to: formal planting around high profile community, amenity and play areas, street and plot planting.

Figure 16 Planting in different areas of a development

6.3 Biodiversity and tree and shrub planting

Structural heterogeneity of planting is important in creating high quality places for wildlife. A varied structure provides a greater range of features used by different wildlife, and so provides for a greater diversity of species.

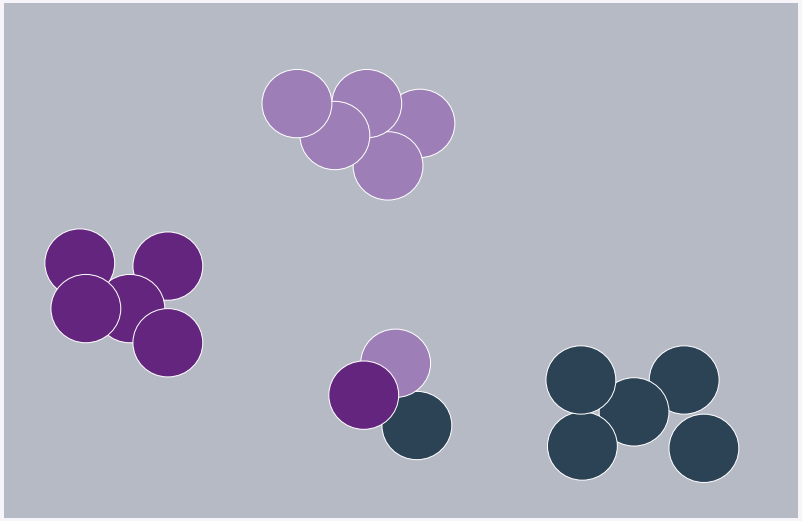
There are four key principles to consider when planting blocks of trees or shrubs to make the most of structural planting for wildlife. Depending on the size of plot, aim to use a combination of these planting patterns (see also Figure 17):

- vary the number of species in clumps or groups of trees using one to three species
- vary the area of clumps or groups of trees
- vary the space between clumps or groups of trees
- vary the space between trees within clumps or groups of trees.

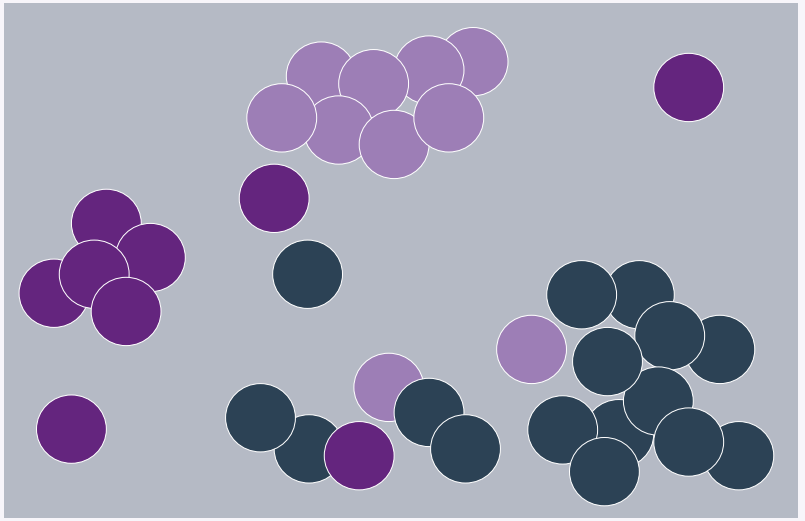
In addition, straight planting lines are usefully avoided as, although they might provide minor easement of maintenance, they:

- create wind funnels, which cool the micro-climate, lower humidity, limit shelter and cause cooling in spring when wildlife, especially invertebrates, needs warmth
- cause sight lines, so remove concealment that is important to many animals.

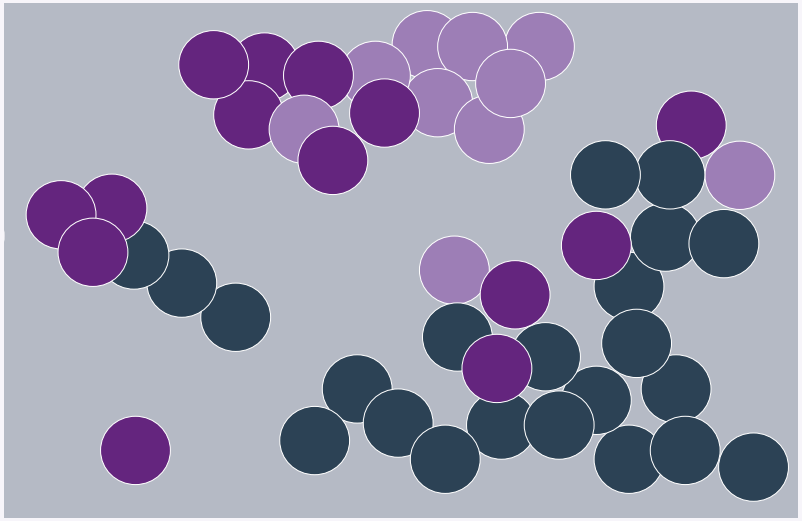
Applying these principles to create naturalistic landscaping with trees helps diversify both horizontal and vertical structure making it attractive to more wildlife.



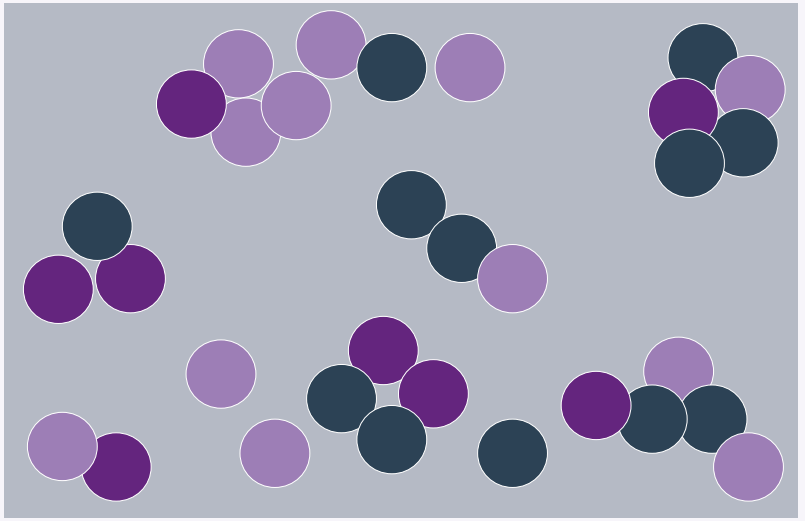
A. Pure clumps or two-three matched species in a clump to develop a native wood.



B. Varied clump sizes to increase diversity of new native woodland.



C. Varied spacing between clump sizes to increases diversity of new native woodland.



D. Varied spacing within clump sizes increases diversity of new native woodland.

Figure 17 Techniques for maximising the value of tree and shrub planting in structural landscape areas (coloured dots represent three different tree species)[29]

This range of tree planting options will attract different species by the different degrees of openness and or of clumping of the tree cover. Where there is enough space the ideal would be to provide a variety of open and more closed canopy areas, as illustrated at figure 17c.

Where a more closed canopy woodland is intended, the planting densities need to take account of the growth character of the trees and how the canopy will spread with time. Close spacing (3-4m apart) will lead to complete canopy cover in just a few years. Management will then be needed to reduce competition and to allow light through to encourage understory shrubs and flora. Wider spaced trees will close the canopy later, and will have better form, and stronger roots which will improve durability over time.

More open spacing (c10m apart) interspersed with shrubs at 2-3m spacings promotes increased surface area of canopy vegetation through bigger tree canopies, so will provide more foraging opportunities for wildlife as well as more shade.

Unless a greater than 30% failure, plant losses do not need replacing as the gaps provide natural spaces for self-seeding and break up planting patterns.

Changes in maintenance practice to help limit climate change impacts:

- only use tree guards where essential – each plastic tube causes up to 0.5kg of carbon emissions
- avoid herbicides, which can lead to increased soil moisture loss, instead mulch with wood chip or biodegradable textile, or weed manually
- plan for phased thinning, coppicing and pruning of trees and shrubs, including, where relevant, ornamentals, to avoid stress from over-crowding of trees.

6.4 Creating biodiverse grasslands

In just 50 years during the mid 20th century, 97% of unimproved grasslands were lost in England and Wales.[30] By creating new native flower-rich grassland in landscaping, some degree of repair will be made. All grasslands, other than sports pitches and amenity play areas, could and should, be flower-rich. Meanwhile, there are suitable flowering lawn seed mixes and turfs that can tolerate regular mowing, and still provide colour and nectar.

Key points in creating flower-rich grasslands:

- flower-rich grasslands need low nutrient soils
- understanding the soil type present is key to identifying which seed mixes to use
- there are some mixes available with fewer species that suit higher nutrient levels in the soil
- wildflower grassland turf is available although this can be expensive
- locate wildflower grasslands in low impact areas where mowing can be reduced to once or twice a year to allow flowering and setting of seed.

Changes in maintenance practice helps modulate the impacts of climate change:

- Leaving grass longer by reducing mowing frequency and raising cutter heights increases water evapotranspiration from the leaves, and reduces emissions from mowing operations
- Raising the cut height to above 5cm, as well as cooling the atmosphere, attenuates and helps clean storm water run-off and encourages more percolation into the soil
- Leaving unmown strips increases interception and reduces the extent of mowing.

6.5 Planting and managing for climate resilience

The climate is already heating rapidly and is putting increasing amounts of stress on urban populations. The relatively low extent of green space, combined in urban areas with the volumes of buildings and pavement, and emissions from heat sources, cause urban areas to heat significantly more than rural areas. However, strategic planting design helps reduce urban temperatures and may help sequester carbon.[31] As well as providing direct shade, vegetation and tree canopy cover significantly reduces the effects of heat from hard surfaces, thus reducing street level temperatures. And the variance in temperatures between sun and shade, together with the evapotranspiration from trees creates airflows which help cool the local atmosphere by up to 3°C.

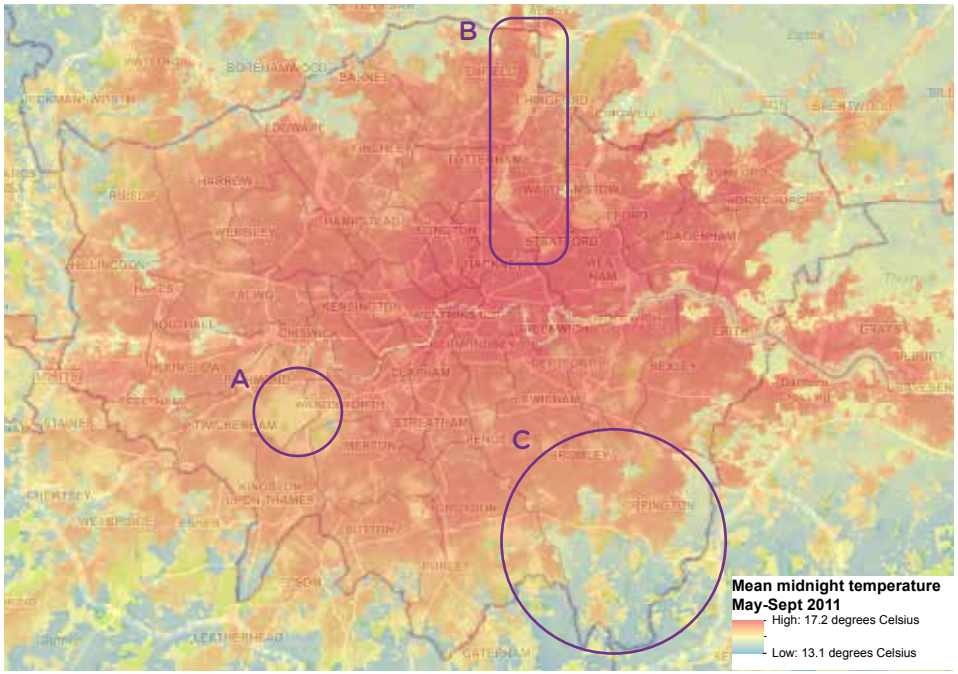


Figure 18 The cooling effects of vegetation. Paler colours indicate areas with more vegetation. Area A is Richmond Park and Wimbledon Common, B is the Lea Valley and C is Bromley, London's 'Greenest Borough'.

Canopy cover of more than 40% has the greatest impact in reducing daytime temperatures.[32] Quickly generating this scale of cover will require relatively high planting density of canopy spreading species and varieties. The need to thin these out to maintain the desired canopy cover will need to be factored into aftercare plans.

Combining tree cover with other vegetation, such as shrubs and grassland increases the overall effect, as the increased structural complexity traps more humidity, thereby reducing temperature at ground level.

6.6 Adaptation of planting to survive increasing temperatures

Choosing what to plant in the face of a changing climate is important. The trees, shrubs and other plants used need to suit the increasing stresses they are likely to face over their lifetimes. Research points to good establishment as being of key importance for long term viability of trees and shrubs. Trees of a local provenance are found to establish better than those from elsewhere. At the same time, most of the UK's native trees and shrubs have quite extensive climate space to the south in Europe. This is a strong argument for planting at least a good proportion of locally native trees and shrubs for resilience in relation to climate.

Climate mitigation through avoiding peat

As one of the largest customers of the horticulture industry, the housebuilding industry has a pivotal role in removing peat from the supply chain. Peatlands worldwide are hugely important carbon stores, but these are destroyed when they are drained, and peat removed for use in the horticulture industry. The Government's target is to end the use of peat in horticulture by 2030.[33] There is also a need to switch from plastic to biodegradable pots for all container grown plants.

There are alternative growing mediums to peat, and the imperative is for nurseries to move to peat free composts. Meanwhile, planting in winter means that stock can be supplied bare rooted as root desiccation risk is lower, so avoiding the need for peat.

7 Adaptive use of existing structures and materials for wildlife enhancement

Creative use of materials and opportunities presented in the design and build of a new development can generate innovative solutions to providing for wildlife within the context of the primary purpose of the site. Materials generated from site clearance and construction where repurposed have a use in creating new features instead of being carried off site with costs involved. Meanwhile, features of the build in terms of hard landscaping and structures where adapted provide valuable habitat for wildlife and so become multi- instead of single purpose. These solutions will work on any site but have their most obvious application on formerly developed land in urban areas.

7.1 Structures and hard landscape features

Installed to provide services around the development, hard landscape features as well as performing their primary function can also present opportunities to help wildlife. For example, with crib retaining walls, using different fills sown or planted with suitable nectar plants will provide habitat for bees and other insects, and even nest sites for birds. Bus and bike shelters lend themselves to innovation that provides habitat and small-scale SuDS features; transformed with flowering extensive green roofs and incorporating bug habitats into their vertical surfaces, they provide a point of reference and interest. Meanwhile, through judicial and carefully planned use of lighting, dark bat-friendly corridors can be incorporated.

Permeable surfaces

An important component of source control in the SuDS management train. In addition to block paving, permeable tarmac and concrete can also be used.

Bee planters

Ideal as features in and around amenity areas or even as a traffic barrier, these simple to make planters provide nectar and home to solitary bees.

Green roof habitat shelters

In some UK cities bus shelters have been given a green roof. You can also find green roof bike and bin shelters with habitat walls at each end.

Crib retaining walls

Provide more wildlife opportunities than conventional retaining walls. Cells can be planted with nectar rich plants, some packed with soft sand for solitary bees while larger aggregates at the base will provide shelter for amphibians and reptiles.

The Rootlock retaining system uses non-woven geotextile bags filled with substrate materials from site and interlocked with plates. Bags can be pre-seeded with an appropriate seed mix, hydroseeded or planted in situ during or after installing.

Lighting

This has negative impacts on all wildlife, not just bats. Any lighting plans should follow guidance published by Bat Conservation Trust. They should provide dark areas, particularly where wildlife might commute along linear vegetation corridors.

Signs and miscellaneous furniture

Signs and notice boards can also provide wildlife benefit by designing them as large bug houses for solitary bees. Similarly, timber art such as totem poles or other wooden constructions can be drilled with holes for solitary bees.

Figure 19a Hard landscape features

7.2 Soft landscape features using repurposed materials

Waste materials generated from the development work provides a different scope for wildlife. These might include timber, rubble from demolition works, or excess topsoil, which when incorporated into a range of landscaping features add wildlife opportunities and thereby interest to materials that would otherwise need to be removed from the site:

- beetle, butterfly and solitary bee banks provide dry warm topography for different species depending on the soil types used
- hibernacula for invertebrates, reptiles, amphibians and small mammals can be incorporated beneath the wildlife banks through placement of demolition materials
- timber from trees removed or lopped in preparing the site provide deadwood features, which can either be protruding or buried as both will host an array of unusual wildlife
- recycled demolition material used as substrate that replicates some brownfield features.

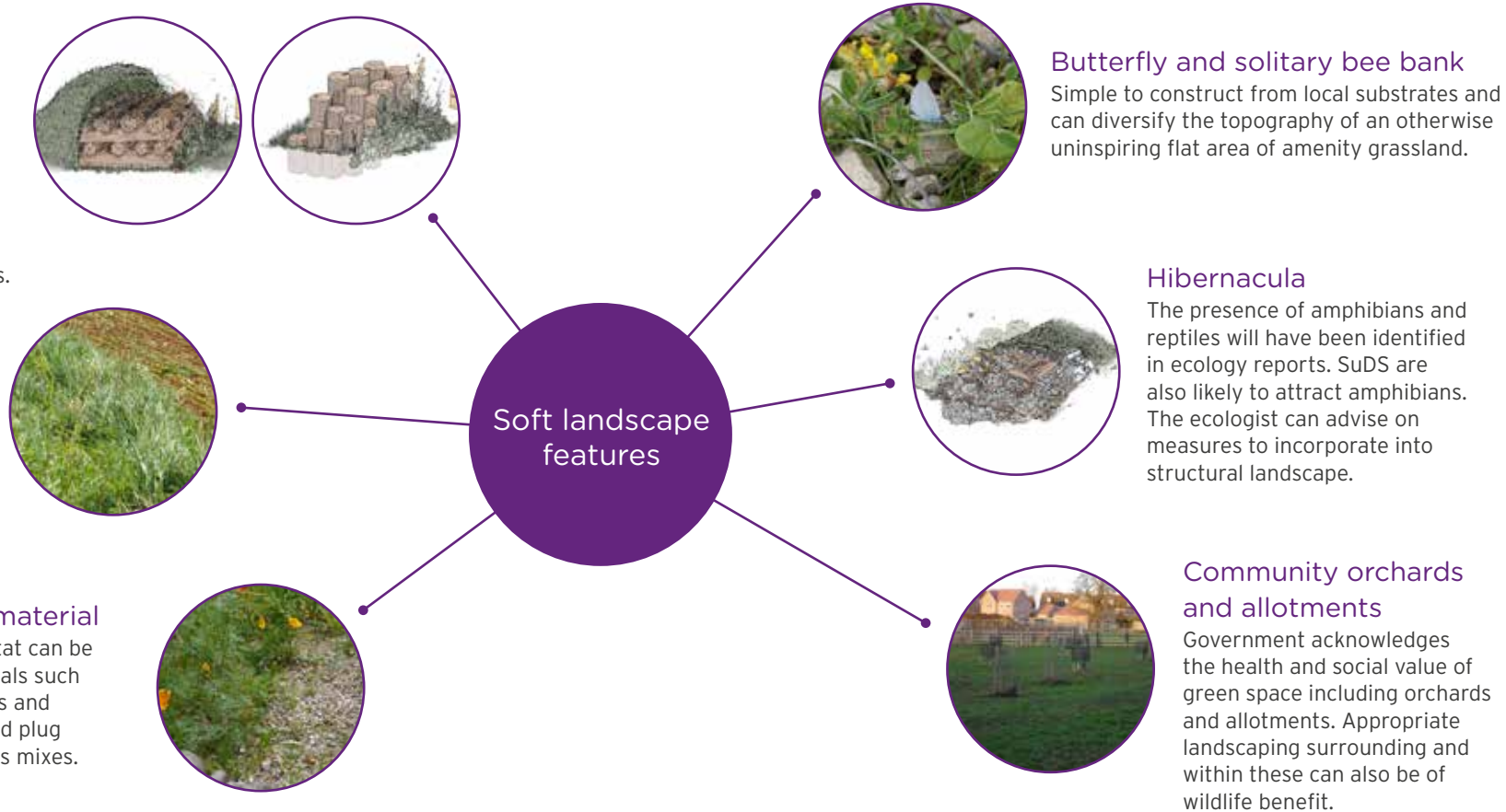


Figure 19b Soft landscape features

7.3 Replicating Brownfield features

Brownfield refers to those developments taking place on formerly developed land. In some situations brownfield sites, especially those on lighter soils, e.g. sandy soils, that have been left abandoned for some time, such as derelict factory sites, or old rail facilities, develop important wildlife habitats which provide refuge for some now very rare flora, invertebrates and black redstart.

This abandonment, combined with cycles of disturbance and low fertility substrates lead to a fine-scale mosaic of terrestrial and sometimes aquatic habitats, which are quite specialised and hence important for biodiversity. It is possible to replicate some of these so-called brownfield features in new landscapes.[34]

It is useful to use the features and plant species that were present on the original site as references when designing the replacement features. These features present opportunities for creative design so that they fulfil their wildlife potential and at the same time are attractive aesthetically.

Recycling of materials to create, for example, hibernacula mounds using waste materials like crushed concrete or old bricks, and habitats for butterflies, solitary bees and tiger beetles etc (see Figure 19a and 19b), that are formed by sparsely sowing typical native plants on low-nutrient substrates to provide a patchwork of bare sandy ground and vegetation, adds to the sustainability of the development. Meanwhile temporary pools are easily formed by digging shallow depressions.

8 Buildings and providing for wildlife

A number of species now depend on buildings for nesting and roosting. Several have declined, in part, because buildings have changed to restrict their access to roof and cavity spaces. However, there are now options for providing alternative spaces for them, by incorporating specialist features within the built fabric that are designed to provide suitable spaces for birds like swifts and bats primarily, as well as for solitary bees (see Bee Bricks page 20). Where they are located on the building is important, as too is their position in relation to the habitats that these species forage in.

Meanwhile, other adaptations to the design of buildings will, as well as helping wildlife, provide climate resilience. Green roofs insulate buildings, attenuate run-off and provide habitat for wildlife, and pale renders reflect rather than absorb heat so reducing heating of the building.

Barratt Homes, Kingsbrook, Aylesbury

Figure 20 Features can be built in or connected to buildings that benefit wildlife and deliver other benefits such as reducing energy use and reducing run-off.

8.1 Nest sites for birds

Four species have been significantly affected by changes to buildings, so are now in most need:

- swift
- house sparrow
- starling
- house martin.

They can readily be helped by providing external or integral nest features. House holder surveys discussed in section 2 point to a strong acceptance of these features.

Provision of integral nest sites for swifts is through hollow chambers fitted into the fabric of a building while in construction. Although targeting swifts they will also be used by house sparrows, tits and starlings so are considered a 'universal brick'.[35] There are several commercially available products that are discrete and fit in with the brickwork etc of the building. NHBC will not accept Magnesium Oxide (MgO) or Magnesium Sulphate (MgSO4) building boards as materials used in the fabrication of integral bird or bat bricks.

Swifts prefer to nest in reasonably close proximity, as do sparrows, so nests should be clustered in suitable areas of a development, fitted adjacent to the roofline in the cold loft space of a gable or tight to the eaves of hipped roofs. Fitting at a ratio of 1 nest brick per house across the development will ensure sufficient nest sites for colonial species. 3-5 can be located in one house, so helping locate them in suitable locations for access to foraging habitat. The British Standard BS42021 sets out details on nest box installation for the above species into domestic and commercial properties.[36]

Newly installed nest bricks may take several years to be found by swifts. Swift callers have been trialled and found successful in speeding colonisation.[37, 38]

Figure 21 Integral swift bricks (top) and house martin nest cups (bottom)

Species	Habitat requirements	Additional notes
Swift 	Forages widely on airborne insects. Good cover of suitable habitat such as tree canopy, open grassland and wetland increases insect availability. Building dependant in which to nest.	Maintain clear flight lines to / from nests without tall trees close to house. Multiple nests reduce competition between individuals and other species.
House sparrow 	Uses dense hedges and shrubs for cover, feeds in seed-rich grassland within close proximity to the nest.	Multiple nests reduce competition between individuals and other species.
Starling 	Feeds mostly in short grass in gardens or amenity areas. Also takes fruits and berries from trees and shrubs.	Sometimes considered noisy around houses. Smaller entrance holes prevent access to integral boxes. Alternative nests can be provided with several boxes mounted in close proximity on trees in a local green space.
House martin 	Forages widely on airborne insects. A diverse local landscape with trees, open grassland and water bodies helps boost insect availability. Mostly depend on buildings for nest sites.	Multiple nests reduce competition between individuals and other species. A shelf placed c1m beneath the nest catches dropping and can be cleaned at the end of the season. They will build their own nests close to artificial nests.

Table 6 Habitat requirements of building-nesting birds

All aspects are suitable, for all species mentioned, particularly when sheltered by deep eaves. Elevations exposed to particularly sun, or driving wind and rain are better avoided. If the front of a box is thick enough e.g.: behind the fascia brick which protects it from severe heat, then south facing is acceptable.

8.2 Roost features for bats

Several species of bat roost in houses. To help maintain and encourage an increase in populations, some of the things developments can do to help include:

- retaining and enhancing existing mature landscape features e.g. trees, hedges, ponds and streams, within the development as these are favoured foraging areas
- ensuring good connectivity between roosts and foraging areas by providing native hedges and trees
- locating integral roost bricks where they are warmed by the sun
- designing the lighting plan to avoid illuminating roost entrances or the areas between the roost and foraging areas. Where lighting is necessary, follow the industry guidance[39]
- diversifying roost provision: some species roost in boxes on trees, others in boxes integrated into buildings. It is usually best to locate bricks in / around clusters of houses
- for targeted enhancement for specific species seek specialist ecological advice.

Figure 22 Bat bricks located above the habitation

8.3 Green roofs

Green roofs are increasingly being used in urban apartment developments. As well as helping insulate buildings, they reduce rainfall run-off by up to half,[40] and contribute to cooling the local atmosphere.[41] Where solar panels are installed on a green roof the efficiency of the solar panels is improved as vegetation around them helps maintain their optimal operating temperature.[42]

Extensive green roofs are appropriate to many situations, including small scale installation on a flat garage roof, shed, bin store or cycle store.

Extensive roofs that provide the most benefit for wildlife incorporate:

- a mix of fine grasses and wildflowers, sown on a shallow nutrient-poor substrate. Wildflower turfs may also be used instead of seed
- a diversity of surface topography; with piles of stones and even small ephemeral water features.

(Avoid sedum monoculture layers, which provide less water retention and have low biodiversity value. It all flowers at the same time in a limited window for pollinators to use.)

Intensive green roofs, analogous to roof gardens, suit formal settings in, for example, apartment buildings (see case study 9.1). Meanwhile so-called blue roofs store rainwater in designed reservoirs. These require specialist construction to account for loadings and are unlikely to suit typical housing development scenarios.

9 Case Studies

9.1 Intensive and extensive green roofs

Situated on the north bank of the River Thames, the 3.4ha Fulham Riverside is being developed on the site of a former supermarket, car park and derelict buildings in a joint venture by Barratt Developments Plc and L&Q.

The first phase was completed in 2019, including a new supermarket, 267 residential units and a car park. An adjacent derelict river jetty was converted into the sales suite and offices, and in turn this will become an education centre.

The roof of the sales office was designed to provide an extensive green roof planted with a combination of flower rich turf and sedum. Completed four years ago, the flora has become well established and diverse, attracting pollinating bumblebees and butterflies in the heart of London.

The green roof needs minimal maintenance, with just two visits per year, whereas intensive green roofs need monthly visits for mowing and pruning. This demonstrates the low-cost amenity and wildlife value, as well as climate resilience of extensive green roofs.

The roofs of the apartment blocks in phase 1 of Fulham Wharf have been designed as a formal landscaped intensive green roof, featuring water features, lawns, trees and shrubs together with community plazas and play areas.

Many of the trees and shrubs planted are native, including semi-mature field maples and large specimens of columnar cultivars of oak, along with hornbeam and limes. Several of the shrub borders combine nectar-rich planting with high wildlife-value herbaceous plants. The wildlife and amenity value provided by the landscape design is high, with a lot of opportunities for wildlife to shelter, forage and breed among the vegetation while residents can relax in pleasant surrounds.

It has won two awards: The British Association of Landscape Industries (BALI) 2016 National Landscape Awards, Principal Award and the Best Landscaped Development in the Sunday Times British Homes Awards 2016.

An extensive biodiverse roof provides habitat for invertebrates, some often rare, to feed and breed

An intensive green roof provides opportunities for amenity and wildlife benefit

9.2 Retaining and integrating habitats in a country park setting

Great Denham Village, by David Wilson and Barratt Homes, is situated just west of Bedford. It is a mixed-use site of housing, a local centre and two schools. Associated with the development is a 64-hectare public green space known as Great Denham Country Park alongside the River Great Ouse. This greenspace demonstrates multi-functional landscape design at a large scale, incorporating recreational space, wildlife features and climate resilience.

The park comprises two distinct areas. The larger 'Estate Park' designed as a typical 'historic' park, featuring open grassland with scattered trees, copses, and native hedges, as well as areas designed to seasonally flood, temporarily storing water after heavy rains. The estate park incorporates sports pitches, trim trails, NEAPs (Neighbourhood Equipped Area for Play) and cycle paths.

Changes were advised for the management specification for most of the grassland in the estate park outside the impact areas, to reduce mowing to once annually but with regularly mown paths through them. This reduces disturbance and makes them attractive to ground nesting (skylark and meadow pipit now breed and barn owls regularly hunt over the area). It also allows plants to flower and set seed, which has seen a dramatic increase in butterfly and bumblebee numbers and diversity.

The second, smaller area alongside the river and further from the housing, 'Riverside Meadows', is quieter and more secluded, with flower-rich grassland. Mature trees and old field boundary hedges and ditches were all retained and have been enhanced with additional planting, and a network of ponds to attract wildlife and temporarily store flood waters from the adjacent river.

This parkland design demonstrates how mixing informal and more naturalistic design that retains existing features can work to provide people with space to play and exercise in a tranquil setting that allows wildlife to flourish.

Originally flood meadow, this area was converted to arable farmland. This development works with existing trees, hedges and ditches that have been retained and incorporated sensitively into the new design. Retaining and enhancing the existing features helps maintain links with the surrounding countryside, enabling wildlife to move safely through the area.

Seasonal flooded wetlands, scattered trees and small copses and retained hedgerows feature throughout the estate park

The Riverside Meadow area has been retained and buffered existing trees and hedgerows, incorporating them into the new landscape, along with permanent ponds and wetlands

9.3 Informing homeowners

Making new and prospective homeowners aware of the wildlife they might find on a development will help generate interest and can thereby give the housebuilder a new marketing angle.

Kingsbrook, Aylesbury, is a large scale, 2,450-home Barratt development with extensive green infrastructure designed in collaboration with the RSPB and combines existing features with new landscaping.

An annual leaflet for residents sets out the progress being made in creating wildlife habitat, which also provides amenity space for the new community. Further leaflets explain elements of the wildlife-friendly scheme, such as information on hedgehog highways, what residents can do in their own gardens to benefit wildlife, the swift and bat bricks being installed, the trees and shrubs being planted, and the wildflower meadows being sown. On-site interpretation boards are being deployed to the new parks and greenspaces.

Other Barratt divisions are also providing residents with information on the different features installed. At Spinney Fields, Long Itchington, David Wilson's Mercia Division produced a guide for residents explaining features on site and things they can do in their own gardens. The guides developed for Long Itchington and Kingsbrook led to the production of customer-facing guides that Barratt have produced to help people to transform their own gardens into wildlife-friendly spaces.

The value of interpretation is becoming increasingly apparent with sales teams and is supported by research into people's perceptions of integral swift bricks (see section 2). People are more positive when they are informed about the benefits of nest bricks prior to occupation. This is something that should be also considered with other wildlife features; at Kingsbrook, people's understanding and acceptance of wildflower verges improved when they were properly explained. Meanwhile the London House Sparrow Parks Project found people were only happy to accept wildflower areas that don't always look their best, once they were aware of why and what was happening.[43]

Various leaflets and booklets have been produced for the homeowner

Signs are used in gardens to highlight features

9.4 Integral bird and bat bricks and hedgehog highways in new developments

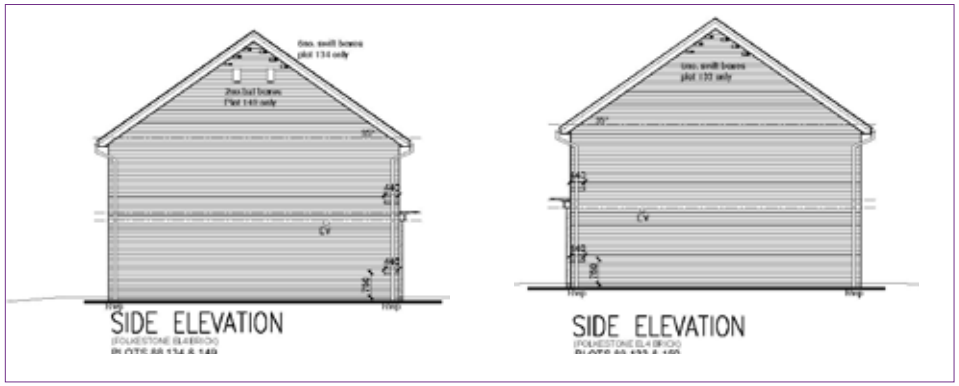
Local authorities are increasingly starting to include requirements for integral bird and bat bricks as a planning condition, while developers like Barratt often include them, along with, for example, hedgehog highways, as voluntary mitigation submitted with a planning application.

At the Barratt Kingsbrook development at Aylesbury, hundreds of swift bricks (which will also benefit house sparrows), house martin nest cups and bat roost bricks will be integrated within many of the houses. To date, over 200 swift bricks, 50 house martin cups, 50 bat bricks and hundreds of hedgehog highway connections have been installed. Furthermore, barn owl, kestrel, and starling boxes have been placed in the development's open spaces. Meanwhile, an opportunity was taken by Barratt to involve and engage the local school, who constructed several invertebrate boxes.

The integral swift bricks were specifically designed for ease of fitment, to meet cost parameters and to meet the needs of the swifts.

Despite best intentions it is easy for integral features to be missed out during construction, and they can be costly to retrofit. Here, some of the nest bricks and hedgehog highway connections were not installed in the first phase of development as planned, so had to be retrofitted at additional cost. The omission was inadvertent because they were included on a separate ecological drawing, and not on the working drawings used by the bricklaying and fencing contractors.

A different approach has been adopted leading to a 100% success rate of correct first-time installation. Ecological features are now included on the contractors' construction drawings. For the swift bricks, the plot number, quantity and location are also indicated on the house elevations, while the GPS location for hedgehog highways are given on the fencing drawings. This approach is now being rolled out to other BDW developments.



Locations for swift and bat bricks are marked onto working drawings for bricklayers

Locations of hedgehog highways are GPS marked onto fencing contract drawings.

9.5 Ensuring boundaries enable hedgehogs to move through a housing development

Situated just west of the village of Long Itchington in Warwickshire is the 150-home development of 'Spinney Fields'. The 7.45ha site is surrounded by mixed farming and a network of hedges, ditches, woods and wetlands and is close to the Grand Union Canal.

The hedgehog is enormously popular with people and are a gardener's friend as they eat slugs and snails, yet has experienced an enormous crash in numbers, as many as 90% have been lost over the last 40 years. One on the issues they face is not being able to access safe places to forage. It was therefore decided to include a network of hedgehog highways, linking gardens and greenspace to help hedgehogs living nearby to move into and around the new development.

All gardens have holes cut into the fence boundaries. Information about them and why they are there was provided to new residents when moving in. Holes were located away from the house, and close to corners, and cut at ground level, using a 130mm core drill. Each hole has a 'hedgehog highway' marker made from recycled plastic tacked to the fence adjacent to the hole, indicating what it is.

Following the success of this project Barratt Mercia now outlines in their guidance documents that hedgehog highways be incorporated into all gardens where it is possible.

Other features included within the development that will also assist hedgehog conservation include native hedgerow planting, provision of deadwood, flower-rich grassland and ponds.

Hedgehog highways have been installed across the whole Long Itchington development

9.6 Delivering biodiversity in gardens

Approximately 87% of UK households have gardens, which total around 433,000 ha countrywide.[44] This is a huge potential resource for wildlife, which in turn brings health and social benefits.

Barratt working with their partners, the RSPB create wildlife friendly gardens in their show homes and provide customers with guidance on replicating this in their own gardens.

Cromwell Heights, Preston was the first Barratt-RSPB wildlife garden; here David Wilson North West asked the RSPB to design a wildlife-friendly show home garden. The garden was filled with a range of pollinator-friendly plants, a pond, hedgehog highways to link adjacent gardens, bug boxes, a scented garden and deadwood features. The product was positively received; both the sales team and customers complimented the improved visual appeal and saw the benefits to wildlife.

Following on, David Wilson Homes Mercia paired RSPB with a garden designer at Nicholsons to design a wildlife-friendly show home garden for Spinney Fields, Long Itchington. This too proved a success with sales teams and customers and received an award in the 2017 BIG Biodiversity Challenge organised by CIRIA.[45] Interpretation was installed around the garden to explain the features to customers. The garden has also been used to engage school community groups.

Through the partnership the RSPB then worked with Nicholsons to develop two guidebooks; one to be shared with consultant designers and contractors, that provides guidance on delivering wildlife-friendly show gardens. The other was written for customers, who, encouraged by the show home garden, would be inspired to make their own gardens wildlife-friendly.[46]

In August 2018, the commitment was made to install wildlife-friendly gardens in all show home complexes at new BDW developments. Gardens are certificated either bronze, silver or gold, depending on the types and numbers of wildlife-friendly features included.

A view of the Cromwell Height garden

A view of the Long Itchington garden

9.7 Hibernacula creation

Maple and Stanford Park, west of Stanford Le Hope, Essex is a 350-unit development which includes 51ha of Strategic Public Open Space (SPOS) in the form of a country park. The park is designed to be a multi-functional high amenity area of wildlife value. A path network meanders through a mosaic of semi-natural habitats that includes flower-rich grassland, scrub, ponds and native hedges.

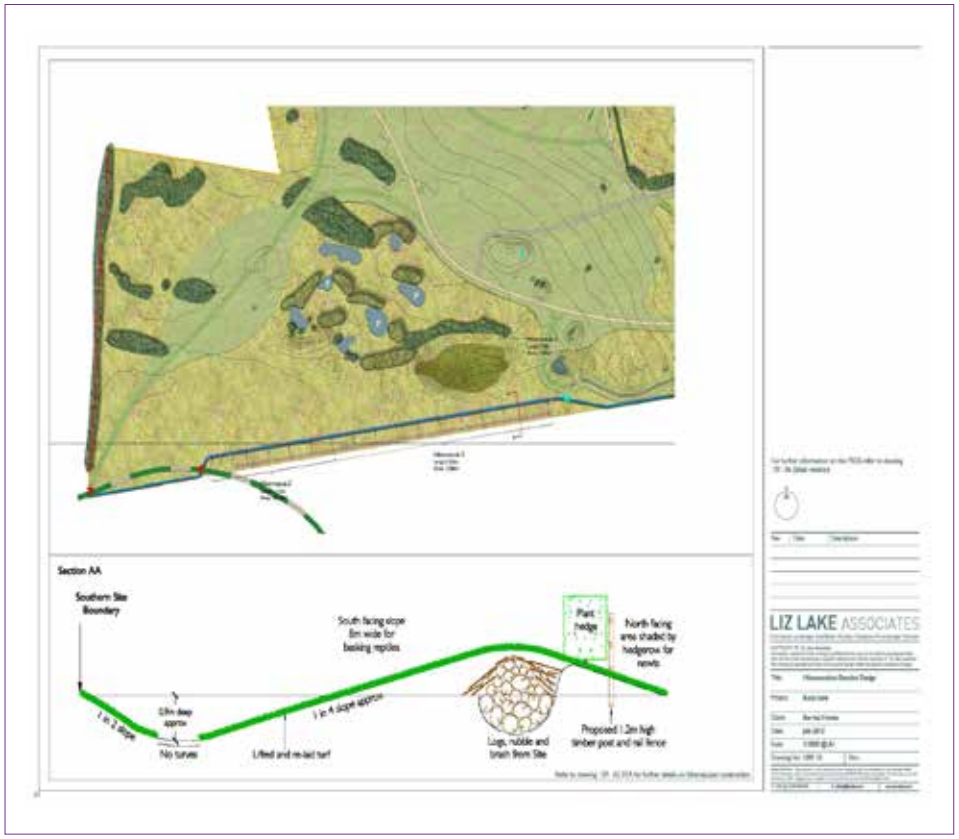
The project needed to mitigate the protected amphibians and reptiles present, including great crested newt and four of the UK's six reptile species. To achieve this, habitats were created in the park and the species translocated to them. As well as creating a wildlife-rich area this provides a focal point for the community to enjoy.

Three new ponds were created along with 300m of hibernacula and around 30ha of wildflower meadow. Meanwhile native hedgerows were relocated.

The ponds and hibernacula were constructed to receive the translocated great crested newts and reptiles. The hibernacula mound was constructed using logs rubble and brash sourced from the site. This sits alongside a ditch, the arisings from digging this were placed over the rubble and log mound, which itself was backed by the translocated hedge. The whole feature was 13m wide and 1m high.

Each habitat created provides enhanced value for the target reptiles and amphibians, and at the same time provides opportunities for other wildlife such as nesting birds and butterflies.

As well as successfully mitigating for protected species, and providing valuable amenity, this example demonstrates how retaining and reusing materials on-site including demolition materials can benefit biodiversity and arguably reduce costs.



Schematic layout and design for the hibernacula at Maple and Stanford Park

9.8 Protecting and mitigating heritage and wildlife features

Garnett Wharfe is a 210-home development on a former paper mill site on the River Wharfe, Otley, West Yorkshire. During construction, 95% of materials found on site were recycled.

Alongside the new homes, old mill buildings were retained and turned into a restaurant. A riverside visitor centre has been built and a 1 in 100-year flood alleviation channel has been designed. Two Archimedes Screws were installed in the weir to produce renewable energy from the river's flow to offset the carbon emissions from the homes. Construction materials for dwellings, stone boundary walls and other buildings sought to replicate the natural stone of the area to ensure the development remains in keeping with the character.

In addition to protecting the cultural heritage and providing new sustainability features, there was a considerable amount of ecological mitigation. This included the creation of a bat chamber for Daubenton's bats and bat bricks for other species built into the fabric of the buildings, an otter holt was constructed along with two fish passes to allow migrating salmon to safely pass the Archimedes Screws and weir.

Aerial view of Garnett Wharfe

An ecology park provides the site with approximately 4ha of public space which has been extensively planted with trees. The bat chamber uses an original mill race entrance so that bats can easily find their new home. Crevices formed within the chamber give them a safe place to roost. A live video feed from the chamber to the visitors' centre has been set up. Monitoring surveys will be carried out under a Natural England licence.

Garnett Wharf looking at otter wall

An otter holt was discovered on the bank of the river along with some evidence of otter presence, A permanent wall was erected to provide a 20m buffer between the holt and construction work and to safeguard it for future occupation by otters. Within the development, is a flower-rich swale and balancing pond which further enhances the ecological value and helps manage storm run-off water.

A long-term management plan is in place to ensure all features and the site's public open spaces will be managed in perpetuity.

This site demonstrates the importance of considering our cultural and heritage connections and ensuring they are represented alongside biodiversity. The existing and new community members in Otley will benefit from the new facilities and from being able to get closer to nature via the Visitors' Centre and riverside walkway.

9.9 Connecting riverine habitats in partnership

Riverside Quarter at Mugiemoss is situated on a brownfield former papermill adjacent to the River Don in Aberdeen. Ecology surveys highlighted several protected species including birds, bats, red squirrel and otter nearby. This played a crucial role in identifying the potential for retention of habitats, enhancement interventions and establishment of green infrastructure to re-connect historically fragmented habitat corridors, particularly the woodlands to the east and west of the site and the culverted Bucks Burn.

Enhancements and mitigation used included retaining existing bat boxes in surrounding trees and designing artificial lighting to avoid impacting on the bats. Meanwhile, the largest enhancement project was restoring a section of the Bucks Burn. As the Burn had been culverted under the papermill and as otter were found to be using habitat within and adjacent to the River Don and the Bucks Burn, it was agreed via the Masterplan that the culvert should be opened up and the banks reprofiled to improve the hydrological dynamics of the burn, restore its natural substrate and restore connectivity of the riparian corridor through the landscape, and thereby the ecological links between two Local Nature Conservation Sites. An artificial otter holt was constructed to provide an additional resting site within the newly enhanced habitat.

As well as improving habitat quality, the daylighting of the Bucks Burn provides a focus for the development, strengthening the green infrastructure and creating opportunities for homeowners and others to engage with wildlife within easy reach of their homes. A close partnership between Barratt, EnviroCentre (river restoration specialists and ecologists), Complete Weed Control and the local Brighter Bucks Burn Gardening group brought this project together. Landscape architects designed a naturalistic yet accessible space, using native species aligned with habitats found upstream of the site. Ecological monitoring has shown that otter, badger and bats continue to use the site and invasive plant species have reduced in areas where construction had risked their spread. Habitat creation is planned to continue so to strengthen connectivity for the freshwater and terrestrial ecosystems in the local nature conservation sites.

Opening of the culvert provides a more sustainable and natural flow through the Bucks Burn, close to its original route, with new habitats and reduced potential for blockages and flooding. Additionally, as green spaces mature its value as an attractive residential development will grow, benefiting homeowners.

Views across the development and the 'daylighted' Bucks Burn which now provides a focus for the development and greater wildlife opportunities.

9.10 Delivering complete Sustainable Drainage Systems (SuDS)

Springhill Cohousing community is a 34-unit development located close to the centre of Stroud in Gloucester. Constructed between 2002 and 2003, it remains one of the few developments in the UK where a full SuDS was integrated at the masterplan design stage.

The scheme incorporates permeable pavements, an under-drained swale, surface cascades, planted swale, open channel rills, an ornamental pond and a detention basin play area. Together these show how SuDS at or near the surface can optimise the social and wildlife benefits by combining soft and hard landscaping with multi-functional use of space in a high-density, urban environment.

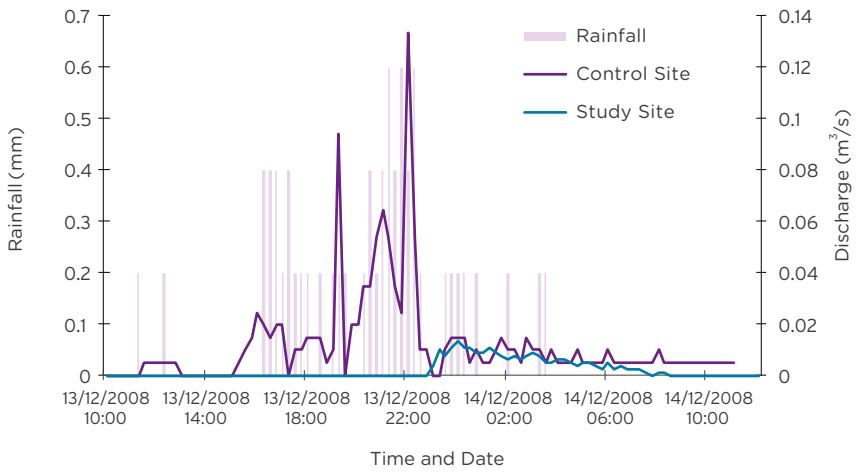
Permeable paving is used to collect and store run-off in open graded stone. Meanwhile sub-surface tanks provide extra storage capacity when needed. Water leaving tanks is joined by un-attenuated roof run-off that flows through an under-drained swale, through a tile cascade into a further swale. This cleans run-off water, which then infiltrates into the ground. Excess flows go to a raised pool. The run-off from hard surfaces go to a rill alongside the pedestrian street.

Overflow from the rills and pond is directed to a detention basin which stores up to 600mm of surface water. During nearby flooding, no impacts were felt at the site, with only 300mm of temporary storage needed at any time. Source control treatment of run-off is essential, which is assured at Springhill, where water flows through the management train, providing many features of interest and aesthetic value.[47]

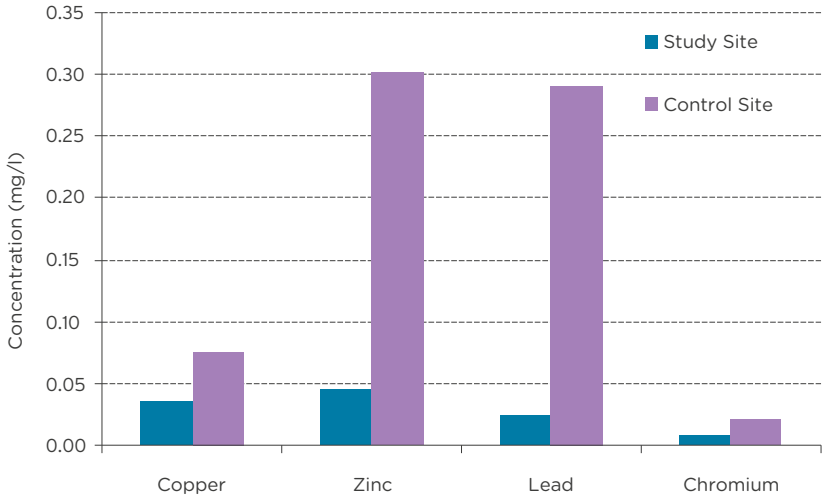
The SuDS scheme at Lamb Drove, Cambourne near Cambridge is another example of a full management train. Features include water butts, permeable pavement, green roof, swales, filter strips, under-drained swales, detention basins and a retention pond.

Comparatively more wildlife was attracted to the landscape of Lamb Drove than a nearby control site. The SuDS also slowed discharge rates and improved water quality with lower levels of heavy metals than at the control site.[48] Micro-plastics from car tyres in un-treated road run-off are also a serious source of pollution in rivers and wetlands.[49] This demonstrates the importance of full SuDS management trains in new developments to help filter pollutants before they reach on-site detention basins and ponds and or discharge into rivers, something which conventional pipe-to-basin designs fail to do.

Springhill and Lamb Drove need only minimal maintenance yet still function over and above their requirements.



Comparison of Discharge at Lamb Drove and the Control Site on the 13th and 14th December 2008



Comparison of heavy metal concentrations at Lamb Drove and Control Site (2008 – 2011)

Resources

The following resources aim to help identify where additional information can be accessed in order to support design and implementation of the measures discussed in this guide.

Ecological services

A directory of ecological consultants can be found at: **cieem.net**

CIEEM provide an advice resource hub, accessible to non-members, on a wider range of topics relevant to this guide: **cieem.net/i-am/resources-hub**

Blue-Green infrastructure

Urban Greening Factor (UGF) This guide illustrates concepts that achieve UGF. Increased interest by local authorities, eg: **www.london.gov.uk/sites/default/files/urban_greening_factor_lpg_pre-consultation_draft.pdf**

Economic benefits of blue-green infrastructure: Horton, B. et al (2019) B£ST Guidance – Guidance to assess the benefits of blue and green infrastructure using B£ST. CIRIA

Landscaping plant choices

Wildflower seed mixes (examples): **naturescape.co.uk** and **wildseed.co.uk**

Flowering lawn turf (example): **wildflowerturf.co.uk**

Pollinator friendly plants database: **beekind.bumblebeeconservation.org** NB: some species included in this database are identified as INNS and should be avoided

SuDS resources

Graham, A et al (2012) Sustainable drainage systems – maximising the potential for people and wildlife. A guide for local authorities and developers. RSPB and WWT

Woods Ballard, B, et al (2015) The SuDS Manual CIRIA available from the CIRIA website

Bray, R et al (2012) UK Rain Garden Guide, Reset Development

Kukadia J et al (2018) Designing Rain Gardens: A Practical Guide. Urban Design London

Tree pits – companies supplying and fitting: **GreenBlue URBAN solutions and stockholmtreepits.co.uk**

Wildlife priorities

Lists of UK Priority Species and Habitats: **jncc.gov.uk/our-work/uk-bap**

Bats (and birds)

A comprehensive guide to incorporating the needs of bats and other biodiversity into buildings: Gunnell, K et al (2013) Designing for biodiversity – a technical guide for new and existing buildings (2nded) RIBA Publishing

Bats and lighting guidance, available from the BCT.org.uk website:

Miles, J. et al. (2018) Bats and Artificial Lighting in the UK; Guidance note: 08/18. ILP & BCT

Hedgehogs

Information and advice: **hedgehogstreet.org**

Reptiles and amphibians

Information and advice: **arc-trust.org**

Invertebrates

Planning hub and Brownfields hub: **buglife.org.uk**

Beebricks & range of other nest products: **www.greenandblue.co.uk**

Swifts

Residential birdbox guidance: **actionforswifts.blogspot.com/p/rbbg.html**

Swift attraction call systems: **actionforswifts.blogspot.co.uk/p/attraction-call-systems-for-swifts.html**

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2 Benefits to people of wildlife friendly developments

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Glossary

Attenuation	Reduction of peak flow and increased duration of a flow event.
Bat roost box (brick)	A fabricated enclosed roost chamber integrated into the fabric of a building, close to the roof's eaves or verge, during construction.
Bee brick	A fabricated brick with different sized small diameter holes for solitary bees, integrated into walls at between 1.2m and 2m from the ground on sunny elevations close to nectar rich plants.
Bioretention bed	Landscaped shallow depression designed to receive heavily polluted run-off from roads. Planted with colourful shrubs and herbaceous plants. Under-drained with drainage layer and engineered sand (see also rain garden).
Biosolar green roof	A biodiverse green roof with solar panels. Solar panels operate more effectively when used in conjunction with vegetation.
Blue infrastructure	Naturally occurring or created water bodies incorporated into urban design in conjunction with SuDS features. When in combination with green infrastructure referred to as blue-green infrastructure.
Brownfield	Previously developed land. Some have developed to be important wildlife sites and conform to the UK Priority habitat Open Mosaics on formerly developed land.
Check dam	A small barrier within a swale or rill to slow flows, control erosion and trap sediment. They may be constructed from large stones or logs or other material.
Detention basin (infiltration basin)	A vegetated depression, usually dry but designed to store water temporarily and attenuate flows when needed, with potential to incorporate wildlife features.
Engineered soil	A man-made substrate mixing soil with crushed stone, sands, etc to increase permeability and withstand compaction whilst retaining porosity. Typically used where there is a need to increase infiltration.
Evapotranspiration	The combined effect of evaporation and transpiration by the foliage of plants. Assists in cooling the local atmosphere.
Filter strip	A strip of grass collecting silt and sediments and slowing run-off flow from hard surfaces. They are often used in conjunction with swales.
Flowering lawn	Lawn grass with often native flowering plants tolerant of regular mowing and able to flower in shorter lengths of grass added, either sown from seed or laid as turf.
Geotextile	A permeable fabric usually made from polypropylene or polyester, that is laid over soil to separate substrates, filter, reinforce, protect or drain.
Green Infrastructure	A network of multi-functional green space that provides a range of environmental and quality of life benefits for local communities. See also blue infrastructure.
Green roof	A roof designed to have plants growing on its surface. They provide a degree of attenuation of rainwater and promote evapotranspiration. Also referred to as biodiverse roofs.
Gully pot	Kerbside drains collecting road etc run-off to divert into the drainage network. They trap solids, to reduce contaminated sediment entering water courses. Gully pots can trap wildlife, particularly amphibians.

Hibernacula	Structure occupied by an animal, frequently bats, reptiles and amphibians, during winter.
Management train	The combination of different processes in a SuDS, to reduce pollution, slow flows and reduce water volumes before the water enters the main catchment.
Permeable surface	A hard surface through which water can percolate. These are commonly types of block or slab paving, asphalt or concrete products.
Priority habitat	Government list of threatened terrestrial and freshwater habitat types and in need of conservation, referred to as Habitats of Principle Importance. Each UK country has its own listing.
Priority species	Government list of the most threated species requiring conservation action, often referred to as Species of Principle importance. Each UK country has its own listing.
Rain garden	Landscaped, shallow free draining depression that slows run-off and improves water quality of rainfall received from paved surfaces and downpipes. They can be a variety of scales from domestic to public realm and can be as a raised planter bed (see also bioretention bed).
Residential planting	Refers to formal landscape around house and street frontage, local centres, meeting places and play areas. Mixed palettes of native and non-native plants are usually used.
Rill	Hard landscaped linear SuDS channels used to move (convey) water between each treatment stage of a SuDS management train. Constructed from impervious materials. (Compare swales)
Run-off	Surface water flow to the drainage system. Accentuated where the ground is impermeable, saturated or rainfall is particularly intense.
Sealed or impermeable surface	A hard surface, often asphalt, concrete etc that prevents water percolation into soils below. (See also Permeable surface)
Structural planting	A term referring to landscape forming the soft interface to the edge of a development and its open spaces or that buffers retained natural corridors through a development.
Source control	SuDS feature that manages run-off close to where it lands on hard surfaces. These include green roofs, rain gardens and filter strips that replace the need for gully drains and pots.
Substrate	A medium on which vegetation grows, including soils, sub-soil, wood and masonry.
Swale	A soft landscaped channel used to move (convey) water between each stage of a SuDS management train.
Swift box (brick)	An enclosed nesting chamber integrated into the fabric of a building, close to the roof's eaves during construction.
Urban Heat Island	Effect where urban areas are warmer by 2°C or more, than surrounding countryside due to absorption and retention of heat by hard pavements and building surfaces. It is most prevalent at night and in calmer air conditions.

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