MAYOR OF LONDON

LONDON SUSTAINABLE DRAINAGE ACTION PLAN

2016

MAYOR OF LONDON

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CONTENTS

EXECUTIVE SUMMARY

London is outgrowing its drains and sewers. The combined sewer system originally built over 150 years ago by Joseph Bazalgette has served us well, but it was designed for a smaller city with more green surfaces. The combined challenges of London's growing population, changing land uses and changing climate mean that if we continue to rely on our current drains and sewers, we face an increasing risk of flooding.

To make the most effective use of our existing and planned drainage infrastructure and avoid increased flood risk, we need to change how London's drainage system operates. Rainwater should be managed as a valuable resource rather than a waste product. We need to roll back the tide of impermeable surfaces. They should be replaced with 'sustainable drainage' systems that mimic the ways that nature manages rainwater and add to the services provided by our existing drains and sewers. The need for more sustainable drainage is now widely recognised internationally and embedded in our national and local planning systems including in the Mayor's London Plan.

This action plan addresses a specific need to promote the awareness, and the retrofitting, of sustainable drainage systems right across London. It contains a series of actions to make our drainage system work in a more natural way which will bring a wide range of benefits including:

- steadily reducing flood risks by easing the burden on our drains and sewers
- reducing pollution of our tributary rivers and streams
- creating more pleasant landscapes, streets and settings for London's buildings
- providing opportunities to save water
- providing opportunities for school activities and studies related to the water cycle

The main focus of the action plan is on the retrofitting of sustainable drainage to existing buildings, land and infrastructure. It is recognised that funding pressures mean there will not be funds specifically for a large-scale drainage improvement programme. Instead the key is to identify when and where other planned maintenance, repair or improvement works are scheduled and then to identify opportunities to retrofit sustainable drainage as part of those works. This way sustainable drainage can be introduced at a much lower cost. In some cases these measures can save money, for example where 'harvested' rainwater replaces large scale water supplies used for irrigation, toilet flushing or vehicle/plant cleaning.

The action plan aims to set the direction for the next 20 years, but includes 40 actions specifically for the next five years. These actions will be implemented, in part by Greater London Authority staff, and in part by others and include a commitment to measure and report progress annually. It is also important that the awareness of rainwater management is spread more broadly across London's institutions and individual Londoners – we can all make a contribution to the vision:

Vision
By 2040, London will manage its rainwater more sustainably to reduce flood risk and improve water quality and security. This will maximise the benefits for people, the environment and the economy.

PART 1: WHY WE NEED AND WANT MORE SUSTAINABLE DRAINAGE

Surface water management in London

Surface water is the rainwater that falls on the city's surfaces; on the ground, streets, pavements, roofs, parks, and gardens.

Flooding

When this water does not soak into the ground or drain through normal drainage systems, but lies on or flows over the ground instead, it can cause surface water flooding. Whilst London is currently very well protected against flooding from the tidal Thames, it has a relatively lower standard of protection against surface water flooding.

The London Regional Flood Risk Appraisal (RFRA) identifies the high potential risk of surface water flooding in London (GLA, 2014). It notes London's density of development, high proportion of impermeable surfaces and general lack of records as particular problems. The Mayor's Climate Change Adaptation Strategy (GLA, 2011) identified surface water flood risk as the greatest short-term climate risk to London.

In 2007, other areas of the country, including parts of western England, Sheffield, York and Hull, suffered severe flooding. This was initially from surface water as a result of heavy rainfall, and later from rivers as the rainwater naturally moved through the system. London was spared the worst of those storms. However, it was clear that had these storms been concentrated over parts of London, it would have caused huge disruption, high economic impacts and long recovery times, especially if major infrastructure was severely affected. Within London, there have been several localised examples of surface water flooding - most recently during heavy rainstorms in summer 2015 and 2016. Widespread use of sustainable drainage systems will help reduce the impact of such heavy storms.

Water quality

The quality of water in London's tributary rivers is generally poor to moderate. Of 41 London river waterbodies monitored for the Thames River Basin Management Plan in 2015, three were classified as bad, five as poor and 33 as moderate. No waterbodies were classified as good or very good. Classifications can change from year to year. The overall aim of the EU Water Framework Directive is to improve water quality in rivers and lakes. However, it is clear that there is scope for major improvement within London. Removing pollutants from surface water discharges will be an important part of any improvements. Many sustainable drainage techniques can help to do this. Sustainable drainage will also help to maintain improved base flows in our tributary rivers, which again will help to improve the health of those rivers.

Drought

London is often mistakenly perceived as having abundant rainfall. However, London (and indeed the whole of south east England) is classified as 'seriously' water stressed. That means that more water is taken from the environment than the environment can sustain in the long term. Fifty-five per cent of all the rain that falls in the Thames Valley is abstracted and used. This is more than anywhere else in the UK, and more than almost everywhere in the world. London is usually relatively resilient to drought and it takes two consecutive drier-than-normal winters to create water supply issues. In 2006

and 2012, London experienced significant droughts, and in 2012 only avoided serious water restrictions by the having the wettest spring in a century. Some sustainable drainage techniques retain water for later use, either directly through rainwater harvesting systems or indirectly through infiltration. It is also important that vegetated sustainable drainage systems are drought resilient and that new green infrastructure sustainable drainage doesn't need significant irrigation in dry weather.

Surface water management challenges

The frequency and severity of future surface water flooding, drought and poor water quality in London depend on several different factors. Some of these factors are physical, others are social, and some are a result of London's historical development, whilst others are the result of projected future trends. These are explored further in the following sections.

Physical

The climate of the future is likely to be increasingly different from that of the past. The south east of England is expected to experience warmer, wetter winters and hotter, drier summers. It is also expected there will be more frequent and intense extreme weather events, such as heatwaves and heavy rainfall events. By the middle of the century, the probability of a rainstorm likely to overcome the drainage system will have increased from a 1 in 30 (3.3 per cent) chance to a 1 in 13 (7.7 per cent) chance in any one year (UK CIP, 2002).

Like all cities, London has a high proportion of impermeable surfaces, which prevent water from soaking into the ground. As well as this, the clay soils found under parts of London reduce the rate of infiltration, which results in more water at the surface. This is often used as a reason not to install sustainable drainage solutions. However, there are a range of sustainable drainage techniques that do not depend on infiltration. The soils in most areas have some degree of permeability and should be tested in line with best practice (BRE, 2016).

London also has relatively old drainage systems. Routinely built to very high standards, it was designed to manage lower return period storms than now used and to cater for a smaller population. In general the drainage system can be split into two distinct systems. In central and inner London there is a combined sewer system that carries both rainwater and foul water in the same pipework and sewers to the major sewage treatment works of Beckton and Crossness. The key challenge in the combined sewer area is that rainfall can quickly fill the sewers. This leads to overflows into the rivers (mainly the Thames) of untreated sewage mixed with rainwater. These are known as combined sewer overflows (CSOs).

In 2014, the Government gave permission for the Thames Tideway Tunnel (TTT). This project is considered necessary to address the current problems of combined sewer overflows into the Thames. These problems are basically caused by the rainwater flowing into the combined sewer network. The TTT will not increase capacity in the combined sewer system, but will prevent all but the most severe sewer overflows into the Thames. Thames Water is also progressing towards a planning application for the Counters Creek Storm Relief Sewer on the Kensington and Chelsea / Hammersmith and Fulham border. This will address problems of capacity and sewer flooding in the area.

In outer London, there are mainly separate systems that convey rainwater into local tributary rivers and foul water to sewage treatment works (see Figure 1). There are two main problems with the separated drainage systems. Firstly, there are widespread problems of pollution caused by the 'misconnection' of foul pipes into the surface water drainage system within the separated sewerage areas. This means that untreated sewage finds its way into local streams. Secondly, there is the impact of the 'first flush' following a heavy rainstorm. This is especially significant following a prolonged dry period. The storm has the effect of washing urban surfaces into local rivers and streams. It takes with it a concentrated first flush of organic litter (such as leaves and bird/animal faeces), human litter/debris, tyre, metal and motor fluids from road surfaces. This has a severe impact on water quality in those local streams.

It is becoming more complex and expensive to increase the capacity of London's drainage systems using traditional underground piped networks, like the Tideway Tunnel and Counters Creek project. This is due to the necessity for large-scale and widespread excavations in many streets. There is also the need to work in and around the vast amount of infrastructure that now lies under most streets.

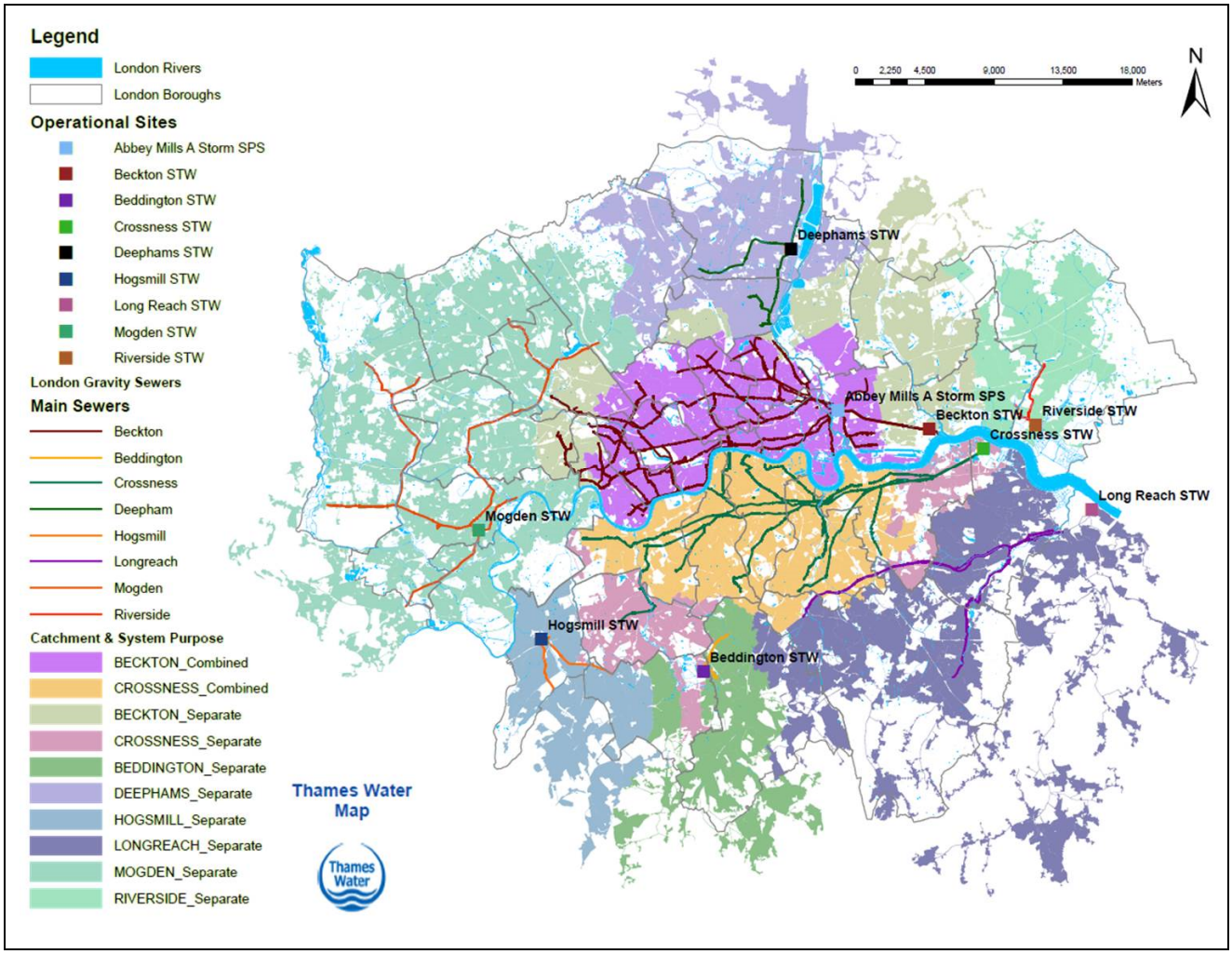


Figure 1: Combined and separated sewer systems. Source: Thames Water

Social

Flood risk tends to affect poorer communities the most. Poorer people are more likely to live in flood risk areas. They're less likely to have insurance to cover any loss or damage. They're also less likely to have the means to install flood resilience or adaptation measures. Floods are therefore likely to have more of an impact on the poorest people in London.

Over the past few decades, more and more front gardens (and to some extent, rear gardens) have been paved over with impermeable surfaces. Estimates vary, but two-thirds of front gardens are at least partially covered by surfacing other than vegetation (London Assembly, 2005). The annual average loss of vegetated garden land in London is the size of 2.5 Hyde Parks (London Wildlife Trust, GiGL & GLA, 2010). A recent poll for the Royal Horticultural Society also suggested that almost a quarter of London's front gardens have been paved over (RHS, 2015). This is placing an ever increasing strain on our drainage systems. It needs to be not only stopped, but reversed, if flood risk is to be managed.

In the past 25 years, London's population has grown significantly, by nearly two million people. The London Plan estimates the population will be over nine million by 2020, and nearly ten million by 2031. The London Infrastructure Plan suggests that by 2050 the population will be over 11 million. The increase in population will certainly add to the base sewage flows and demand for water supplies. If planned and designed traditionally, the increased population would also lead to an increase in impermeable area. Such trends would exacerbate pressures on the city's drainage and water supply systems, potentially increasing the risk of flooding and drought.

Thames Water has modelled the impact of London's projected population growth and climate change on its foul and combined sewers to understand how they'll cope with these future challenges. It shows that for a relatively common rainfall event in 2050 (one expected on average once every other year), some areas of London wouldn't have enough drainage or sewerage capacity to manage the expected flows. This would lead to an increasing risk of surface water and sewer flooding.

Figure 2 shows the mapped output of this modelling for the 2050s. Areas in red on the map are where the projected flows in the system exceed capacity and some flooding would be expected.

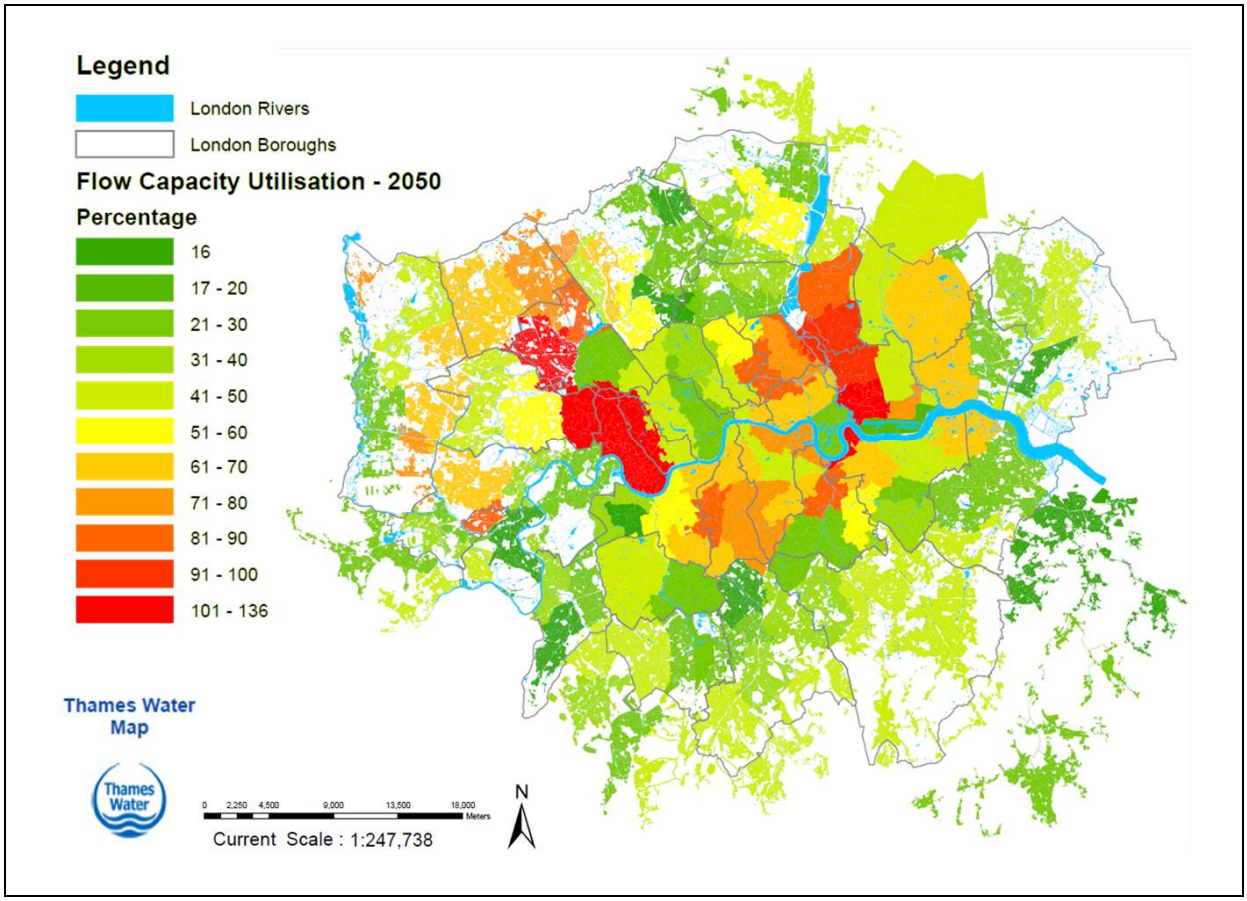


Figure 2: Modelled foul and combined sewer capacity for the 2050s. Source: Thames Water

What is sustainable drainage?

Sustainable drainage includes both good management practices, such as retaining permeable surfaces, and the installation and use of sustainable drainage techniques. Sustainable drainage techniques help capture, use, delay discharge or absorb surface water. They can also reduce the volume and/or concentration of pollutants reaching watercourses. Green infrastructure forms of sustainable drainage also have a wide range of other benefits over and above the direct drainage benefits. This action plan focuses mainly on sustainable drainage techniques, rather than management practices. It has a clear preference for green infrastructure sustainable drainage. However, it accepts that in some instances hard engineered sustainable drainage will be required.

Box 1: Definition of green infrastructure

A network of green spaces - and features like street trees and green roofs - that is planned, designed and managed to deliver a range of benefits. These include recreation and amenity, healthy living, mitigating flooding, improving air quality, cooling the urban environment, encouraging walking and cycling, and enhancing biodiversity and ecological resilience. (Green Infrastructure Task Force 2015)

Sustainable drainage techniques

Details on particular techniques can be found in a range of other documents and websites. It is also possible that new techniques or variations on techniques may be developed in future. Table 1 details some of the more common techniques that are used. This is not intended to be comprehensive and, of course, any one building or site may successfully incorporate a range of techniques. A particularly useful reference will be the Sustainable Drainage Manual (CIRIA, 2015). This gives a complete guide to sustainable drainage. It includes a chapter dedicated to the use of sustainable drainage in urban areas, with a useful range of illustrations. CIRIA has also produced the BeST tool (CIRIA, 2015), which enables users to quantify the benefits of a range of sustainable drainage techniques. The Susdrain website (CIRIA, 2016) is a valuable source of guidance advice and discussion within the sustainable drainage profession.

Table 1: Summary of sustainable drainage techniques

Technique	Summary
Rainwater harvesting	Capture of rainwater into a tank(s) for use (usually non potable) such as irrigation, toilet flushing, vehicle or plant cleansing. For some premises the rainwater harvesting can generate major cost savings on water bills. Care is needed to prevent the development of bacteria, algae and insect infestation. Systems are now available to combine rain water harvesting with tanked attenuation. That means water is stored during dry periods and released ahead of predicted storms. This ensures that the attenuation capacity remains available when needed.
Green/brown/ blue roofs	Used on flat or shallow pitched roofs to provide a durable roof covering which also provides thermal insulation, amenity space, biodiversity habitat as well as attenuation of rainwater. The use of roof areas for Solar PV energy generation is sometimes quoted as a reason for not installing a green roof. However the two uses of a roof can be combined. There is even some evidence to suggest that by keeping a roof cooler, the green roof actually increases the efficiency of the PV panels. Depending on the design, such roofs can attenuate differing volumes of rainwater. The term 'blue roof' is reserved for those roofs designed to maximise water retention. This is a relatively recent area of increased focus and can involve effectively an attenuation tank at roof level. This reduces or avoids the need for pumping of basement tanks.
Raingardens	Planted areas usually close to buildings (but not immediately adjacent) that allow the diversion of a portion of rainwater from either downpipes or surrounding paved surfaces. These techniques can be incorporated into the landscaping plans for a site. They're most effective if the landscaping regime is designed with the aim of capturing as much rainfall as possible. Raingardens can either allow infiltration into the ground or have tanked systems for water retention, depending on the site and soil conditions. There are also a limited number of vertical raingardens attached to building walls with rainwater downpipes diverted through a stacked series of planters.

Technique	Summary
Bio-retention	A chain of landscaped features, potentially including reed beds, filter drains, etc. designed to hold and treat surface water. These are often used where there is a high risk of low-level pollution, for example from road run-off. However, it does require areas of open space. Design can vary widely depending on site conditions and available space. At a small scale this could include flow through planters or stormwater tree pits (often referred to as Stockholm Tree Pits).
Permeable pavements / surfaces	Permeable hard surfaces which work in much the same way as traditional impermeable surfaces apart from the ability to allow rainwater to pass through. Permeable blocks are well used. Recent innovations have enabled the development of bound granular surfaces with both high load bearing and high permeability properties. Permeable surfaces can either allow infiltration into the ground or have tanked systems for water retention, depending on the site and soil conditions. They are suitable in even the most densely built-up development. However, they're not well suited to roads carrying heavy or fast motor traffic.
Swales	Dry ditches used as landscape features to allow the storage, carriage and infiltration of rainwater. Often used as linear features alongside roads, footpaths or rail lines, they can also be integrated into the design of many open spaces.
Detention basin/ponds	Landscape features designed to store and in some cases infiltrate rainwater. Detentions basins are usually dry, whereas a pond should retain water. These features need areas of open space but can often be combined with other sustainable drainage techniques.
Discharge to tidal river/ dock/canals	Discharging clean rainwater directly to tidal rivers, canals or docks isn't normally a sustainable drainage technique. Other more productive techniques should be used first. However, it is generally more sustainable than discharging to the combined or surface drainage systems. Residual surface water can be discharged to tidal/large waterbodies, in some cases with no limitation on volumes. Some storage may be required to allow for outfalls becoming tide locked. Care is needed to prevent scour in the receiving waterbody and potentially to prevent pollution. Consent from the EA, the asset owner and where applicable the Canal and River Trust will be required.
Storage tanks	Usually but not necessarily below ground level, they attenuate rainwater for later slow release back into the drainage system. They don't provide the wider benefits of green infrastructure sustainable drainage. They can also have the disadvantage that pumping may be required to empty the tank into the drainage system - especially if the tank is at basement level (see also Blue roof above). Where tanks are designed for large storm events, care is needed to ensure that they still perform a useful sustainable drainage function for low order storms. This action plan therefore recommends the use of the Susdrain Method 2 tank design (Anthony McCloy for Susdrain, 2015).

Technique	Summary
Geocellular storage	Similar to storage tanks except that the volume is made up from multiple units rather than a single tank. Can underlie permeable surfaces.
Oversized piping	Using larger than necessary pipework creates more room to store rainwater. Potentially more sustainable than storage tanks/geocellular storage if the pipes drain by gravity and do not require pumping. However, lacks the wider benefits of the green infrastructure based techniques.
Design for exceedance	This involves designing areas within a site such that they will flood and hold water during rare storm events (typically a frequency of once in ten years or longer).

Sustainable drainage maintenance

Maintenance varies for different types of sustainable drainage technique. Overall maintenance needs are unlikely to be excessive but will be different to traditional engineered drainage systems. Maintenance requirements such as flushing and unblocking pipe networks may be lower than traditional drainage systems, but there may be an increase in soft landscaping maintenance. Many activities such as keeping flow routes clear of debris will remain essentially the same.

As with any operational system, appropriate maintenance is a key part of sustaining operational effectiveness. Long term maintenance plans for sustainable drainage are equally important to maintenance plans for other infrastructure. Without appropriate maintenance the effectiveness of sustainable drainage systems will decrease. This will be particularly important where sustainable drainage systems are being relied upon to provide a flood risk management role. In most new build projects the sustainable drainage system is designed with a specific maintenance regime. This is often controlled via a planning condition. A similar approach should be taken for retrofit projects and would be a suitable requirement of any funding agreement to implement sustainable drainage.

International experience of sustainable drainage

A number of cities around the world have developed long-term plans to increase the use of sustainable drainage techniques, including several in the US. One of the earliest adopters was Portland, Oregon. It has a sustainable drainage plan dating back to the early 1990s that's proved to be a great success (City of Portland, 2016). Philadelphia has a 25 year plan, complemented by a range of financial incentives and changes to water bills. It was adopted in 2011. The first years of implementation have shown significant success in the implementation of a more sustainable drainage regime (City of Philadelphia, 2011).

New York City has started a programme of installing thousands of small-scale raingardens to collect rainwater, primarily from streets. However, it should be noted that the US context is very different to the UK. In the US, there are generally fewer organisations responsible for rainwater management. Drainage responsibilities largely remain with municipal city governments.

In Copenhagen, Denmark, severe thunderstorms over recent years have caused serious flooding in parts of the city. This has led to a rethink of rainwater management in the city, the use of more sustainable drainage, and the use of specific areas (such as local streets and surface car parks) to temporarily store relatively shallow depths of rainwater. The development of the Copenhagen Cloudburst Plan is a good example of planning to manage severe thunderstorm events.

In Melbourne, Australia, a wide range of sustainable drainage retrofit projects have been carried out across the city with the dual aims of improving water quality and reducing flood risk. These projects have also resulted in improvements to the public open spaces, building settings and urban streets.

International experience suggests that two key things are required for any large-scale sustainable drainage programme to be successful. First, it must be integrated into city governance and the planning departments. Second, it must have clear, cross-cutting political support. Through the development of this action plan, both of these elements are now in place for London.

The case for sustainable drainage in London

Thames Water's modelling (Figure 2) will be used to help prioritise certain areas or sewer catchments for future improvements to the existing drainage system. However, given the interconnected nature of London's networks, more sustainable drainage is required across all of London. The implementation of this action plan will seek to ensure that rainwater run-off is either slowed down or removed from this system. That will ensure that in 50-100 years there'll be no need to replicate or extend the Thames Tideway Tunnel.

In outer London, during heavy rainstorms, London's tributary rivers absorb large volumes of rainwater from urban areas. This is a natural part of our drainage system but significant quantities of polluting matter and litter can be washed into the rivers from streets, pavements and road gullies. In extreme cases, the deluge of pollution can kill fish in the rivers. Sustainable drainage measures can help tackle this water quality problem by holding back the peak rainwater volumes and reducing the "flushing" effect on the drainage system. Some sustainable drainage techniques, such as reed beds and filter drains, can be specifically designed to remove pollutants. Furthermore, because sustainable drainage systems slowly release water back to the streams and rivers, they can increase the un-naturally low base flows that most urban rivers experience and help the overall quality of these watercourses. Sustainable drainage techniques can therefore have a wide range of water quality benefit. Indeed, in the USA and Australia it is these water quality benefits that are often the main reason for implementing sustainable drainage.

It is also clear that adding green infrastructure sustainable drainage (as opposed to hard-engineered techniques) has many other benefits. These include reducing air pollution, reducing noise, creating pleasant amenity areas, improving biodiversity, reducing summer urban heat island effects and potentially providing water for use instead of mains supply. These benefits remain challenging to incorporate into cost-benefit analyses. As a result, sustainable drainage techniques can sometimes appear to be less cost-effective than traditional engineered drainage solutions. However, two approaches offer potential solutions to this problem:

- **SuDS-specific tools**. CIRIA has done work at a national level to show the relative costs and benefits of different sustainable drainage options. The Benefits of SuDS Tool (BeST) is an easy to use means of assessment.

- **Generic ecosystem services tools**. The natural capital approach involves the economic valuation of natural assets, and the services we get from them (like clean water and flood risk reduction), for use in decision-making. A range of tools exists to value different natural assets and ecosystem services (assuming the availability of the necessary data). For example, iTree Eco estimates the value of some of the ecosystem services provided by individual trees, such as carbon storage and sequestration. These are likely to develop and improve in future.

Sustainable drainage vision

The use of sustainable drainage systems in London is increasing but is still at a low level. London faces many challenges in terms of surface water flooding. That, alongside the co-benefits that sustainable drainage can provide, means the Mayor now wants far more sustainable drainage in London.

By 2040, London will manage its rainwater more sustainably to reduce flood risk and improve water quality and security. This will maximise the benefits to people, the environment and the economy.

To make this happen, we will use both the planning system and retrofitting initiatives, working with a number of key partners. The following sections describe both current planning policy and existing key partners and programmes.

National planning policy

Proposals to increase the use of sustainable drainage techniques are in line with England's planning policies, as set out in the National Planning Policy Framework (NPPF). Sustainable drainage is seen as a means by which developments can avoid increasing the risk of flooding elsewhere. Following the government's consultation 'Delivering Sustainable Drainage' (Defra & DCLG, 2014), there is stronger guidance to support the NPPF in terms of sustainable drainage.

Since April 2015, planning authorities have been responsible for the approval of sustainable drainage designs for all major planning applications in consultation with the lead local flood authority (LLFA). In London, the relevant borough is both the local planning authority and the LLFA.

The London Plan

The London Plan's Policy 5.13 (Box 2) is aimed at ensuring that sustainable drainage techniques are used wherever practical for new developments. This policy has remained broadly unchanged since 2004 and is understood to be working well for large-scale development. It is anticipated that in any future London Plan the broad thrust of the policy will remain.

The policy requires developers to aim for greenfield run-off rates. However, it also recognises that in such a densely built-up city as London this may not always be possible. In particular, given that the vast majority of development is targeted on brownfield sites.

The policy contains a hierarchy of broad drainage methods. Methods are preferred that make beneficial use of any rainfall captured, for example for irrigation or other non-potable uses like vehicle cleaning. The policy also places a preference for sustainable drainage measures that retain water in surface features over methods than store water below the surface. The policy recognises the discharge of rainwater directly to tidal rivers or docks can be a sustainable method of managing rainwater, rather than requiring sustainable drainage features to be incorporated into the development. The Sustainable Design and Construction Supplementary Planning Guidance (GLA, 2014) gives further detail on the implementation of this policy.

New development will be an important aspect of future sustainable drainage delivery. This action plan provides a dedicated section and series of actions relevant to the planning system.

Box 2: London Plan Policy 5:13 Sustainable Drainage

Planning decisions

A. Development should utilise sustainable urban drainage systems (Sustainable drainage) unless there are practical reasons for not doing so, and should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy:
   1 store rainwater for later use
   2 use infiltration techniques, such as porous surfaces in non-clay areas
   3 attenuate rainwater in ponds or open water features for gradual release
   4 attenuate rainwater by storing in tanks or sealed water features for gradual release
   5 discharge rainwater direct to a watercourse
   6 discharge rainwater to a surface water sewer/drain
   7 discharge rainwater to the combined sewer.

   Drainage should be designed and implemented in ways that deliver other policy objectives of this Plan, including water use efficiency and quality, biodiversity, amenity and recreation.

Local Development Framework (LDF) preparation

B. Within LDFs boroughs should, in line with the Flood and Water Management Act 2010, utilise Surface Water Management Plans to identify areas where there are particular surface water management issues and develop actions and policy approaches aimed at reducing these risks.

Drain London

In 2008, the GLA, Thames Water and the Environment Agency commissioned a short scoping study to check the RFRA findings and to suggest ways of improving surface water flood risk management. This confirmed that London is at high risk. It suggested that surface water risk mapping should be carried out across London. The production of a Surface Water Management Plan (SWMP) would be an important next step. This scoping study coincided with the government receiving the Pitt Review into the 2007 flooding events. This review identified 14 London boroughs amongst the top 15 local authorities most at risk of flooding, including surface water flooding.

The GLA then bid to Defra to fund a new project, known as Drain London. This would model surface water flood risk, and map and produce SWMPs for London. Defra provided £3.2 million on the basis that this work would cost around £100,000 per borough. The GLA allocated a project manager for Drain London and Defra delivered the funding in 2010. The project was split into three tiers.

Tier 1 (2010-12)

- Established the modelling and mapping standards.
- Split London into manageable surface water catchments, loosely based on borough boundaries.
- Gathered all known existing data and purchased any missing data (for example, Lidar and Geological datasets).
- Established the borough groupings (originally there were 8 groups, but groups 1 and 2 have merged and groups 7 and 8 have re-modelled themselves slightly).

Credit: Greater London Authority

Figure 3: Current Drain London Groupings

Table 2: Current Drain London Group Members

Group	Borough
1&2 NW London	Barnet, Brent, Ealing. Harrow , Hillingdon, Hounslow
3 Central London	Camden, City of London, City of Westminster, Hammersmith & Fulham, Islington, Kensington & Chelsea
4 Lee Valley	Enfield, Hackney, Haringey, Newham, Tower Hamlets, Waltham Forest
5 NE London	Barking & Dagenham, Havering, Redbridge
6 SE London	Bexley, Bromley, Greenwich, Lewisham
7 London South Central	Lambeth, Southwark
8 SW London	Croydon, Kingston , Merton, Sutton, Richmond, Wandsworth

The new Flood and Water Management Act 2010 and the creation of boroughs as LLFAs meant it became important for each borough and the City of London to have its own surface water mapping and SWMP.

Tier 2 (2011-2012)

This tier undertook the surface water modelling itself and worked with borough officers to produce SWMPs. The work was split into eight contracts, one for each of the Drain London groups. The work also delivered Preliminary Flood Risk Appraisals (PFRAs) for each London borough which became a requirement of the EU Flood Directive 2009. The modelling identified areas of flood risk which contain a range of critical infrastructure and over one million properties (although most of those properties are at a fairly low level of risk). It also identified Critical Drainage Areas, which were the main areas that contribute to the areas of highest surface water flood risk.

Tier 3 (2013- 2016)

This tier examined in detail some of the areas that the Tier 2 work highlighted as being at high risk of surface water flooding. Nearly 30 high flood risk areas and a range of important infrastructure have been investigated to date. A range of sustainable drainage demonstration projects were part-funded by Drain London to show how surface water can be managed more sustainably. Drain London funding has also been used to monitor the water attenuation performance of experimental and conventional green roofs at London Underground's Ruislip depot.

Over five years, the Drain London project has led to a much better understanding of surface water flood risk. It has also tested a number of approaches to mitigate that risk. These approaches show that sustainable drainage techniques suitable for all parts of London can help address London's

surface water flood risk. Sustainable drainage has been shown to deliver substantial benefits in a London context. Now the aim is to encourage further uptake of sustainable drainage.

Partner support

The GLA alone cannot implement sustainable drainage on a widespread basis; it will require an integrated approach from a wide range of partners. The Environment Agency, Thames Water and London Councils have all supported the GLA in drawing up this action plan and have committed to support a range of the actions. Further advice has been taken from London boroughs, TfL and several non-governmental organisations and their support will be critical to the success of the actions.

Thames Water

Thames Water owns and manages London's public sewerage systems. Rainwater is deliberately designed to flow into the combined sewer system that covers most of central and inner London. Yet in most of outer London rainwater is also accidentally and incorrectly connected to the foul sewerage system. As a result, there are some areas where the sewer system has limited capacity. With the projected large growth of London's population through to at least the middle of the century, capacity will come under further pressure. The removal of rainwater from the sewer system would free up capacity for foul water flows and delay. It might even remove the need for what could be expensive and disruptive upgrading of parts of the sewerage network.

As a result, Thames Water has allocated funding in the period 2015-2020 for projects that can remove surface water from the combined or foul sewerage system across its operational area. The programme is known as "Twenty4twenty" and aims to stop at least 20 hectares of drained land from discharging rainwater into the sewers. The programme applies not just to London but across the Thames Water operational area, so some projects may be developed in other towns and cities. However, due to the extent of combined sewers in the capital, at least 50 per cent of the available funding will be put to use in London. This action plan supports this initiative and is keen to see its success used to demonstrate the need for similar funding beyond 2020.

Environment Agency

The Environment Agency is an executive non-departmental public body, sponsored by Defra. It has principal responsibilities in England to protect and improve the environment, and to promote sustainable development. It takes a strategic overview of all sources of flooding, including surface water flooding. Over £12million of government investment (via Flood Defence Grant in Aid (FDGiA)) has been allocated to help London boroughs manage surface water flood risk in 35 projects over the next six years.

London boroughs

London boroughs have been LLFAs since 2010 and are now settled into this role. Each LLFA has or is producing a Local Flood Risk Management Strategy. These strategies, building on the Surface Water Management Plans provided through Drain London, are expected to give a prominent role to sustainable drainage as a flood risk management tool. Furthermore since April 2015 borough planning departments should be seeking specific input from their LLFAs with respect to sustainable

drainage measures in 'major' planning applications. As awareness of sustainable drainage projects grows, more schemes are being developed that incorporate sustainable drainage techniques. Many boroughs are now carrying out localised projects. Most of these follow a similar approach to this action plan, with the project being woven into wider objectives of upgrading facilities or improving the appearance and function of buildings and public spaces. The GLA has launched a register to record such examples across London. It is anticipated this will form a body of evidence about good practice and opportunities.

Transport for London

TfL is the organisation that implements the Mayor's transport strategy. It owns around 2,300 hectares of land across London, including buildings, land attached to Tube stations, railways and highways. This makes TfL one of London's largest landowners, and it has demonstrated some early sustainable drainage projects across London. Examples include green roofs at stations and depots and raingardens in the public realm. Given the extent of land that TfL owns and manages it is clear that further sustainable drainage activities are possible in relation to TfL assets. TfL is developing specific guidance to help increase delivery in relation to its assets.

Non-governmental organisations (NGOs)

A range of NGOs have already played an important role in both implementing sustainable drainage projects and in raising awareness of the need for and benefits of sustainable drainage. Groundwork London, Thames21, London Wildlife Trust, Wildlife & Wetlands Trust and many locally focused groups all have important roles to play. Indeed some of these have already delivered sustainable drainage systems across a range of sites. They have good community engagement strengths and could take an increasing role in this field. In particular, they can help with implementing local projects where the brokering of community relationships is essential.

PART 2: THE SUSTAINABLE DRAINAGE ACTION PLAN

The Sustainable Drainage Action Plan

The aim of this document is to set a long-term strategy and series of actions for increasing sustainable drainage implementation. The emphasis of the strategy is to use whatever technique, or combination of techniques, best suits particular buildings, developments, land or neighbourhoods. This action plan should not be used to suggest that particular techniques can or can't be used. It is intended to commit a wide variety of organisations to actions that will increase the use of sustainable drainage over a long time period. To account for longer-term uncertainties, the plan makes firm shorter term commitments and sets a direction for the longer term. The implementation of the action plan will be monitored and reported on annually and progress will be reviewed. If necessary, actions will be amended and new actions introduced.

Monitoring

The action plan will be monitored, and progress reported on, an annual basis to allow trend analysis and exploration of new opportunities. The number of known sustainable drainage retrofit projects will be reported along with the area drained, volumes, and flow rates where available. Measuring the net impact of the action plan on surface water flooding, however, is recognised as a difficult task. The multiple variables of weather, new development patterns, economic trends, water consumption behaviour and investment in sewerage and drainage infrastructure will all change the net flows in sewers. Nevertheless, in the interests of having a simple and reliable metric to report, we will work with Thames Water and others to develop simple, practical measures of the average and/or peak flows at key points in the sewer network. This will be monitored to determine the overall success of the programme. We will also develop an online Sustainable Drainage mapping tool, where we will crowd source information on sustainable drainage projects that get delivered across London.

Glossary

Throughout this action plan, the suggested lead organisations and partners for action delivery are listed in tables. The abbreviations for these organisations are listed in Table 3.

Table 3: Action plan abbreviations

Abbreviation	Lead organisation / partner
GLA	Greater London Authority
TW	Thames Water
TfL	Transport for London
LA	Local authority
LB/s	London borough/s
LLFA	Lead local flood authority

Abbreviation	Lead organisation / partner
LC	London Councils
CIRIA	Construction Industry Research and Information Association
EA	Environment Agency
LoDEG	London Drainage Engineers Group
LU	London Underground
DLR	Docklands Light Railway

Understanding the opportunities and benefits of sustainable drainage

There are a wide range of opportunities to manage rainwater more sustainably, and these should be taken wherever feasible. There are, however, often-quoted reasons why sustainable drainage techniques either cannot be implemented or are limited. This includes the presence of clay soils, ground contamination, sub-surface utilities and high groundwater. As a result, the Drain London project has commissioned consultants to map the opportunities for sustainable drainage at a London-wide scale. The project will highlight any particular locations where there are either very good, or much more limited, opportunities. The output from this project will be available later in 2016.

The importance of maintenance has been highlighted in Part 1. However, it is also worth investigating whether there are any limits on the amount of certain types of sustainable drainage that should be implemented. For example, a concentration of infiltration techniques could lead to long-term changes in ground moisture levels, and lots of small-scale storage tanks requiring pumps to release rainwater following a storm will have an increasing energy requirement. This will be considered in future reviews of the action plan. However, the position at the start of this plan is that a significant increase in the use of sustainable drainage is required. As such, in no way should implementation of existing opportunities be put on hold or resisted awaiting longer-term research.

The actions outlined in this part of the action plan are aimed at understanding these wider and longer-term implications, and establishing a monitoring framework.

Table 4: London-Wide Actions

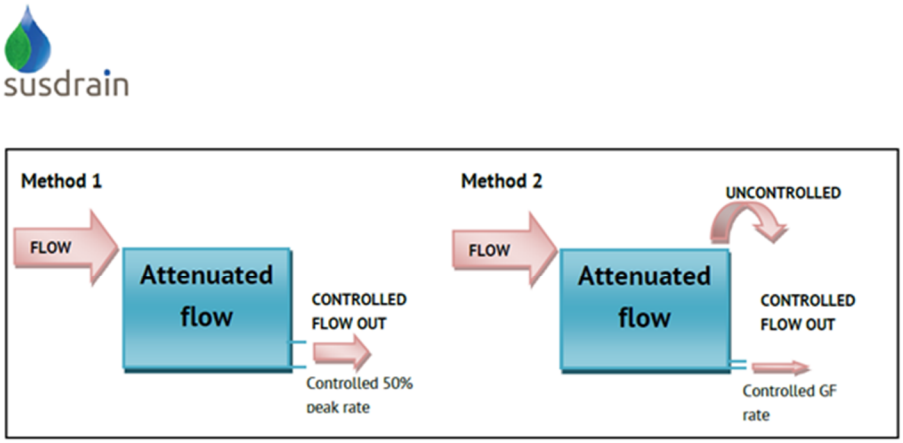
No.	Action	Lead Organisation	Partners	Timescale
1	Publish the results of the London-wide Sustainable Drainage Opportunity Model	GLA	TW EA LC	2016
2	Raise awareness of the need for, benefits of and delivery of sustainable drainage within London	GLA	LBs Project delivery organisations Non-governmental organisations	2016 on
3	Deliver a programme of sustainable drainage demonstration projects	TW LBs GLA Non-governmental organisations		2015 – 2020

Delivering sustainable drainage through new developments via the planning system

This is an area of the action plan where there is already significant activity. This is not surprising as implementing sustainable drainage on new development is often cost-neutral and can even offer cost savings compared to conventional drainage techniques. Furthermore, as mentioned in part 1, national and London-wide planning policies have promoted and required sustainable drainage for many years (the London Plan has contained a Sustainable Drainage Hierarchy since 2004).

Evidence from the strategic planning applications referred to the Mayor shows that most applications over recent years have included proposals to significantly reduce rainwater discharge. These reductions are often to greenfield run-off rates but almost always achieve at least a 50 per cent cut in the site's previous peak run-off. The relatively small proportion of development that is proposed on greenfield sites has generally been able to retain greenfield run-off rates. There's been a lack of monitoring of smaller-scale development proposals. However, it's expected that these would show generally fewer proposals for sustainable drainage, particularly at the household level.

There is an indication that in some cases the design of attenuation features to reduce peak flows for larger events may mean reductions for lower return period events are not significant. This is highlighted by the two concept designs shown in Fig 4 below. In future, there'll be a clear preference for the Method 2 design, to ensure the attenuation benefits are realised for the majority of storms.



From Susdrain Factsheet "Designing attenuation storage for redeveloped sites", by Anthony McCloy
http://www.susdrain.org/files/resources/fact_sheets/01_15_fact_sheet_attenuation_for_redeveloped.pdf

Figure 4 Susdrain Method 2 attenuation tank design

With the changes to the NPPF Guidance in April 2015, the delivery of sustainable drainage for major new development is set to increase significantly. This means that planning applications for major new development are now referred to LLFAs for their comments. Developers have to give increased attention to the drainage arrangements for these new developments. There's also an expectation that sustainable drainage techniques will be used unless there are clear grounds for not doing so.

The London Plan

We will work with Drain London partners, and the development and drainage industries, to test whether any changes are required or would be desirable in order to inform future reviews/replacement of the London Plan. Of particular relevance to this research is the recently revised SuDS Manual (CIRIA, 2015). This contains specific guidance relating to sustainable drainage measures for large urban areas.

Much of the new development in London will be dispersed in small-scale developments, which will be individually dealt with through the normal planning process. There will also be significant concentrations of new development within the London Plan opportunity areas. These areas offer the scope for strategic level redesign of drainage regimes, to include sustainable drainage systems within a wider Water Sensitive Urban Design approach. This action plan commits the GLA to examine each of the Opportunity Area Development Frameworks, as they come forward and identify the most appropriate drainage strategy for those areas. For some opportunity areas there are particularly important opportunities to improve the sustainability of the regime. This includes the Vauxhall Nine Elms, Battersea and Old Oak Common opportunity areas. In such cases a more detailed Integrated Water Management Plan is being delivered.

This section of the action plan aims to support London boroughs in their planning role. It serves to coordinate experiences and monitoring of sustainable drainage delivery. That way best practice can be established and shared.

Table 5: Actions

No.	Action	Lead organisation	Partners	Timescale
4	Maintain a strong London Plan policy to support sustainable drainage in new development	GLA		Continuous
5	Collate information on sustainable drainage delivered through the planning system	GLA	LBs	2017 on
6	Provide strategic guidance on sustainable drainage requirements for major development locations	GLA	Partner LBs TW EA	Continuous

No.	Action	Lead organisation	Partners	Timescale
7	Provide detailed Integrated Water Management Plans for specific opportunity areas	Development partners	GLA EA TW LBs	Continuous

Retrofitting sustainable drainage across London

Through the planning system, new development will deliver steady incremental increases in the amount of sustainable drainage techniques implemented across London. However, new development typically affects only around 0.5 per cent of land each year. Therefore, any step change in the use of sustainable drainage requires that existing land and buildings are retrofitted with more sustainable drainage measures.

The remainder of this action plan examines a range of key land uses in the public and private sectors. Different elements of the public sector own, manage, and control enormous amounts of land, buildings and infrastructure throughout London. The main sectors are examined below but include education, housing, transport and health land use sectors. Large commercial sector ownership and management is also hugely significant across London. This action plan seeks to influence those organisations controlling larger plots of land, such as major commercial owners and large format shops and businesses. Whilst sustainable drainage measures should be considered by all property owners/managers, this action plan must target efforts. At present, working with larger organisations, including those in the NGO sector is the main focus. This could be reviewed in future years.

It is fully recognised that all public sector organisations are under tight budgetary control, and commercial organisations will need to prove a good business case for investment. Other than the Thames Water 'twenty 4 twenty' programme there is limited funding specifically available for measures like retrofitting of sustainable drainage as a one-off project. However, there are funds available for more multi-functional projects that bring a wide range of public benefits. One example is green infrastructure sustainable drainage projects.

This action plan proposes to offer guidance and influence existing expenditure plans that public sector and commercial organisations will already have. We expect that where there are opportunities to incorporate sustainable drainage as part of other required maintenance, repair or improvement of facilities, these options should be duly considered and implemented if practical. There may still be some initial extra cost involved in such measures. However, this will be marginal in most cases and there may be opportunities for some sustainable drainage options to offer cost-savings, either at installation stage and/or in terms of maintenance and operational requirements. Sustainable drainage opportunities can also often allow the integration of drainage with a range of other objectives. For

example, greenspace management, water demand, noise reduction, air quality improvement or improved visual appearance.

To realise the opportunities that do or will exist, organisations must be aware of the importance of sustainable drainage and its relevance to their operations. It is also necessary for the relevant organisations to share, at least at a general level, their planned investment programmes. This will allow enough lead-in time to identify and incorporate sustainable drainage techniques without significant additional cost or time implications.

Each broad land use sector is now considered in turn. However, we recognise there'll be many cases where one land use sector needs to work with another in order to deliver the most effective sustainable drainage solution. Examples include drainage from a highway diverted onto adjacent parkland, or drainage from a residential area diverted onto an adjoining school playing field.

Education sector

Credit: Wildfowl & Wetlands Trust

Figure 5: Coppetts Wood Primary School SUDS for schools

Table 6: Education sector options and opportunities

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Green/brown/blue roofs	Major roof repairs, refurbishment or building extension
Raingardens, flow through planters, stormwater tree pits and downpipe diversion	School extension or refurbishment, or some minor works/landscaping improvement
Permeable surfacing	Resurfacing of car parks or hard surfaced playgrounds

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Attenuation tanks/geocellular storage	Resurfacing of car parks or hard surfaced playgrounds – may be combined with permeable surfacing
Rainwater harvesting	School extension or refurbishment, or some minor works
Swales, bio-retention	Playing field/landscaping enhancements
Ponds, wetlands	Within landscaping around the school. Ponds can provide valuable educational opportunities

The education sector has a wide range of buildings and premises. This includes primary and secondary schools in both the public and private sector, and higher and further education establishments. A high proportion of these buildings have flat roofs, which may prove suitable for green roof technologies. Perhaps most significantly, many schools, colleges and universities have outdoor spaces/playgrounds, playing fields, and/or car parking areas. These offer the potential for significant surface water storage and infiltration via a range of possible techniques. In general, education premises in outer London tend to have bigger external spaces. That means they have a wider range of sustainable drainage retrofit opportunities than schools in more densely built-up parts of London. For some schools/colleges there may be limited opportunities.

It is notable that with London's continued growth, there will be significant growth in the education sector. The London Infrastructure Plan is projecting the equivalent of up to 550 new schools and colleges in London by 2050. In reality, much of this capacity may be accommodated by expanding existing schools/school sites. This presents both a challenge and an opportunity for introducing more sustainable drainage. On the one hand, more densely developed school sites will mean that current areas of open space (whether hard surface or soft landscaping) will be reduced and some scope for sustainable drainage may be lost. On the other hand, the capital investment in those premises provides exactly the mechanism necessary to change the drainage regime of the school site. If planned and designed as part of an overall upgrade or extension of the school, the implementation of sustainable drainage measures can be achieved at minimal, or even zero, extra cost. The provision of green roofs has the additional benefit that the long-term maintenance and repair costs of the roof should be reduced.

Drain London has already worked with a number of secondary schools across London at risk of surface water flooding. This work has demonstrated that there are significant opportunities for surface water

storage or diversion through the use of green roofs, raingardens, swales, detention basins and wetlands.

The 'SuDS for Schools' programme (run by the Wildfowl & Wetlands Trust in partnership with the Environment Agency and Thames Water) has also provided a range of sustainable drainage techniques at ten schools within Barnet, Enfield and Haringey. This has demonstrated that schools have huge potential for sustainable drainage measures. It has also shown that the implementation of these measures can be linked to water cycle topics on the national curriculum and provide good examples for students to study. One of the important conclusions from this work was that even where external space was limited there was still some scope for measures like raingardens.

In recent years, the Water for Schools Programme (run by the London Sustainable Schools Forum: http://www.londonsustainableschools.org/water-for-schools.html) has implemented two pilot rainwater harvesting schemes. These have captured water for use in the school toilet systems, leading to savings on water bills. This work also demonstrated that taking a comprehensive look at water supply systems in schools is a good way to identify leaks and faulty or inefficient plumbing appliances. The repair and upgrade of these plumbing systems led to significantly greater water savings and notable cost savings on annual water bills. On their own, such rainwater harvesting systems would take several years to pay for themselves. However taken as part of a wider refurbishment or extension of a school, this should be an incremental cost with payback in a shorter time period.

Actions

This section of the action plan sets out a programme of activities to engage with, advise, and lobby key decision makers in the education sector to promote and deliver more sustainable drainage throughout the sector. The key theme is that retrofitting sustainable drainage should form part of already planned maintenance, repair and improvement programmes. Once opportunities have been identified with large education sector providers, other smaller-scale opportunities can be examined.

Table 7: Education sector actions

No.	Action	Lead organisation	Partners	Timescale
8	Produce guidance and good practice examples of sustainable drainage applicable to the education sector	GLA	TW EA Local authority education depts. SuDS for Schools Susdrain	2017
9	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement public sector schools	GLA	Local authority education depts. and other publicly funded schools	2017
10	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works in higher education establishments	GLA	Higher education providers	2017
11	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works in private sector schools	GLA	Private sector education providers	2019

Housing sector

Credit: Groundwork

Figure 6: Groundwork estate retrofit project in Hammersmith & Fulham

Table 8: Housing sector options and opportunities

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Green/brown/blue roofs	Major roof repairs for residential buildings. Small scale repairs to garages, sheds and other structures
Raingardens, flow through planters, stormwater tree pits/diversion of downpipes	Landscaping enhancements
Rainwater harvesting	Major refurbishment programmes for larger buildings/estates
Swales, bio-retention, ponds, basins and soakaways	Refurbishment and landscaping enhancements dependent upon space and ground conditions

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Oversized pipes, attenuation tanks, geocellular storage	Refurbishment and landscaping where space is limited or ground conditions for infiltration unfavourable
Permeable surfacing	Resurfacing of footpaths, hard surfaces or car parks

This section focuses on the larger providers of housing. This includes housing associations, local authority social housing and large-scale private rented sector providers.

With over four million homes, the housing sector represents a large proportion of London's total surface area. Recently, the number of new homes has been growing at around 30,000 per year. However, it is generally recognised this must increase to around 50,000 per year to keep up with continued population growth and with the backlog of demand that already exists.

A key consideration for the housing sector is that properties tend to have a long life span. There are still a large number of Victorian brick-built homes in use today. Many are well over 100 years old and make up some of the most sought-after properties in London. Many of the early public sector housing estates built after the First World War are almost 100 years old. The large tracts of outer London built during the inter-war years are now 80 years old and look set to remain a key part of London housing for the foreseeable future. This longevity means that it is important to get sustainable drainage measures built into the design of new housing. It also means that if sustainable drainage can be retrofitted to existing stock, it should provide benefits for the long-term. Conversely, the fact that buildings are generally long lasting is an indication that they can be maintained without the need for frequent major repairs. Therefore the opportunities to retrofit sustainable drainage will generally occur infrequently for any given building.

An initial distinction should be made between properties with pitched roofs and those with flat roofs. Flat-roofed properties may be suitable for a green/brown/blue roof. Such roofs can have valuable benefits in improving the insulation of the buildings, keeping them both warmer in winter and cooler in summer. A well designed green/brown/blue roof can also reduce long-term maintenance and repair costs of flat roofs.

Addressing the retrofit of London's housing stock is likely to be challenging given the diversity of ownership and management. A large proportion of the housing stock is owned either by individuals/families, or by owners of small and dispersed property portfolios. There is a range of relatively easy measures which can be applied to such properties, especially those with garden areas. These are covered in the 'What can you do? Delivering sustainable drainage through domestic and local neighbourhood ' section.

Many municipal or housing association residential estates have relatively large areas of communal open space. These can often provide good opportunities for retrofitting rain gardens and diverting downpipes into those raingardens. For example, the Neighbourhoods Green initiative aims to raise the profile of open space for social housing residents. It works with social landlords to raise the quality of their design, management and safe use. Sustainable drainage is considered as part of this work (National Housing Federation 2011).

However, care is required to avoid areas too close to the buildings themselves, to avoid the risk of damp or changes to the ground conditions surrounding foundations. Also, areas that are likely to contain numerous services should generally be avoided due to the large increase in costs that moving or protecting such services is likely to incur. The architectural design of some estates included the provision of concealed downpipes. In other words, it's not clear exactly where the downpipes are as they are hidden beneath the facade of the building. In such cases, alterations to divert such downpipes will be slightly more complex and costly. However, in general this shouldn't be an insurmountable difficulty.

Nevertheless, there are still likely to be major opportunities to create raingardens in communal housing areas. Recent demonstration projects in Enfield, Hammersmith and Fulham, Haringey and Newham have shown a variety of sustainable drainage techniques being implemented. Such schemes divert rainfall from downpipes and also provide more diverse and attractive landscaping for the residents or potentially small food growing areas. In general such projects are relatively cheap.

For residential locations next to the Thames, tidal rivers or docks, a relatively easy approach is to divert rainwater into the river or dock. This is not normally considered to be a form of sustainable drainage. However for the heavily urbanised areas of London it is a more sustainable approach to managing rainwater that would otherwise be carried into the combined sewer system. This method of rainwater management is usually relatively easy to introduce together with other renovations of a building. But it will need to accommodate the regular tidal fluctuations. It may also be necessary to store or discharge to the surface water sewer during high tide periods.

The GLA runs the RE:NEW programme which is mainly aimed at improving energy efficiency in London's housing stock. It could also consider opportunities to improve water and drainage efficiency.

Actions

This section sets out a programme of activities to engage with, advise and lobby the key decision makers in the housing sector in order to promote and deliver more sustainable drainage in the sector. The key theme is that retrofitting sustainable drainage should form part of already planned maintenance, repair and improvement programmes. Once opportunities have been identified with the larger social landlords, other smaller-scale opportunities will then be examined.

Table 9: Housing sector actions

No.	Action	Lead organisation	Partners	Timescale
12	Produce guidance and good practice examples of sustainable drainage applicable to the housing sector	GLA	TW EA LA housing depts. Susdrain	2017
13	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works in the socially rented housing sector	GLA	Housing associations LA Housing depts. GLA Re:New	2017

Transport sector

Before **After**

Credit: Greysmiths Associates

Figure 7: Derbyshire Street pocket park, Tower Hamlets

Table 10: Transport sector options and opportunities

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Rainwater diversion from gullies to street trees or swales, or potentially to non-highway land	Maintenance of road gullies/drainage, or more substantial capital works enabling a larger scale diversion
Street Trees, stormwater tree pits	New or replacement street trees
Permeable surfacing	Resurfacing of car parks, footways, cycle paths
Swales	Landscaping enhancements
Rainwater harvesting	Refurbishment of bus/rail depots, especially where there is a requirements for water for cleansing
Raingardens	Landscaping enhancements around buildings and transport assets
Green/brown/blue roofs	Refurbishment of buildings and depots

The transport sector has many and varied opportunities to introduce sustainable drainage, and importantly is a sector with regular, if limited, funding for capital and maintenance works. This action

plan recognises that most of the transport sector's linear assets (roads and railways) offer limited scope for sustainable drainage. Rail and Tube lines can often run in cuttings, making it difficult to divert rainwater away from them: indeed such cuttings are often at some level of flood risk due to their low topography. Similarly, major road underpasses can often be prone to flooding. Perhaps the only realistic options for heavily urbanised roads are the creation of permeable parking areas and the diversion of rainwater into stormwater tree pits. Some good examples of such 'Stockholm' tree pits have recently been built in London. It is generally accepted that permeable surfacing is not suitable for any but the lightest trafficked road surfaces. Transport for London (TfL) is running a permeable road surfacing trial during on a section of the A127 in east London. Initial results confirm previous concerns that permeable surfaces are not able to manage large traffic flows without rapid deterioration. Instead the focus must be on highway land away from the carriageway and potentially diverting surface water into adjacent low impact spaces.

Whilst acknowledging the above constraints, many linear assets have large tracts of land alongside them, such as road verges, footways and trackside vegetation. In the case of rail and road routes through outer London, there are often areas of parkland, greenbelt, or indeed farmland alongside several miles of road or railway. These offer the potential for rainwater to be diverted into such areas for sustainable drainage. This could reduce flood risk to the transport asset and potentially to the wider neighbourhood. There are also lots of opportunities to design sustainable drainage into traffic calming measures, examples of which are increasing in London.

Diffuse pollution from transport infrastructure is a huge factor affecting the quality of London's rivers. Major roads are likely to generate significant amounts of pollutants that can be washed into receiving drains and waterbodies during heavy rainfall. The ability to treat surface water from road or rail corridors using infiltration or bio-retention sustainable drainage techniques is therefore a good opportunity to reduce the pollution loading for watercourses and groundwater.

In common with many other buildings, transport sector buildings can lend themselves to green/brown/blue roofs and also realise the benefits of insulation and reduced long-term maintenance. London Underground has constructed a green roof at its Ruislip Depot. Where such buildings are being upgraded or extended, there are likely to be opportunities to incorporate some sustainable drainage measures at little extra cost.

There are often reports of surface water flooding at main line rail termini, given the size of the roof area of these stations. However, it should also be noted that these and some other transport buildings may be of historical and architectural significance. This means they may not be suited to green roofs and or other sustainable drainage techniques.

More modern or utilitarian buildings may be better suited to green/brown/blue roofs. Buildings such as maintenance depots or bus garages can be well suited for rainwater harvesting schemes for vehicle cleansing, thus reducing water bills. The West Ham bus depot is a good example, as it incorporates a green roof with a rainwater harvesting system that is used to supply water to wash the bus fleet.

Many outer London rail and tube stations have station car parks. These areas may be suited for permeable surfacing or sub-surface storage if the car parks are resurfaced or redeveloped.

Actions

This plan sets out a programme of activities to engage with, advise and lobby the key decision makers in the transport sector, in particular with the Mayor's own agency TfL (for example, through the Mayor's Transport Strategy), to promote and deliver more sustainable drainage throughout the sector. The key theme is that retrofitting sustainable drainage should form part of already planned maintenance, repair and improvement programmes.

Once opportunities have been identified with the main sector providers, other smaller-scale opportunities will then be examined.

Table 11: Transport sector actions

No.	Action	Lead organisation	Partners	Timescale
14	Produce guidance that includes good practice examples of sustainable drainage in the streetscape public realm	TfL		2016
15	Prepare a standard for retrofitting green infrastructure	LU		2017
16	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within TfL owned/managed transport assets	GLA	TfL LU DLR London Overground	On-going
17	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within other highway authorities' transport assets	GLA	Highways authorities Highways England	2017

Health sector

© Medical Architecture 2015

Figure 8: Green roof at Springfield Hospital, Wandsworth

Table 12: Health sector options and opportunities

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Green/brown/blue roofs	Major roof repairs, refurbishment or building extension
Raingardens and downpipe diversion	Hospital extension or refurbishment, or some minor works
Stormwater tree pits	New or replacement street trees, car park re-modelling/landscaping
Permeable surfacing	Resurfacing of car parks

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Swales, bio-retention	Extension or major refurbishment where hospital has extensive undeveloped grounds

The NHS, and indeed private sector health providers, has a wide range of premises across London. Some of these are relatively small, for example some doctors surgeries, and offer only limited scope for sustainable drainage. However, other premises such as major hospitals are large buildings offering a range of opportunities for sustainable drainage, both at roof level and within the grounds. A high proportion of health sector buildings have flat roofs that may prove suitable for green/brown/blue roof technologies. These also offer the potential added benefits of improving insulation and reducing long-term maintenance costs. In some parts of London, hospitals are set in extensive grounds and have large car park areas. Such sites offer considerable opportunities for the storage, infiltration or diversion of rainwater away from sewers. Some even have the capacity to absorb rainwater from surrounding streets and neighbourhoods. There is also evidence that pleasant natural surroundings correlate with improved health and recovery (MEBIE2 study: Natural England 2014).

Drain London has worked with 11 major hospitals to assess surface water flood risks. This has illustrated some ways in which flood risk can be mitigated, at the same time as improving the resilience of the hospital's operation. Examples include locating critical equipment and utilities above potential flood levels or by diverting potential flood water away from the most sensitive areas. This work also highlighted that there are opportunities for green roofs, permeable car parking areas and rain-attenuating landscaping to be incorporated into periodic major maintenance.

Actions

This section of the plan sets out a programme of activities to engage with, advise and lobby the key decision makers in the health sector in order to promote and deliver more sustainable drainage throughout the sector. The key theme is that retrofitting sustainable drainage should form part of already planned maintenance, repair and improvement programmes.

Once opportunities have been identified with the large health sector providers, other smaller-scale opportunities will then be examined.

Table 13: Health sector actions

No.	Action	Lead organisation	Partners	Timescale
18	Produce guidance and good practice examples of sustainable drainage applicable to the health sector	GLA	NHS EA TW Susdrain	2017
19	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within the NHS estate	GLA	NHS Trusts	2018
20	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within the private sector health providers' estate	GLA	Health providers	2019

Retail sector

Credit: Marks and Spencer

Figure 9: Green wall and green roof on an M&S store, Sheffield

Table 14: Retail sector options and opportunities

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Green/brown/blue roofs	Major roof repairs, store extension or refurbishment
Raingardens, flow through planters, downpipe diversion	Roof repairs, minor alterations, landscaping
Permeable paving	Resurfacing of car parks and pedestrian areas
Stormwater tree pits	Street tree planting, landscaping of car parks
Attenuation tanks, geocellular storage	Remodelling of car parks or large pedestrian areas, maybe linked to permeable paving
Design for exceedance	Temporary storage of surface water in re-modelled car parks, service yards, landscaped areas

Supermarkets and large-scale retail units have large, generally flat or shallow sloping roofs. There may be good opportunities to introduce green/brown/blue roofs onto some stores, although it is generally anticipated that these will be limited, since the relatively lightweight retail unit roof construction often lacks the structural support required for such a roof. However, a new lightweight green roof technology will be tested by London Underground that is 40 per cent lighter than conventional green roofs. These may be appropriate for the retail sector in future.

Huge opportunities do however exist to divert downpipes into raingardens or rainwater storage areas within the grounds or car parks of the stores. These measures could be incorporated into the resurfacing of a car park or into improved landscaping for stores. Resurfacing of car park areas also offers a good opportunity to store or infiltrate rainwater. Permeable supermarket car parks have been introduced in a number of locations nationally with very positive results. Care will be needed where stores have been built on previously contaminated ground. It is also unlikely to be practical to introduce permeable surfacing to delivery yard areas due to the likely damage caused by the manoeuvring of delivery vehicles.

Car parks, yard areas and landscaping can be designed so that they can temporarily hold rainwater in longer term return periods (say once every ten years). This can offer a simple and cost effective way of reducing flood risk at locations with large roof areas/car parking areas.

Shops in town centres are generally of smaller building footprints and not surrounded by large car park areas. There will therefore be limited opportunities for major sustainable drainage retrofitting here. Instead, sustainable drainage will generally take place in more comprehensive redevelopment. That means opportunities will be picked up via the planning system or upgrades and improvements to the public realm, where stormwater tree pits and raingarden planters may be ideal solutions.

Actions

This section sets out a programme of activities to engage with, advise and lobby the key decision makers in the retail sector in order to promote and deliver more sustainable drainage throughout the sector. The key theme is that retrofitting sustainable drainage should form part of already planned maintenance, repair and improvement programmes.

Table 15: Retail sector actions

No.	Action	Lead organisation	Partners	Timescale
21	Produce guidance and good practice examples of sustainable drainage applicable to the retail sector	GLA	TW EA BIDs Susdrain	2017
22	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within the major supermarkets estates	GLA	Supermarkets LBs	2017
23	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within DIY and other large format retailers' estates	GLA	DIY stores and other large format stores LBs	2017
24	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within retail estate owners' proposals	GLA	Retail estate owners BIDs	2018

Recreational land / other open space and sports stadia

Credit: Greater London Authority / Environment Agency

Figure 10: Swales installed at Mayesbrook Park, Barking and Dagenham

Table 16: Recreational land options and opportunities

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Swales	Maintenance of grounds
Bio-remediation, detention ponds, wetlands, de-culverting	Upgrades to facilities, landscaping projects
Rainwater harvesting	Refurbishment of buildings and depots
Green/brown/blue roofs	Refurbishment of buildings and depots
Permeable surfacing for car parks	Resurfacing of car parks
Stormwater tree pits	Tree planting
Storage tanks/geocellular storage	For large roof or paved areas

The public sector owns and manages large areas of open space and recreational land. This includes parks, gardens, sports pitches, and (mainly in outer London) a number of golf courses. These help

form part of London's 'green infrastructure'. Much of this land will drain naturally, either via infiltration or to tributary streams. These land uses offer good opportunities to absorb or hold more rainwater from adjoining areas and potentially to improve the quality of the water entering these watercourses. During upgrading or remodelling works, these spaces could be designed to hold more surface water using relatively natural means. Given the record rainfall in several parts of the country over recent years, it's time to be more proactive in our approach to storing water in such open spaces.

We know that where heavy clay soils are present, there will be limitations to infiltration techniques. Also, that where open spaces are particularly heavily used, the ground can become compacted and rainwater runs off at high rates, not unlike hard surfacing. Nevertheless open spaces provide opportunities for a wide range of sustainable drainage techniques. It is also increasingly common for sports pitches to be synthetic, for example football pitches and tennis courts. This offers a chance to consider diverting rainwater into surrounding landscaped areas or into geocellular units below the playing surface.

Besides the London boroughs, there are a number of other agencies that own and/or manage open space in London. The City Corporation owns iconic spaces, such as Hampstead Heath, Epping Forest and a range of commons. The Royal Parks Agency owns and manages the eight Royal Parks in London. Finally, the Lee Valley Regional Park Authority owns and manages a significant amount of land in the Lee Valley. These agencies can all play an important role to help improve the management of rainwater in London.

A range of open spaces is also owned and managed privately either by not-for-profit sports clubs and associations, or on a commercial basis. Again, golf courses in outer London are relatively common but there are also many other sports facilities that offer sustainable drainage opportunities. Even where playing surfaces are impermeable, there are often large surrounding areas capable of storing and/or infiltrating surface water.

Major sports grounds have a combination of hard surfaced stadia, circulation space and car parks, as well as the playing surfaces themselves. Here, it's worth considering rainwater harvesting, since the pitches will require irrigation and there is a requirement to flush large numbers of toilets. This could offer reduced water bills. There are examples already, like Arsenal's Emirates Stadium and Tottenham Hotspur's training facility in Enfield.

Open spaces require management and maintenance and are occasionally remodelled. This means that there are a range of opportunities to introduce more sustainable drainage. There are a number of grant programmes aimed at funding improvements and changes to such open spaces. When such programmes are being considered, this is a good opportunity to design in sustainable drainage measures and locations to retain and infiltrate rainwater.

The GLA manages the All London Green Grid, which is a policy framework to promote a network of 'green infrastructure' across London. The Green Infrastructure Task Force looked at how a more strategic and long-term approach to green infrastructure investment and delivery can be encouraged. There are also a number of non-governmental organisations that promote a more sustainable water

environment, including sustainable drainage, such as Thames21, Groundwork and London Wildlife Trust. These organisations provide important networks through which to promote sustainable drainage opportunities.

Actions

This section sets out a programme of activities to engage with, advise and lobby the key decision makers in the open space/recreational sector in order to promote and deliver more sustainable drainage throughout the sector. The key theme is that retrofitting sustainable drainage should form part of already planned maintenance, repair and improvement programmes.

Table 17: Recreational land actions

No.	Action	Lead organisation	Partners	Timescale
25	Produce guidance and good practice examples of sustainable drainage applicable to the open space/recreational sector	GLA	London boroughs NGOs Landscape Institute	2017
26	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works in parks and open spaces	GLA	Royal Parks Corporation of London Lee Valley Regional Park Authority London boroughs London Playing Fields Association Major sports /stadia owners	2017

Other public sector buildings

Credit: Greater London Authority

Figure 11: TfL offices at 55 Broadway, Westminster

Table 18: Other public sector land options and opportunities

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Green/brown/blue roofs	Building extension or refurbishment, major roof repairs
Raingardens and downpipe diversion	Major roof repairs
Permeable surfacing	Resurfacing of car parks
Rainwater harvesting	Refurbishment, may also be worthwhile as a standalone investment

Whilst certain public sector functions have been highlighted earlier, both national and local government, as well as a range of other public agencies, own and/or manage a significant number of other buildings and areas of land. These are typically offices, but may also include supplies depots, waste management sites, vehicle depots, museums, galleries and community centres/halls.

The guidance and best practice proposed for other sectors is likely to cover the range of other public sector buildings and land. For example, there are likely to be opportunities for green/brown/blue roofs to be incorporated into some buildings, particularly those with flat roofs. This would offer additional insulation and reduced maintenance costs. For offices and other buildings with high occupancy rates or high non-potable water demand, putting in a rainwater harvesting system may prove cost-effective, particularly for toilet flushing. For depots, some waste management sites and vehicle holding sites, the use of rainwater harvesting for site, plant or vehicle washing purposes may prove cost-effective.

Actions

This section sets out a programme of activities to engage with, advise and lobby the key decision makers in the wider public/governmental sector in order to promote and deliver more sustainable drainage throughout the sector. The key theme is that retrofitting sustainable drainage should form part of already planned maintenance, repair and improvement programmes.

Given that this action plan already contains a range of engagement activities with other public sector agencies, the actions here are delayed for some years. However, those other discussions may in due course, reveal a range of public sector opportunities.

Table 19: Other public sector land actions

No.	Action	Lead organisation	Partners	Timescale
27	Examine local authority development proposals, capital and revenue programmes for sustainable drainage opportunities	GLA	LBs	2018
28	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within the central government departmental and quango estates	GLA	Central government depts. and quangos	2018

Commercial office sector

Credit: Greater London Authority

Figure 12: Rain garden at John Lewis Headquarters, Victoria

Table 20: Commercial office sector options and opportunities

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Green/brown/blue roofs	Major roof repairs, office extension or refurbishment
Raingardens and downpipe diversion	Roof repairs, major and minor refurbishment and landscaping works
Direct discharge to tidal rivers or docks	Roof repairs, minor refurbishment work, resurfacing work
Permeable car parks, tree pits	Resurfacing and landscaping of car parks
Rainwater harvesting	Refurbishment, may also be worthwhile as a standalone investment

Commercial offices face many of the same opportunities and constraints as public sector offices. However, offices in town centre and central London locations will generally offer limited sustainable drainage opportunities due to the density of development. In contrast, offices in out-of-centre business parks may offer many opportunities in their surrounding car parks and landscaped grounds.

Given the density of employees, most offices should consider the potential long-term benefits of reducing water supply costs by using rainwater harvesting systems to supply toilets. These are likely to prove financially viable in many cases.

For office locations adjacent to the Thames, tidal rivers or docks, a relatively easy approach is to divert rainwater into the river or dock. Not normally considered a form of sustainable drainage, for the heavily urbanised areas of London it's a more sustainable way to manage rainwater that would otherwise be carried into the combined sewer system. This method of rainwater management is usually relatively easy to introduce alongside other building renovations. However, it will generally only be applicable for tidal waterbodies. So there may be a need for storage in high tide conditions.

Offices in less densely built-up areas (typically along arterial roads or within business parks) are likely to offer major opportunities. These include introducing green/brown/blue roofs, diverting rainwater downpipes into raingardens or permeable areas, and adding permeable surfacing to car parks. Together, such measures can provide a significant reduction in rainwater run-off. If combined with other works (such as a wider refurbishment programme, re-roofing, or resurfacing of car park areas), these can be put in at minimal additional initial cost. It is recognised that in many outer areas of London, the office sector is shrinking. This may mean that there are fewer opportunities for retrofitting. It may also mean that any conversion to residential premises provides a good opportunity to introduce more sustainable drainage. Any major redevelopment will be expected to provide sustainable drainage through the planning system.

For offices in more built-up locations it's likely the only options may be adding green/brown/blue roofs when major roof repairs are required, or introducing a rainwater harvesting system.

Actions

This section recognises that this is a more diverse sector than some others, and so the timescale for engagement is slightly later than other sectors. The likely guidance and good practice examples will be similar to those for some other sectors so no specific guidance is proposed.

Table 21: Commercial office sector actions

No.	Action	Lead organisation	Partners	Timescale
29	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works with major office owners/occupiers	GLA	Major office owners/ occupiers BIDs	2019

Industrial sector and major utilities

Table 22: Industrial sector and major utilities options and opportunities

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Green/brown/blue roofs	Major roof repairs, premises extension or refurbishment
Raingardens and downpipe diversion (potentially to tidal rivers or docks)	Roof repairs, minor works
Permeable car parks, stormwater tree pits	Resurfacing or landscaping of car parks and yard areas
Detention ponds, swales, bio-retention	As part of remodelling work, where land permits
Rainwater harvesting	Refurbishment, may also be worthwhile as a standalone investment

It is widely recognised that London's industrial sector has shrunk over past decades. However, in several parts of London there is an important remaining industrial sector, some of which is now expanding and intensifying its activities. Businesses such as distribution and storage facilities should be considered here too. This section also addresses the premises of the major water, energy and telecoms utilities. These utilities often have large-scale sites, many of which are likely to remain as long-term land uses in London. There may be further rationalisation of the telecoms and mail sector land over the future years given the changes in those industries.

Industrial premises often have large buildings. In common with other large buildings, these may offer the opportunity for a green/brown/blue roof. However, the roof construction is often relatively lightweight and may not be able to support a vegetated roof (depending on the availability of lightweight green roof technologies in the future). The diversion of downpipes to raingardens, swales, and detention ponds is likely to be generally feasible. However attention should be paid to potential for rainwater to come into contact with contaminants, and to consider the possibility of previous ground contamination.

Resurfacing or landscaping of car park and yard areas will present the opportunity to introduce sustainable drainage measures, like permeable parking surfaces, at relatively low extral initial cost. However, if HGVs are likely to use parking or servicing areas, it may not be appropriate to use permeable road surfacing due to the risk of damage to its surface. Given industrial uses, issues of

potential ground contamination may limit some of the sustainable drainage techniques available, notably infiltration techniques.

There are a large number of industrial and utility premises in the London parts of the Thames Gateway. These may also offer the opportunity for rainwater to be discharged to the Thames or the Royal Docks.

For industrial premises that use large volumes of water as part of their processes, like for cleansing or cooling, then rainwater harvesting schemes may prove cost-effective in reducing long-term water bills.

Actions

This section sets out a programme of activities to engage with, advise and lobby the key decision makers in the industrial/utility sector in order to promote and deliver more sustainable drainage throughout the sector. The key theme is that retrofitting sustainable drainage should form part of already planned maintenance, repair and improvement programmes. Once opportunities have been identified with the large industrial sector providers, other smaller-scale opportunities will be examined.

Table 23: Industrial sector and major utilities actions

No.	Action	Lead organisation	Partners	Timescale
30	Produce guidance and good practice examples of sustainable drainage applicable to the industrial sector	GLA		2018
31	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within Thames Water's estate	TW	GLA	2017
32	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within energy companies' estates	GLA	Utilities companies	2018

No.	Action	Lead organisation	Partners	Timescale
33	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within telecoms companies' estates	GLA	Telecoms companies	2019
34	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within the Environment Agency's estate	EA	GLA	2017

Agricultural sector

Table 24: Agricultural sector options and opportunities

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Swales	Land management grants
Storage ponds	Changes to agricultural practices
Rainwater harvesting	Wherever, cost-effective
Design for exceedance (temporary flooding of low impact land during heavy rainfall events)	Wherever, cost-effective

Although London is a relatively densely built-up city, it does have some quite extensive areas of agricultural land between the urban area and the London boundary. Most of this is protected from development by the Metropolitan Green Belt.

Whilst much of this land will drain and infiltrate naturally, modern farming practices can lead to increased rates of rainfall run-off. Most of London's tributary rivers originate or flow through these agricultural areas. As a result, agricultural drainage practices can lead to rainwater rapidly running off the land into local watercourses and lakes/ponds. This can carry a significant pollutant load from livestock and from fertilisers and pesticides applied to crops. As a result, sustainable drainage measures are valuable tools on agricultural land. They can be used to add biodiversity value to farmland, improve water quality in watercourses, and hold back potential flood waters before they reach urbanised parts of London.

There are likely to be relatively easy opportunities to implement sustainable drainage in agricultural areas. However, there are also likely to be fewer potential funding mechanisms to enable such works to take place. Most farms already have rainwater harvesting systems in place to provide water for irrigation or livestock. Also, green/brown/blue roofs are not likely to be viable on many buildings. Instead, the general focus should be on land management practices.

There has been a recent focus on a catchment management based approach to flood risk management. This approach, using natural measures is becoming an increasingly important aspect of catchment-wide planning and modern agricultural practice. Undoubtedly there will be some scope for this within the green belt areas of London. It must also be remembered that farms are commercial businesses providing the most essential of all products, food. Thus there'll be a continuing need to ensure that agricultural land can continue to be productive and not damaged by flooding.

Actions

This section sets out a programme of activities to engage with, advise and lobby the key decision makers in the agricultural sector in order to promote and deliver more sustainable drainage throughout the sector. The key theme is that retrofitting sustainable drainage should form part of already planned maintenance, repair and improvement programmes. Given the limitation of the range of measures and uncertainty over funding, these actions are focused towards the end of the engagement programme.

Table 25: Agricultural sector actions

No.	Action	Lead organisation	Partners	Timescale
35	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within agricultural estates	GLA	National Farmers' Union Farming representatives	2020

What can you do? Delivering sustainable drainage through domestic and local neighbourhood measures

Table 26: Options and opportunities for individuals

Likely sustainable drainage options	Likely opportunities to implement sustainable drainage
Water butts	Garden improvements
Raingardens and downpipe diversion	Roof repairs, extensions, community landscaping projects, garden improvements
Green/brown/blue roofs	Major roof repairs, extensions
Permeable driveways	Resurfacing of driveways, patios and other hardstanding areas

The previous sections have focused on the land uses, owners and occupiers of larger buildings, sites and areas of land in London. Yet the largest area of land coverage is that of single/small blocks of individually occupied residential homes. Each specific home or apartment block can only make a small contribution to improving the sustainability of London's drainage system. However, collectively they could make a major contribution.

Perhaps just as importantly, action at the individual/community level can help to raise awareness of and demystify London's drainage issues and the wider benefits of a sustainable drainage approach.

Sustainable drainage measures can be readily introduced in individual homes at minimal cost. Perhaps the most common example is the installation of water butts. These can easily be installed as a DIY project in most houses, and can reduce water consumption when irrigating gardens or washing vehicles. Typical water butts cost under £50 and contain approximately 200 litres. Smaller versions are also available and multiple water butts can be linked to provide additional storage. There is a growing market for more bespoke water butts that also act as decorative features, garden benches or planters. For larger gardens, there are also options to install more industrial-scale products. For a water butt to be effective in rainwater management it must be able to absorb the flow from a storm. In other words, it must not be full. One way of achieving this is to have an overflow from the water butt discharging to a flower bed or pond within the garden.

With careful design considerations, some roof downpipes can be diverted into ponds or flower beds around individual homes. Care is needed not to introduce permanently damp conditions adjacent to buildings or to change the load bearing characteristics of the soil structure around buildings. This is particularly important for older houses, which tend to have relatively shallow foundations compared to homes built under modern Building Regulations.

Over the past few decades, there has been a trend of paving over front, and to an extent rear, gardens (London Wildlife Trust, GiGL & GLA, 2010). This has led to a huge increase in the area of land draining into public sewers. Planning changes in 2008 require planning permission for new impermeable areas of front gardens, this should see this issue controlled and there is a growing availability of highly permeable hard surfacing. However it's not clear how effective this planning change is. This is especially since more areas of back gardens are being made impermeable through extensions and patios, and these often do not require planning permission.

In any case many paved garden areas already exist and these are relatively easy to convert to more sustainably drainage areas. As the paving systems/driveways become older, owners will consider renewing them. This is an opportunity to encourage, and possibly incentivise, the re-introduction of more sustainable drainage. Some London boroughs have led 'De-pave' projects to remove small areas of paving, creating landscaping opportunities and allowing more natural drainage.

Some houses and many apartment blocks have flat roofs. When the time comes for a major refurbishment or repair of those flat roofs, there will be opportunities to introduce a green/brown/blue roof. This offers associated benefits of improved insulation and long-term reductions in maintenance costs. This opportunity is covered under the earlier section for the housing sector, which is aimed at large-scale housing providers.

The Drain London partnership is leading a series of urban greening demonstration projects. These highlight how streets and neighbourhoods can be modified to provide for more sustainable drainage, whilst improving the look and amenity of residential areas. The lessons learned from these early pilots will be communicated into further programmes over the lifetime of this action plan.

There may also be opportunities to divert rainfall into small areas of landscaping or under-used land in and around local streets and estates, areas such as road and footpath verges. This plan will consider the need for a Fund for local people to suggest such areas and bid for funds to enable such areas to become more sustainably drained. It's important to remember that not all such areas may be suitable for retrofitting sustainable drainage measures, and that the landowner's consent will be required.

Table 27: Actions for individuals

No.	Action	Lead organisation	Partners	Timescale
36	Produce guidance and good practice examples of sustainable drainage applicable to the individual homes, small apartment blocks or local neighbourhoods	GLA	NGOs London boroughs	2017
37	Consider a grant/incentive scheme to encourage individuals or local communities to implement their own sustainable drainage scheme	GLA		2017

Funding opportunities and regulatory incentives

The emphasis in this action plan is to find opportunities and techniques for implementing sustainable drainage techniques that have limited financial impact. As a result, the focus is on identifying situations where other relevant works are likely to be done, This will mean any extra additional drainage works will only be a marginal part of a wider project. In some cases, there may be opportunities to save money either in direct drainage infrastructure provision or over a longer timeframe. This includes through cuts in water bills, reductions in energy costs to heat/cool buildings, and/or reductions in maintenance requirements.

There is currently a little-known mechanism where a direct financial benefit can be gained by water bill customers for disconnecting their property from mains drainage. For Thames Water domestic customers who can prove they are completely disconnected from the local surface water drainage system, there is a discount available on the sewerage element of the water bill of around five per cent. It appears that this provision is little known amongst water customers and take-up in London is minimal. A significant issue is that in a densely built-up city like London, it is generally hard for many sites to be able to store, infiltrate or use all the rainfall that falls on the site during a heavy storm. In such a case, there will be some discharge of rainwater to the surface water system. There is no proportional incentive for a partial disconnection from the drainage system.

During 2015, the government consulted on the Charging Guidance for OFWAT (Defra 2015). This considered the whole charging regime for water supply and wastewater, as well as for surface water. The consultation recognised the need to manage surface water more sustainably and supported the idea of cost-reflective charging to incentive this. However, it also recognised that parks, open spaces, and some premises with low rateable values, high public benefit, and/or large buildings could be adversely impacted by a charging system based on the area drained. Such adversely affected buildings could include community halls, places of worship, schools and hospitals. The subsequent guidance (Defra, 2016) states that the Flood and Water Management Act 2010 allows water companies to offer concessionary schemes for community groups for surface water drainage charges. The government also plans to review its 'Guidance to Water and Sewerage Undertakers in relation to Concessionary Schemes for Community Groups for Surface Water Drainage Charges'.

International experience suggests that for the retail and commercial sectors in particular, the use of financial incentives can be very effective. Philadelphia, for example, introduced a new drainage fee based on the surface area of a building or area of land. This means that any property with a large surface area, like a supermarket, that drained to the local drainage system would be faced with a large extra charge. For such cases, this approach has made it more viable to invest in sustainable drainage techniques. Indeed, the downspout disconnection programmes of Portland and Philadelphia (US) and Toronto (Canada) suggest significant investment in sustainable drainage can be justified once the bill payer is faced with far higher charges to discharge rainwater.

Other public policy/regulatory interventions may also have implications for the management of surface water. For example, anecdotal evidence suggests the increasing use of parking restrictions and controlled parking zones, combined with increases in vehicle ownership, may have led to increased numbers of front gardens being paved over. A review of wider public policy interventions is warranted to consider if there are any indirect methods of encouraging more sustainable drainage in future, or if existing policies are unintentionally reducing the take-up of sustainable drainage techniques. This will be considered as part of future reviews of this action plan.

There is also likely to be an increasing role for the non-governmental sector in promoting and encouraging the use of sustainable drainage techniques. This is expected to increase over the lifetime of this plan, as the issues become more widely understood and accepted. Similarly, it is an aim of the plan to ensure future projects funded by the GLA group will check for the inclusion of measures to make drainage systems more sustainable.

Table 28: Funding actions

No	Action	Lead organisation	Partners	Timescale
38	Examine methods of encouraging more sustainable drainage take-up through adjusting water bill incentives and Thames Water investment	GLA	TW EA	2017 onwards
39	Lobby for sustainable drainage to be included in project funding criteria	GLA group	TW	2017-2020

Monitoring

This action plan sets out an ambitious series of actions to address a topic that is not widely understood or promoted. Achieving meaningful results will be challenging and it will take several years to demonstrate real progress. It is therefore important that regular monitoring and reporting of progress is undertaken. The GLA commits to producing an annual update, reporting progress on each of the Actions. The monitoring report will be available on-line and may be linked or indeed part of other GLA monitoring activities. If necessary, the plan will be updated in line with the results of the annual monitoring, with actions amended or new actions introduced. The GLA will also consider any new metrics or methods of monitoring that might help inform progress.

The GLA will attempt to record the sustainable drainage measures that are implemented, both directly as a result of this plan and indirectly by building /land owners or via the planning system. This could potentially be a large task with multiple organisations/individuals carrying out activities. Therefore it will be challenging to maintain a comprehensive record.

Table 29: Monitoring Actions

No.	Action	Lead Organisation	Partners	Timescale
40	Produce an annual monitoring report	GLA		2017 onwards

Appendix 1: Action plan by year

This table shows the same actions already detailed by sector above, but breaks actions down by year.

No.	Action	Lead organisation	Partners	Timescale
Current / on-going actions				
3	Deliver a programme of sustainable drainage demonstration projects	TW LBs GLA Non-governmental organisations		2015 – 2020
4	Maintain a strong London Plan policy to support sustainable drainage in new development	GLA		Continuous
6	Provide strategic guidance on sustainable drainage requirements for major development locations	GLA	Partner LBs TW EA	Continuous
7	Provide detailed Integrated Water Management Plans for specific opportunity areas	Development partners	GLA EA TW LBs	Continuous
16	Identify opportunities and funding for sustainable drainage retrofit at the same	GLA	TfL	Continuous

No.	Action	Lead organisation	Partners	Timescale
	time as planned maintenance, repair and improvement works within TfL owned/managed transport assets		LU DLR London Overground	
1	Publish the results of the London-wide Sustainable Drainage Opportunity Model	GLA	TW EA LC	2016
14	Produce guidance that includes good practice examples of sustainable drainage in the streetscape public realm	TfL		2016
2	Raise awareness of the need for, benefits of and delivery of sustainable drainage within London	GLA	LBs Project delivery organisations Non-governmental organisations	2016 on
2017				
5	Collate information on Sustainable drainage delivered through the planning system	GLA	LBs	2017 on

No.	Action	Lead organisation	Partners	Timescale
8	Produce guidance and good practice examples of sustainable drainage applicable to the education sector	GLA	TW EA Local authority education depts. SuDS for Schools Susdrain	2017
9	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement public sector schools	GLA	Local authority education depts. and other publicly funded schools	2017
10	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works in higher education establishments	GLA	Higher education providers	2017
12	Produce guidance and good practice examples of sustainable drainage applicable to the housing sector	GLA	TW EA LA Housing depts. Susdrain	2017
13	Identify opportunities and funding for sustainable drainage retrofit at the same	GLA	Housing associations	2017

No.	Action	Lead organisation	Partners	Timescale
	time as planned maintenance, repair and improvement works in the socially rented housing sector		LA Housing depts. GLA Re:New	
15	Prepare a standard for retrofitting green infrastructure	LU		2017
17	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within other highway authorities' transport assets	GLA	Highways authorities Highways England	2017
18	Produce guidance and good practice examples of sustainable drainage applicable to the health sector	GLA	NHS EA TW Susdrain	2017
21	Produce guidance and good practice examples of sustainable drainage applicable to the retail sector	GLA	TW EA BIDs Susdrain	2017

No.	Action	Lead organisation	Partners	Timescale
22	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within the major supermarkets estates	GLA	Supermarkets LBs	2017
23	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within DIY and other large format retailers' estates	GLA	DIY stores and other large format stores LBs	2017
25	Produce guidance and good practice examples of sustainable drainage applicable to the open space/recreational sector	GLA	London boroughs NGOs Landscape Institute	2017
26	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works in parks and open spaces	GLA	Royal Parks Corporation of London Lee Valley Regional Park Authority London boroughs London Playing Fields	2017

No.	Action	Lead organisation	Partners	Timescale
			Association Major sports /stadia owners	
31	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within Thames Water's estate	TW	GLA	2017
34	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within the Environment Agency's estate	EA	GLA	2017
36	Produce guidance and good practice examples of sustainable drainage applicable to the individual homes, small apartment blocks or local neighbourhoods	GLA	NGOs London boroughs	2017
37	Consider a grant/incentive scheme to encourage individuals or local communities to implement their own sustainable drainage scheme	GLA		2017
38	Examine methods of encouraging more sustainable drainage take-up through adjusting water bill	GLA	TW EA	2017 on

No.	Action	Lead organisation	Partners	Timescale
	incentives and Thames Water investment			
39	Lobby for sustainable drainage to be included in project funding criteria	GLA group	TW	2017-2020
40	Produce an Annual Monitoring Report	GLA		2017 on
2018				
19	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within the NHS estate	GLA	NHS Trusts	2018
24	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within retail estate owners' proposals	GLA	Retail estate owners BIDs	2018
27	Examine local authority development proposals, capital and revenue programmes for sustainable drainage opportunities	GLA	LBs	2018
28	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within	GLA	Central government depts. and quangos	2018

No.	Action	Lead organisation	Partners	Timescale
	the central government departmental and quango estates			
30	Produce guidance and good practice examples of sustainable drainage applicable to the industrial sector	GLA		2018
32	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within energy companies' estates	GLA	Utilities companies	2018
2019				
11	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works in private sector schools	GLA	Private sector education providers	2019
20	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within the private sector health providers' estate	GLA	Health providers	2019
29	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned	GLA	Major office owners/ occupiers	2019

No.	Action	Lead organisation	Partners	Timescale
	maintenance, repair and improvement works with major office owners/occupiers		BIDs	
33	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within telecoms companies' estates	GLA	Telecoms companies	2019
2020				
35	Identify opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works within agricultural estates	GLA	National Farmers' Union Farming representatives	2020

Appendix 2: References

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