# Working with nature for improved water quality in London

**Zoological Society of London**

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## CLEAN AND HEALTHY WATERWAYS

### AIMS OF THE REPORT

In September 2024, the Mayor of London made the following pledge:

> *"London's waterways are the lifeblood of London, shaping communities, sustaining livelihoods and bringing people closer to nature. Whether you're traveling alongside our rivers, spending time on the water, or wild swimming, our rivers should be accessible to everyone. Yet, for too long, they have been neglected and damaged by pollution. That's why we are coming together to create a plan that will ensure London's waterways are clean and healthy within the next decade. We envision rivers, lakes, reservoirs, and other water sites that are vibrant habitats for nature, free from pollution, and open to all. Our vision is one where nature itself is our partner in this transformation, enhancing biodiversity and creating a sustainable environment where both people and wildlife can thrive. This is not just an environmental challenge—it is a matter of social justice. Every Londoner, regardless of where they live or their background, should have the opportunity to benefit from clean, safe, and thriving waterways. Our 10-year plan will be developed by a group as diverse as London itself, harnessing the collective effort of communities, campaigners, businesses, and government to ensure that our rivers are safe for swimming and healthy for nature."*

This report has been commissioned by the Mayor of London to contribute to the evidence base for the 10-year plan for Clean and Healthy Waterways, alongside other existing research, strategies and plans. This report was written by ZSL with the help of River Partnerships in London (RiPL) members as listed in the acknowledgements. The aim of the report is to:

1. Outline the main pollutants, their impacts and the pathways that they take to rivers and other waterbodies,
2. highlight how nature recovery can help improve the condition of waterbodies, and,
3. outline the practicalities and barriers to delivering nature-based solutions in London.

The scope of the report is waterbodies within the Greater London Authority boundary, focussing mainly on rivers but also including standing waterbodies. It excludes the tidal Thames as water chemistry in the Thames is a function of inputs that are largely outside the Greater London Authority (GLA) area, in the wider Thames catchment. ZSL's State of the Thames Report (2021) gives an overview of the condition of the tidal river through London.

### EXECUTIVE SUMMARY

Within this report we have outlined the main pollutants which are contributing to degraded water quality in London's rivers, their pathways into rivers and how nature-based solutions could help mitigate the impact of some of these pollutants, as well as the key considerations and challenges to implementing these solutions in London. Finally, we outline where Londoners can enjoy outdoor swimming. Realising the shared vision of clean and healthy waterways in London is a huge challenge that will require multiple approaches, new stakeholder partnerships and adopting new ways of tackling old problems. Working with nature to boost natural processes that remove pollutants will be an important part of a wider strategy. However, nature can only handle so much and cannot remove all contaminants. Therefore, the principal approach to cleaning London's waterways must be stopping inputs of pollution at source.

**Pollutants and their pathways**

Some of the main pollutants in London's rivers are the chemicals found in sewage and road run off. The fingerprint of chronic sewage in rivers is high ammonia, low dissolved oxygen and high phosphate levels. Road-run off includes a cocktail of pollutants such as polycyclic aromatic hydrocarbons (PAHs), spilt fuel and oil, metals, particles from tyre wear and road salt. Besides chemicals found in sewage and road run-off, there are numerous other pollutants found in rivers, such as silt, pesticides, chemicals of emerging concern, PFAS, litter, microplastics and de-icers.

Pollutants enter waterways via numerous pathways, with the major inputs including sewage treatment works, combined sewer overflows, polluted surface water outfalls and roads. There are eight sewage treatment works within the M25 and 178 permitted CSO's across North and South London operational areas. Polluted surface water outfalls are the pathway for many pollutants, including those entering because of misconnections or failing or poorly designed sewer assets. In the AMP7 period, the Thames Water Surface Water Outfall Programme identified 3403 properties with a misconnection or defect that was causing them to pollute into a waterway, which was 18% of the properties that were surveyed as part of the narrowing down process. Roads are another major pathway to pollution in London and a study that modelled 3,862.3km of London's roads found that 10% were at high risk of polluting into their nearest waterway.

**How nature recovery can help & the practicalities and challenges of implementing Nature Based Solutions (NBS)**

Nature-based solutions are increasingly being considered to solve some of the issues facing freshwater ecosystems and this report outlines the potential for them to be used within London to improve water quality. As many rivers in London have been separated from their natural floodplains and heavily modified, there is plenty of opportunity within London to restore rivers to a more natural state. In areas where there is sufficient space, river restoration in the form of reconnecting rivers to their natural floodplains, re-meandering and daylighting can not only improve water quality, but also have a range of other benefits. These benefits include flood mitigation, urban cooling and increased biodiversity. Where large scale projects are not possible, riparian planting of reeds and in-channel restoration using hydraulic structures can alter flows, increase oxygen and provide important habitat. Constructed wetlands are another effective nature-based solution that have already been implemented in London. Through the four key mechanisms of nutrient uptake, ultraviolet irradiation, sedimentation and microbial action, constructed wetlands can clean water and prevent high concentrations of pollutants entering rivers. Where space does not allow for more natural improvements, floating treatment wetlands can be used to process pollutants in standing waterbodies, such as docks.

Despite the numerous benefits, implementing nature-based solutions in London is not without its challenges. For example, there can be restricted space in urban areas where infrastructure extends right up to heavily modified riverbanks, lack of long-term funding and an unsupportive and complex policy and regulatory environment, which means that small-scale restoration projects are expected to jump through the same hoops as larger scale projects, for example when attaining Flood Risk Activity Permits. The practicalities of implementing nature-based solutions chapter outlines key challenges that the RiPL organisations have faced based on their experience of implementing NBS in London as well as the expected timelines for completing these types of projects.

**Wild swimming**
There are currently four sites within Greater London with designated bathing water status, the Hampstead Heath ponds and the Serpentine Lake in Hyde Park. Changes are currently being made to the regulations surrounding bathing water designations, with DEFRA applications for designation opening again on 12th May 2025.

Water quality is a key factor when considering the swimmability of London's rivers, although some areas of London's rivers will never be swimmable even with improvements in water quality, particularly the tidal Thames, due to strong tides, busy boat traffic, eddies and underflows.

## Summary of key recommendations
Below is a summary of the key recommendations from this report which have been workshopped and agreed by members of RiPL.

**CIWEM CSO recommendations**
1. Water companies to deploy a hierarchy of catchment-wide measures to reduce storm overflows, prioritising nature-based solutions and active system management over underground storage.
2. Government to implement Schedule 3 of the Flood and Water Management Act 2010, including mandatory multifunctional SuDS (Sustainable Urban Drainage Systems) standards, a conditional right to connect development to public sewers and a route to adoption and long-term maintenance.
3. Strong regulation by Ofwat and the Environment Agency for PR24 and beyond.
4. Government to ban plastic in wet wipes.
5. Government to review the barriers and feasibility to implementing area-based charging for surface water drainage.
6. Water Company and lead local flood authorities to hydraulically model key catchments to identify optimal opportunities to retrofit distributed SuDS.
7. Government to review funding sources and rules to enable grant funding to be pooled and drawn down opportunistically over a period of time.
8. Water Company to create partnership funding pots for use with local authorities on retrofit SuDS schemes where flood risk is not the primary driver.
9. Establish a legal duty on highways authorities to seek opportunities to manage highway runoff through SuDS when undertaking other infrastructure or renewal works. *
10. Local authorities to develop infrastructure coordination services to enable synchronised and coordinated delivery, including of SuDS (CIWEM 2022).

*After RiPL consultation we would also add to this recommendation that as well as duties for highway authorities, local authorities should also incentivise or require rainfall to be managed within private properties via: 1) de-paving of front and back gardens so they are genuinely permeable 2) capture of rainwater from roofs, via rain gardens/planters/smart water butts; 3) installing green/blue roofs.

**Key recommendations for polluted surface water outfalls**
1. Long term investment needed to upgrade London's sewer network
2. At least a doubling of effort and increased in investment by Thames Water in tracing, identifying and fixing the causes of PSWOs.

3. Clarify or update policy and legislation related to the enforcement of misconnection rectification.
4. Develop an accurate map of outfalls in London – each outfall will have a unique identifying reference number and ownership details. Records to be kept of each outfall's pollution history to build a picture of pollution hotspots and repeat offenders across London and the targeting of remediation action and communications campaigns on sewer abuse.
5. Sufficient resourcing of the Environment Agency to support investigation and enforcement action in the cases of PSWOs that are not owned by Thames Water.
6. As a matter of urgency support enforcement of the rectification of identified misconnections. Prioritise legal pressure on the blocks of flats and other properties of multiple occupancy that have been known to be polluting for a number of years.
7. Legislation is needed to incorporate drainage checks at the point of sale of a property in Greater London to ensure they are correctly plumbed in.
8. Ensure mandated in-person checks of drainage during design and build of new developments to avoid new misconnections being added to the system.
9. Increased awareness and communications campaigns across London to stop the wrong things going down the drain and blocking sewers or being put into surface water drains.
10. Research required to review and update findings on misconnections using data from over ten years of Thames Waters SWOP.

**Key recommendations for roads**

1. National Highways and Transport for London and local highways authorities to initiate an intensive retrofit of roadside interventions that trap pollutants at sources, before they enter rivers.
2. Development of consistent approaches between the wide range of outfall owners across London.
3. Reduce traffic volumes and move to cleaner forms of transport.

**Key recommendations for improving pollution investigation and enforcement**

1. Review Environment Agency policy and practice in London to ensure they are adequately resourced and have the mandate to respond to both Category 1 and 2 pollution incidents and where necessary, investigate sources of pollutions and take enforcement action against polluters.

**Key recommendations for recovering nature for cleaner water**

1. Focus on re-naturalising and restoring rivers by working with catchment partnerships to a) identity engineered river reaches in each catchment that can be restored, and b) prioritise at least five locations for constructed wetlands in each catchment.
2. Ensure adequate support for hosting organisations to deliver catchment-based improvements through a partnership approach – this support being both financial and through engagement by all interested parties.
3. Review Thames Water's data on buried watercourses and make it available to the public via the river restoration map. Identify and prioritise river and stream daylighting opportunities across London and set up a task force to make these projects happen in the next five years.
4. Resource an officer to develop and facilitate links between RiPL members and local authorities. Local authorities that need extra capacity and skills will be supported to develop river restoration and wetland creation schemes.
5. Local authorities to prioritise river recovery and nature-based solutions in local plans. Local plans should reference catchment plans.
6. Establish and manage a significant long term blended funding stream to support waterway recovery and the creation of nature-based solutions.

7. Work with Government to ensure that any fines (including through prosecution) are directed back to the catchment that was damaged. Focusing fines on NBS would help ensure the ecosystem recovers and is more resilient to future pollution.

**Key recommendations for species**

1. Work with the London Beaver Working Group to identify additional suitable sites and associated organisations capable of introducing and managing Beaver releases.
2. Sustain the existing Riverfly Monitoring schemes, that uses invertebrates as indicators of river condition, and support spread of the method, to all rivers in London and, linked to the monitoring plan, integrate invertebrate data into the annual State of London Waterways report.
3. Support partners in the London Water Vole Recovery Programme to restore and monitor the return of lost populations of water vole to all rivers in London where habitat quality and connectivity will support them.

**Key recommendations for monitoring**

1. Codevelop a monitoring strategy and plan with NGOs and communities across London. The strategy, which will allow us to track progress on the delivery of the Clean and Healthy Waterways plan, must include key water quality indicators.
2. Create a funding stream to support long term, systematic delivery of the water quality monitoring plan and reporting progress against codeveloped indicators.
3. Develop a London rivers evidence dashboard and keep updated with the latest data or produce a concise and accessible annual State of London Waterways report to check the evidence and progress annually against targets in the Clean and Healthy Waterways plan.

**Key recommendations for social change**

1. Inspire change by communicating the vision for Clean and Health Waterways and raise the profile of the opportunities and benefits of restoring waterbodies across the capital by working in partnership with catchment partnerships.
2. Increase awareness and education on how local communities can contribute to positive social catchment solutions by adapting their behaviours. Demonstrate how local communities can help through their own activities such as volunteering and monitoring.
3. *Increased awareness and communications campaigns across London to stop the wrong things going down the drain and blocking sewers or being put into surface water drains.

   *This recommendation is repeated from the recommendations on outfalls

# POLLUTANTS IN LONDON'S RIVERS AND EVIDENCE OF THEIR IMPACTS


Figure 1. Major rivers in London (ZSL)

Approximately 600km of rivers and streams flow through Greater London to the Thames (Figure 1) (Mayor of London 2025a). Despite the targets set out in The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 to achieve good ecological and chemical status in all surface water bodies by December 2021, in 2025, no rivers within London are currently at good chemical or ecological status (GOV.UK 2024a). Water Framework Directive objectives state that Good Ecological Status (GES) or Good Ecological Potential (GEP) should be achieved by the end of 2027 at the latest, but England are currently not on track to achieve that target either (GOV.UK 2024b).

Ecological status is assigned using various water, habitat and biological quality tests and waterbodies are classified as high, good, moderate, poor, or bad. Chemical status is calculated by assessing 52 different chemical elements and waterbodies are classified as good or failing (GOV.UK 2025a; DEFRA 2023). Within this section we discuss chemical pollutants from a range of sources and their impacts on waterbodies.

## SEWAGE

Sewage principally enters London's waterways through consented discharges such as combined sewer overflows and surface water outfalls that become polluted from the foul sewer network.

For human health the main concerns with sewage entering rivers are related to E. coli and other disease-causing bacteria. Ingestion of these bacteria can cause gastrointestinal infections.

The impact of sewage on the natural environment can be both acute as a pollution event, or chronic, where multiple smaller inputs degrade nature in rivers and other waterbodies over time. When sewage enters a river, the increase in bacteria and other microorganisms draws oxygen out of the water. Severe crashes in oxygen availability during sewage pollution events kill wildlife. As sewage breaks down it releases ammoniacal nitrogen and phosphate. One form of ammoniacal nitrogen, ammonia, is toxic to river life and is found at high concentration in sewage contaminated water (Trach *et al.* 2024). High ammonia concentrations result in fish kills and reduced diversity in local aquatic invertebrates (Johnson *et al.* 2019). The fingerprint of chronic sewage in rivers is elevated nutrient pollutants such as phosphate and low oxygen, the impacts of which are the general breakdown of aquatic ecosystems (Cooper *et al.* 2022; Albini *et al.* 2023).

Ammonia, dissolved oxygen and phosphate concentrations are influenced by sewage entering waterways and are three of the physico-chemical quality elements that are used to assess the ecological status of a river (Environment Agency 2023). Environment Agency data shows that London's rivers are failing to reach 'good' ecological status, with 21 rivers at 'moderate' ecological status, 6 at 'poor' ecological status and 1 at 'bad' ecological status (Table 1). Phosphate is fairly consistently at poor status across catchments, with 24 rivers with a status of 'poor', 2 'bad', 1 'moderate' and only 1 'good' and 1 'high'. Dissolved oxygen is more variable, with 4 at 'bad' status, 5 'poor', 1 'moderate', 6 'good' and 12 'high'. Of the three elements, Ammonia had the most 'high' status rivers at 18.

**Rivers of particular concern for ammonia, dissolved oxygen and phosphate are the Moselle Brook, Pymmes Brook and Salmons Brook in the Lea catchment and all the rivers in the Brent catchment.** This aligns with ZSL Outfall Safari data that shows a high number of Polluting Surface Water Outfalls (PSWO) per km for both the Brent (3-3.8 PSWO per km) and the Lea (1-2 PSWO per km).

In some areas the long-term trends are concerning, for example Environment Agency data shows a 20-year trend of decreasing oxygen availability and increasing ammonia concentration in both the Yeading Brook East and West in the London Boroughs of Hillingdon and Harrow (CVP 2022).

A study conducted on the Thames near Swindon, showed how rivers can quickly recover when sewage pollution decreases. A seven-fold decrease in ammonia was achieved through improved processing at the Sewage Treatment Works (STW). This resulted in improved concentrations of dissolved oxygen in the river and a sustained improvement in the presence and numbers of the less pollution tolerant invertebrate species (Johnson *et al*. 2019).

**Table 1. Data from Thames River Basin District Catchment Data Explorer 2022 survey results. The colour of the cell in the river column shows the overall ecological status of the waterbody** (Key: blue = high status, green = good status, yellow = moderate status, orange = poor status, red = bad status) **(Environment Agency 2023).**

| CATCHMENT | RIVER | AMMONIA | DISSOLVED OXYGEN | PHOSPHATE |
|---|---|---|---|---|
| Brent | Dollis Brook | Moderate | Bad | Poor |
| | Lower Brent | Moderate | Poor | Poor |
| | Silk Stream & Edgware Brook | Moderate | Poor | Poor |
| | Wealdstone Brook | Bad | Poor | Poor |
| Beverley Brook | Beverley Brook | High | Good | Poor |
| Crane | Crane | High | Good | Poor |
| | Portlane Brook | High | High | Moderate |
| | Yeading Brook | Poor | Bad | Poor |
| Hogsmill | Hogsmill | High | High | Poor |
| Lea | Ching Brook | Poor | Moderate | Poor |
| | Cobbins Brook | High | High | Poor |
| | Lea Navigation (Fieldes Weir to Enfield Lock) | High | High | Poor |
| | Lea Navigation Enfield Lock to Tottenham Locks | High | High | Poor |
| | Lee (Tottenham Locks to Bow Locks/Three Mills Locks) | High | Good | Poor |
| | Moselle Brook | Bad | Bad | Bad |
| | Nazeing Brook | High | Good | Bad |
| | Pymmes Brook upstream Salmon Brook confluence | Bad | Poor | Poor |
| | Pymmes and Salmon Brooks - Deephams STW to Tottenham Locks | High | High | Poor |
| | Salmon Brook upstream Deephams STW | Poor | Poor | Poor |
| | Small River Lee (and tributaries) | High | Good | Poor |
| | Turkey Brook and Cuffley Brook | High | High | Poor |
| Marsh Dykes | Marsh dykes | Moderate | Bad | Poor |
| Ravensbourne | Ravensbourne (Catford to Deptford) | High | High | Poor |
| | Ravensbourne (Keston to Catford) | High | Good | Good |
| | Quaggy | High | High | Poor |
| | Pool River | High | High | Poor |
| Wandle | Wandle (Carshalton branch at Carshalton) | High | High | High |
| | Wandle (Croydon to Wandsworth) and the Graveney | High | High | Poor |

## ROAD RUN OFF AND URBAN DIFFUSE POLLUTION

Run off from roads and other hard surfaces contains a mixture of chemicals that are potentially harmful to the environment and to human health, these include; polycyclic aromatic hydrocarbons (PAHs) and other hydrocarbons from exhausts and spilt fuel and oil (Markiewicz *et al.* 2017), metals such as zinc and cadmium (Huber *et al.* 2019), particles from tyre wear (Baensch-Baltruschat *et al.* 2020), and salts that are applied to road surfaces for maintenance (Hintz and Relyea 2019). Some of the chemicals associated with roads carry significant potential risk to public health (Soltaninia *et al.* 2024).

The impacts on rivers of pollutants washed into them from roads and other hard surfaces is very complex. The effects on the receiving waterbodies can be both acute and chronic. Acute impacts are most often witnessed during summer storms after prolonged periods of dry weather when river levels are low. Materials that have built up on the roads are washed into rivers in one quick 'first flush'. High pollution loadings arriving very rapidly can lead to the swift depletion of oxygen in the receiving river that can kill fish in large numbers. The long-term impacts of the other chemicals that often become bound to river sediments is currently poorly understood.

A 2023 Mayor of London and ZSL funded project led by Thames21 and Middlesex University modelled likely concentrations of road pollutants entering rivers to help identify the sections of London's roads that are likely to contribute the most to river pollution. The summary of the project and its findings are available here - road runoff pollution decision support tool (Thames21 2020). The modelling produced a risk assessment of pollution from roads and a decision support tool to identify which broad type of nature-based solutions can resolve the pollution. Modelling was used in the project as the intermittent nature of road run off pollution i.e. when it rains, and the variety and low concentrations of chemicals involved can make direct measurement and quantification of pollution loading of an individual road drain difficult and expensive. Two recent studies using direct measurement have evidenced the issue of road pollutants in river sediments.

A ZSL led study on the Frogs Ditch (ZSL 2021a), a small tributary of the River Crane in the London Borough of Hillingdon, showed total PAH concentrations to be greater downstream of the M4 than upstream. Most individual PAHs were above both the 'Probable' and 'Interim' guidelines, indicating a marked pollution problem.  Based on the results, the Frogs Ditch outfall from the M4 was identified as a priority A (very high) outfall for National Highways. Brierley (2013) showed sediments in the River Wandle are contaminated to above the 'Lowest Effect Level' for multiple heavy metals and for certain contaminants (copper, lead) are above 'Severe Effect Levels'.

## SEDIMENT

Most rivers in London are surrounded in reaches by roads and other impermeable surfaces which can make them more susceptible to flashy responses to rainfall. Water moving rapidly off hard catchment surfaces often has particularly high inputs of sediment, and this sediment is more frequently resuspended in the river channels (Kemp *et al*. 2011; Taylor and Owens 2009). Sediment washed into urban rivers can contain organic matter, concentrations of metals, pharmaceutical products, pesticides, herbicides, hydrocarbons, Polychlorinated biphenyls (PCBs), PAHs, dioxins and radionuclides (Taylor and Owens 2009). All chemicals mentioned in the section 'Road run-off and urban diffuse pollution' are relevant here, as road run-off is a significant contributor to sediment in urban rivers. Also, within London, some rivers are impacted by agricultural sediment loads, which can include faecal pathogens, metals, nutrients, and fertilisers amongst others. Sediment load can also be increased by bank erosion from poaching by agricultural livestock and pet dogs.

In a study that monitored run off from 15 outfalls across London, van Biervliet (2015) showed that the Total Suspended Solids (TSS) loadings in the samples taken after rainfall regularly exceeded the 25 mg/l threshold set by the European Union Freshwater Fish Directive (78/659/EC). Of the 15 outfalls measured, a site named the A240 Rock Ramp on the **river Hogsmill was the highest contaminator**, contributing to two orders of magnitude increase in TSS in the river from <0.5 mg/l to 180 mg/l during peak flows.
As well as causing pollution at the point of entry, high levels of suspended solids washed into rivers can travel a great distance downstream, causing a range of negative impacts on aquatic life (van Biervliet 2015). Sediment can smother and compact gravels, reducing oxygen as well as the available habitat for invertebrates and fish (Kemp *et al*. 2011). More specifically, sediment can have a detrimental effect on fish. Spawning is impacted by it blocking gaps in gravels and reducing oxygen supply to eggs and it can also cause gill irritation, reduce swimming performance, and change blood physiology (Wildfish 2017).

Sediment accumulating over time results in a build-up of pollution concentration in both the riverbed and within animals and plants living within the river. Contaminants can combine and form complex mixtures that can exacerbate their harmful impacts on river ecosystems. Pollutant accumulation in sediment may result in sediment beds that have much higher concentrations of pollutants than the surrounding water, which can be particularly harmful for benthic invertebrates and bottom living fish and means they are at risk of both dissolved and sediment bound pollutants (Thellmann *et al*. 2017).

## OTHERS

### Pesticides

There is an increasing amount of evidence on the impact of pesticides on rivers in the UK. Pesticides can contain chemicals such as fipronil, fipronil sulfone, fipronil sulfide (collectively known as fiproles) and imidacloprid (Perkins *et al.* 2021). In a risk-ranking for surface waters in England, fipronil was identified as the top-ranked organic chemical of concern (Spurgeon *et al*. 2022), and imidacloprid was recently identified as one of the highest risk chemicals of concern across the Thames catchment (Egli *et al.* 2023).

Hampstead Heath ponds, ponds where dogs swim were found to have exceeded environmental toxicity thresholds for imidacloprid and fipronil (Yoder *et al.* 2024).

There is extensive evidence to demonstrate the toxicity of Fipronil and imidacloprid to terrestrial organisms, but there are far fewer studies on the impacts on aquatic organisms (Pisa *et al.* 2015). Although some studies have shown Fipronil and imidacloprid to be toxic to aquatic species such as freshwater mussels, fish and invertebrates (Arslan and Günal 2023; Gibbons *et al.* 2015), further research is required to understand the full extent of the threat of these chemicals to aquatic organisms in rivers (Pisa *et al.* 2015).

### Chemicals of emerging concern (CECs)

The Water Framework Directive lists 45 chemicals as “priority substances” for regulation and monitoring and has a watchlist of 26 chemicals of emerging concern (CECs), which are chemicals which require urgent research into their occurrence and environmental impacts (for the full list see Appendix A) (Egli *et al.* 2023).

A study which sampled for chemicals of emerging concern (CECs) in London's rivers, found that the top five compounds found were pharmaceuticals such as salicylic acid, carbamazepine (antipsychotic/antiepileptic drug), clarithromycin (antibiotic), tramadol (opioid analgesic), and diclofenac (anti-inflammatory drug). Of all CECs measured in freshwaters, high risk to aquatic life was evident, in decreasing order, for imidacloprid (pesticide), azithromycin (anti-biotic) and diclofenac (anti-inflammatory drug) (Egli *et al.* 2023).

### Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) are synthetic chemicals used in numerous everyday consumer products. As well as being used in food contact materials to provide resistance to fat and humidity, and to provide non-stick properties (Ramírez Carnero *et al.* 2021), they are also found in cosmetics, paints, sealants, paper and packaging, electronic devices and more (Glüge *et al.* 2020). Exposure to PFAS has been linked to a wide range of human health concerns, such as cardiovascular and cancer risks (PSAP 2024) and there are concerns of human exposure to PFAS via drinking water, although evidence from the UK is lacking (Royal Society of Chemistry 2023).

Bioaccumulation of PFAS has been demonstrated in several aquatic species and has been shown to alter gut microbiome composition and has led to increased risks of neuro developmental, cardiovascular and metabolic disorders (Nayak *et al.* 2023). However, very few of the PFAS are studied in environmental concentrations and there are few studies on the effects of PFAS on aquatic animals (Banyoi *et al*. 2022).

### Microplastics

A study by Whitehead *et al*. (2021) found that the amount of microplastic concentrations within the river Thames are significant. Once microplastics enter the waterways they are practically impossible to remove and will remain indefinitely. The most common polymers in samples found in a study by Rowley *et al.* (2020), were polyethylene and polypropylene. The toxicological effects of ingestion of microplastics by aquatic organisms requires more research (Rowley *et al.* 2020).

### Glycol and other de-icers

De-icers can contain glycol-based fluids often used at Airports and which are toxic to the environment and to aquatic life (Kent *et al.* 1999; Sulej *et al.* 2021).

De-icing road salt is composed of sodium chloride which can impact the life stages of different aquatic species and have a negative impact on aquatic ecosystems (Findlay and Kelly 2011).

## PATHWAYS AND MANAGEMENT

In this section we describe how pollutants enter rivers and other waterbodies and aspects of the current management of those pathways. It is essential that we understand how pollutants enter waterways and where the current gaps in management are so that we can prioritise the right actions to prevent pollution.

### Sewage treatment works

There are eight sewage treatment works within the M25 that serve ninety nine percent of the GLA population (Thames Water 2100 plan). These are:

- Beckton Sewage Treatment Works
- Beddington Sewage Treatment Works
- Crossness Sewage Treatment Works
- Deephams Sewage Treatment Works
- Hogsmill Sewage Treatment Works
- Long Reach Sewage Treatment Works, Dartford
- Mogden Sewage Treatment Works
- Riverside Sewage Treatment Works, Rainham

Discharges from Sewage Treatment Works (STW) must comply with requirements set out in legislation and environmental permits, but the permit conditions are specific to each STW (Ofwat 2024). According to the Thames Water 2025-2030 Drainage and Wastewater Management Plan, if management continues as it is currently, all eight treatment works that serve Greater London are at risk of operating at or above their permitted levels. Since 2019, there have been microbial breaches, specifically coliform detections, at seven large water treatment works serving London: Ashford common STW, West London, Coppermills STW, East London, Kempton STW, West London & Hampton STW, West London, highlighting the need to address water ingress at these sites (Thames Water 2024a).

A 2024 investigation by OFWAT into STWs and sewerage networks found that Thames Water had failed to ensure the sufficient performance of its sewage treatment works in terms of design, construction, operation, and maintenance to ensure that spills only occur in exceptional circumstances (OFWAT 2024).

The Thames Water five year plan (2025-2030) indicates that Thames water have not yet completed a number of STW upgrades proposed in the last business plan in the Water Industry National Environment Programme (WINEP ) and these are carried over to the next Asset Management Period (AMP), the most relevant to London are Maple Lodge and Hogsmill STW (Thames Water 2025b).

### Combined Sewer Overflows (CSOs)

CSOs are permitted to temporarily discharge untreated sewage into waterways when the sewerage system is at risk of becoming overwhelmed. This can happen during heavy downpours, or when there are sewer blockages or equipment failures. This is regulated by the Environment Agency under The Environmental Permitting (England and Wales) Regulations 2016.

The number of permitted CSOs within the Thames Water operational areas of North and South London is 178. This figure includes storm discharges from STWs, Sewage Pumping Stations (SPSs), and network CSOs. Real-time information on storm over-flow activity is available on the Thames Water Even Duration map.

Since December 2023, it has been a legal requirement for water companies to install Event Duration Monitors (EDM) on all storm overflows (Environment Agency 2024). According to the EDM data from Thames Water, in 2023 there were 619 active storm overflows within the Thames Water area, of which 610 had spill data. Lack of spill data can be due to EDM not being operational or if the water company has not reported the spill data in the annual return. **On average across 2023, there were 27.9 spills per CSO and per spill event, there was an average spill time of 11.6 hours from each CSO.**

EDM monitors only measure the start and end time of flow, not the volume of flow, so the amount of pollution that is being emitted during these spills is unknown. The impact will also vary depending on the volume of the receiving water course and dilution ability.

An issue with CSO's is that Thames Water's mapping of surface water systems is incomplete (Thames Water 2023a; Thames Water 2023b). This means there could be unknown locations that are discharging as CSOs but without a permit of monitoring and therefore not contributing to the official statistics.

Monitoring is showing that CSOs across England are discharging sewage outside of the weather events they are permitted to, in times where there is normal or no rainfall (CIWEM 2022). Giakoumis and Voulvoulis (2023) analysed EDM data, considering the type and location of CSOs and the sewerage networks they are connected to and found that "chronic undercapacity" of wastewater systems is one of the main causes behind the increased frequency and duration of CSO spills in England.

To prioritise rectification of CSOs, the Environment Agency and water companies developed the Storm Overflow Assessment Framework (SOAF). Stage 1 of this network assesses the reason for the overflow having exceeded spill frequency triggers, which comes under exceptional rainfall, maintenance issues or insufficient hydraulic activity. Asset maintenance is listed as a reason for high spills at a large number of CSO's, associated with 60% of high spilling sites in 2021, 38.7% in 2022 and 40.4% in 2023. Once asset maintenance is identified as the cause, these CSOs are removed from the SOAF process and water companies are expected to carry out the required maintenance and resolve the issue in a timely manner. However, Environment Agency spill data indicates that these maintenance issues are not being rectified quickly enough and are continuing to contribute to overspilling in subsequent years (OFWAT 2024).

Giakoumis and Voulvoulis (2023) concluded that the power to resolve the issues lies with the water companies and there is a need to invest and extend water infrastructure. However, it has been proposed in a report by the Chartered Institution of Water and Environmental Management (CIWEM) (2022) that water company only solution could risk investing water-bill payers' money without addressing the root causes of the issue. There are multiple factors that have led to the increased flow of sewage and rainwater into sewer networks, and whilst water companies will need to play a leading role in rectification, there are opportunities for actions to be taken elsewhere, involving other organisations, that could reduce the amount of costly investment needed by water companies (CIWEM 2022). As there is such a strong influence of surface water run-off on storm overflow discharge frequency, organisations that have a role in flood risk management and/or the development of roads, buildings and other hard surfaces, such as local flood authorities, highways agencies and local planning authorities, should also be involved in delivering solutions.

**Recommendations to reduce discharges from CSOs**

In 2022, CIWEM made the following 10 recommendations to enable solutions to reduce discharges from CSOs:

1. Water companies to deploy a hierarchy of catchment-wide measures to reduce storm overflows, prioritising nature-based solutions and active system management over underground storage.
2. Government to implement Schedule 3 of the Flood and Water Management Act 2010, including mandatory multifunctional SuDS (Sustainable Urban Drainage Systems) standards, a conditional right to connect development to public sewers and a route to adoption and long-term maintenance.
3. Strong regulation by Ofwat and the Environment Agency for PR24 and beyond.
4. Government to ban plastic in wet wipes.
5. Government to review the barriers and feasibility to implementing area-based charging for surface water drainage.
6. Water Company and lead local flood authorities to hydraulically model key catchments to identify optimal opportunities to retrofit distributed SuDS.
7. Government to review funding sources and rules to enable grant funding to be pooled and drawn down opportunistically over a period of time.
8. Water Company to create partnership funding pots for use with local authorities on retrofit SuDS schemes where flood risk is not the primary driver.
9. Establish a legal duty on highways authorities to seek opportunities to manage highway runoff through SuDS when undertaking other infrastructure or renewal works. *
10. Local authorities to develop infrastructure coordination services to enable synchronised and coordinated delivery, including of SuDS (CIWEM 2022).

*After RiPL consultation we would also add to this recommendation that as well as duties for highway authorities, local authorities should also incentivise or require rainfall to be managed within private properties via: 1) de-paving of front and back gardens so they are genuinely permeable 2) capture of rainwater from roofs, via rain gardens/planters/smart water butts; 3) installing green/blue roofs.

**Polluted surface water outfalls (PSWOs)**

Much of outer London is served by a separate drainage system (Figure 2). Foul sewers take sewage to a STW and surface water flows via the surface water network to the nearest watercourse. If there are cross overs between the foul and the surface then the point of discharge of the surface water sewer, the outfall, will become polluted and termed a PSWO. Crossovers between the foul and surface water system can be caused by misconnections, blockages or failing and/or badly designed assets, each of which are outlined in more detail in the sections below. In areas of separate drainage, surface water outfalls are also the pathway for a range of other pollutants such as road run off and any chemicals that are washed down surface water drains from activities such as bin, car and window washing.

Up until 2015 there had been no systematic way of surveying and reporting PSWOs to the asset owner for remediation. ZSL, working within the Citizen Crane project, responded to this evidence gap by developing the Outfall Safari community science programme. Outfall Safari volunteers are trained to identify and score outfalls during river walk over surveys based on any visible evidence of pollution (Figure 3). Scores from 0 to 20 are used to rank outfalls, with higher scores indicating higher levels of visible pollution.

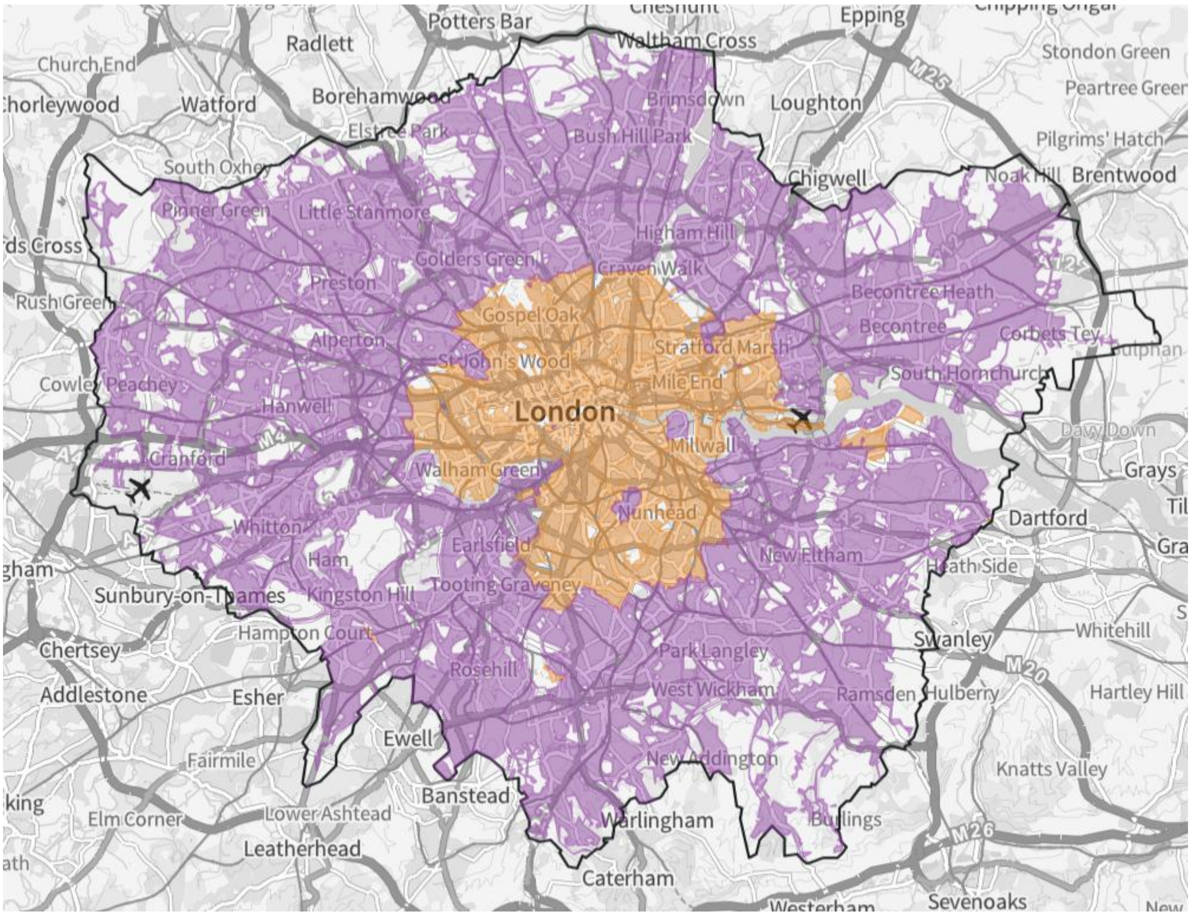

Figure 2. River Health Map showing the areas within Greater London served by combined or separate sewers. Purple = separate sewers, orange = combined sewers (Mayor of London 2025b).

Figure 3. Outfall scoring 20 identified on the lower Brent during ZSL Outfall Safari (Credit: ZSL).

Since 2018 the programme has been funded by Thames Water and surveys every river in London on a four-year rotation.  Assessments of 4465 outfalls have been completed. Most outfalls assessed were non-polluting. In total, 23% of assessed outfalls have shown some sign of visible pollution (scores 4+). Outfalls that are deemed **highly polluting (scores ≥10)** account for 4% of outfalls found. A breakdown of the results from individual London rivers and years are shown in Figure 5. Data from the Outfall Safaris are passed onto Thames Water, the Environment Agency and catchment partnerships for follow up action to remove sources of pollution.

Since 2016 the Outfall Safari programme has:

- Surveyed over 671 km river in London
- Conducted 4465 outfall assessments
- Identified 638 polluting outfalls (≥6)
- Identified 162 outfalls identified that were highly polluting (≥10)
- Seen on average across London of one PSWO (score ≥6) per km of river surveyed
- Engaged 490 volunteers

Looking at the density of polluting outfalls within London catchments (outfalls with a score of ≥6), the lower Brent (2023), Beverely Brook (2024), Dollis Brook (2017 & 2022) had some of the highest number of polluting outfalls per km surveyed. **The Edgware brook Outfall Safari has the highest density, 3.8 polluting outfalls per km, compared to the next highest at 2.3 outfalls per km** (Dollis Brook 2022) (Figures 4&5).

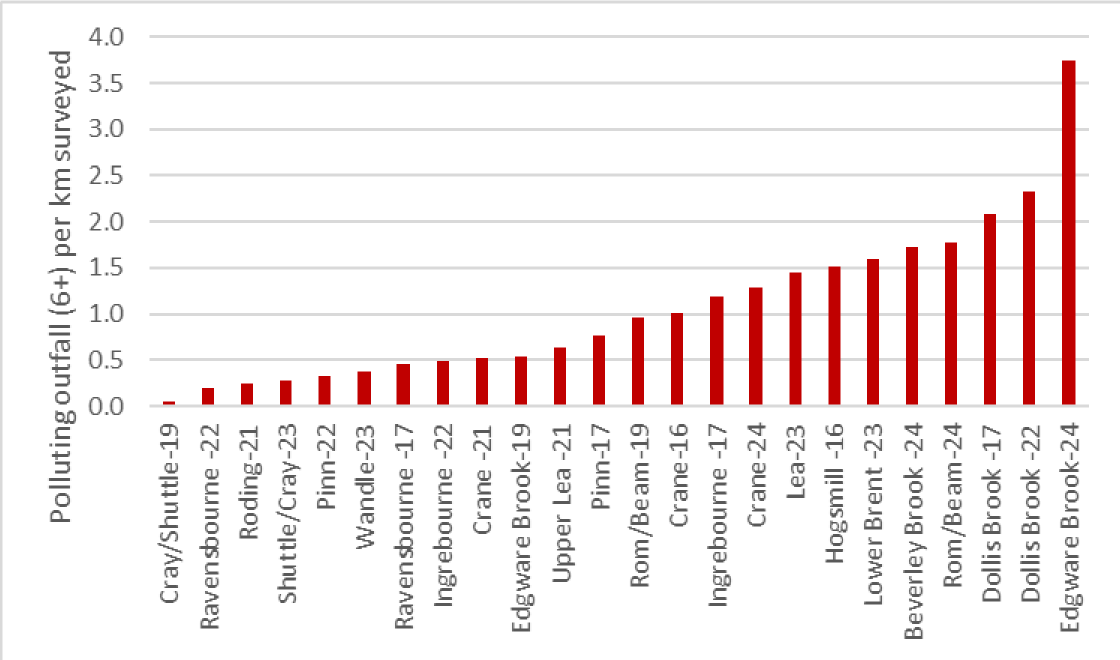


Figure 4. The density of polluting outfalls (≥6) identified during the London outfall safaris, as measured by number of polluting outfalls divided by the length of river surveyed in each respective survey.

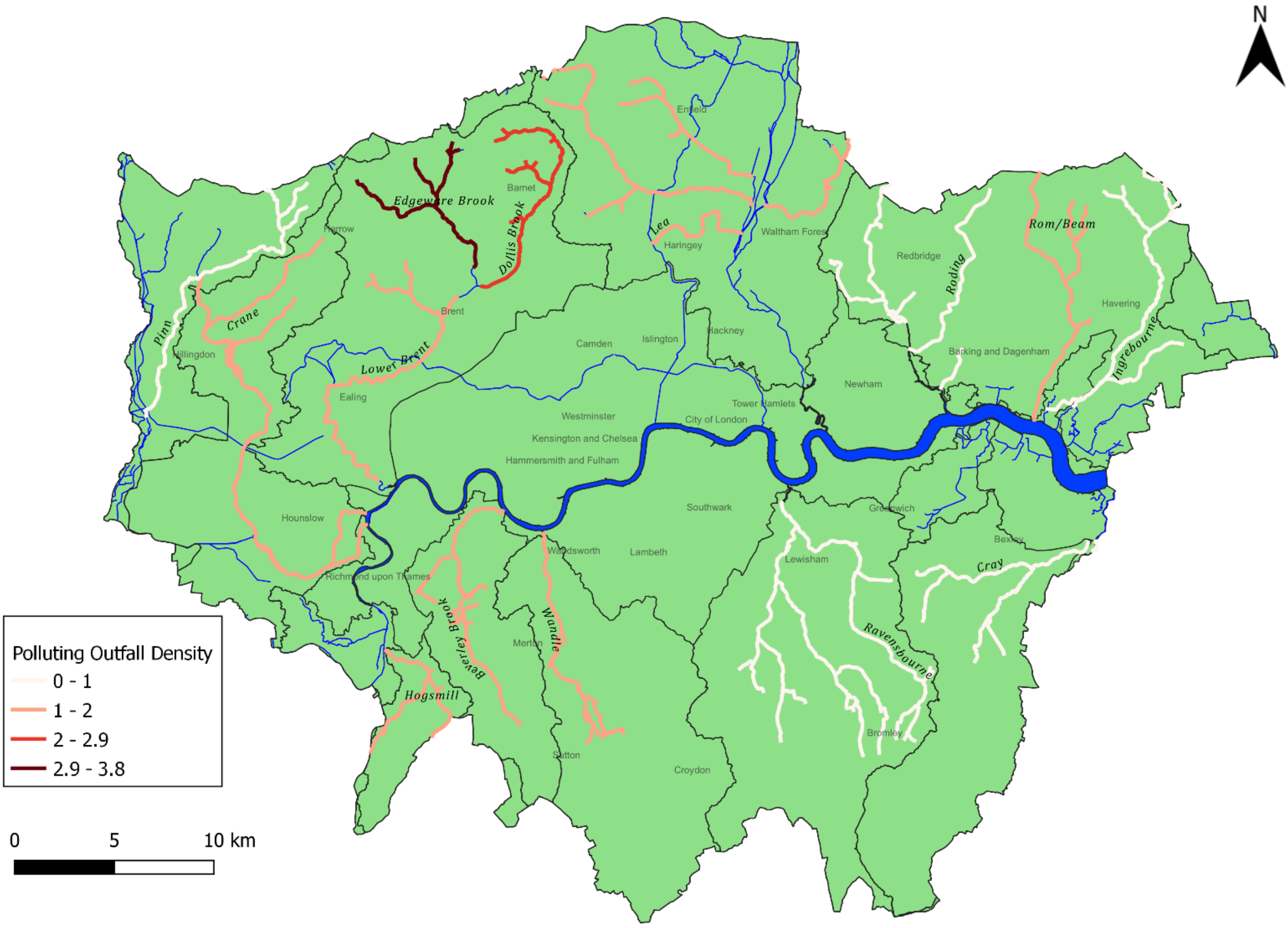


Figure 5. The density of polluting outfalls (≥6) identified during the London Outfall Safaris, as measured by number of polluting outfalls divided by the length of river surveyed in each respective survey.

**Misconnections**
Misconnections can occur two ways, surface water into the foul, which causes surcharging of the sewer network and can lead to CSOs discharging, and foul to surface which discharges sewage and other pollutants into rivers via outfalls (Ellis and Butler 2015). The misconnection rate in London is estimated at around 3-5% of properties (Ellis and Butler 2015). Misconnections to the surface sewers scale between single domestic appliances to whole blocks of flats, as has recently been brought to the attention of the press by Friends of the River Crane Environment (FORCE) and Clean Up the River Brent (CURB) (BBCNews 2024).

The Thames Water Surface Water Outfall Programme (SWOP) team were established to remove misconnections from their network. They follow up on reports of PSWOs from members of the public which largely now come from Outfall Safaris. The SWOP team will take action to remediate their outfall assets. It should be stressed however that ownership of outfalls is often unclear. We understand that Thames Water own a significant proportion of Surface Water Outfalls in London. The remainder of the outfalls are Environment Agency, Highways Agency, local authority or privately owned. **PSWOs that are not Thames Water assets are currently not being investigated by the Environment Agency**.

The SWOP results from Thames Water's Asset Management Period (AMP) 7 (2020-2025) are shown in Table 2 (Barry 2024. Personal communication).

**Table 2. AMP7 SWOP results from Thames Water**

| AMOUNT | SWOP ACTION |
|---|---|
| **194** | Outfalls significantly improved so far and signed off by Environment Agency (minimum AMP target 200) |
| **3403** | Properties with misconnections/defects – 18.8% rate per property surveys (after narrowing down network) |
| **7385** | Individual misconnected appliances |
| **18915** | Properties surveyed |
| **48432** | Total visit attempts |

The Building Regulations 2010 state that an adequate system of drainage shall be provided to carry foul water from appliances within the building to either a public or private sewer or a septic tank or cesspool where appropriate (The Building Regulations 2010). On new-built properties, Building Control (Local Authority Building Control (LABC) or Registered Building Control Approvers (RBCAs)), sign-off connections to the sewage network, which they are required to assess against the Drainage and waste disposal guidance of the Building Regulations 2010. However, checks can end up being a check on the connection itself rather than a check of the connection drainage, resulting in inefficiencies in the compliance process (Ellis and Butler 2015).

Policy around misconnections is also unclear which is hampering their rectification.  Once a misconnection is found if the issue is not rectified voluntarily after a letter from Thames Water legislation gives powers of enforcement to both Thames Water and local authorities. The widely accepted process is that local authorities will enforce rectification. Some local authorities legitimately question this process, and others cite lack of resource for not enforcing rectification. An Environmental Information Request (EIR) to Thames Water in 2025 identified that **812 misconnections** were sitting with local authority Environmental Health

Offices (EHOs) across Greater London for enforcement (Thames Water EIR 2024), with some being there for seven years or more. The number per local authority can be viewed in Appendix B.

In 2024 the voluntary rectification rate (the proportion of priority owners who correct the misconnection) was 77% (Barry 2025). In previous years, this has been as high as 90%. This decrease could possibly be due to factors such as the cost-of-living crisis or public opinion of water companies (Citizen Crane 2025).

When purchasing a property, buyers can choose between three RICs building surveys. Level 1 is recommended for “conventionally built, modern dwellings in satisfactory condition” and does not include a drainage inspection (RICS 2024). Under Level 2, drain covers are lifted and inspected, but this is a more expensive option, is not compulsory and means that misconnections are often left un-rectified when houses are passed between buyers, especially in newer properties where a Level 1 survey is likely to have been advised.

**Blockages**
Accumulation of debris within the foul sewer system can restrict flows and impact the capacity of sewers to accommodate the flow of sewage, which can exacerbate existing capacity and design issues of London sewers. Complete blockages in the foul sewer network can cause sewage to back up and find the nearest route to a river via the surface water drainage network (Figure 6). **In 2024, Thames Water cleared 52,000 blockages from sewers, in their whole drainage area.**


Figure 6. Blockage (Credit: Stephen Barry, Thames Water)

Many blockages are caused when items that do not decompose, such as wet wipes, sanitary products, cotton pads etc, are flushed down the loo and combine with cooking oils and fats, forming blockages (Court *et al.* 2021). Sixty percent of sewer flooding in homes is caused by blockages (Thames Water 2024b) and over the last six years, most internal sewer flooding has been caused by blockages. This is often in pipes with a diameter below 150mm, where 70-80% of incidents result from a blockage (Thames Water

2024c). In 2024, 80% of blockages were caused by items which should not have been thrown down the sewers (Beech and Daman 2024) and **Thames Water estimates that they remove 19 billion wet wipes from their sewers every five years** (Thames Water 2024d). Overtime some agglomerations of fats oils and other debris can build into massive structures called 'fatbergs'. These often appear in the media, with one of the largest ever fatbergs discovered in East London in 2017, weighing 130 tonnes and measuring 250m long (BBCNews 2017).

Better sewer maintenance and a programme of educating the public from putting the wrong thing into the sewer network are two important approaches to reducing the impact of blockages. By the end of AMP7, Thames Water will have installed 19,500 sewer depth monitors on their network to identify and respond to blockages sooner and to monitor the performance of the sewer network (Thames Water 2024e).

Since April, Thames Water visited 4000 restaurants to educate business owners on the dangers of throwing fat, oils and grease down the drains (Beech and Daman 2024). This forms part of their 'Bin it, don't block it' campaign, which aims to educate consumers of the dangers of both flushing items down the loo such as wet wipes and sanitary products and pouring cooking oils, fat and grease down drains (Thames Water 2025a).

**Failing or poorly designed sewer assets**

Pollution incidents can arise from poorly designed or failing assets such as chamber defects, cracks, collapsed walls or missing rodding eye caps allowing foul water to cross over into the surface water system (Ellis *et al*. 2004). Table 3 shows the causes of PSWOs in London rivers (Barry 2024). Many causes of pollution are due to infrastructure issues such as dual manholes (Figure 7). Dual manholes allow shared access to both foul and surface water sewers that are sometimes in open channels. They can result in cross contamination of both foul to surface water and surface water to foul (CIWEM 2014).

**Table 3. SWOP results from AMP7 (2020 – 2025).**

| NUMBER | POLLUTION CAUSE |
|---|---|
| **1314** | **Defects found additionally to physical misconnected pipework, which are also a potential pollution source** - Properties where there are misconnected appliances but in addition to these misconnections there may be some additional defect, for example a crack in the benching of a sewer pipe or a missing gulley divider |
| 291 | **Private blockages -** These are blockages that specifically occur in a customer's private drainage system, before they reach our sewers. Many times, the blockage can result in sewage overflowing and entering the surface water systems, resulting in pollution to the local watercourse. |
| 500 | **Private surface water caps missing** - These are properties where a surface water caps that are part of a customer private drainage are missing; this can cause sewage to enter the open cap and be discharge to the local watercourse. In these cases, TW offer to replace the cap for free to the customer but require their permission to do so as it is part of their private drainage system. |
| 102 | **Private defects** - This is a very broad category of defect that encompasses any type of defect except those not defined elsewhere, for example it does not include blockages, missing surface water caps, damages or missing gulley dividers or any housekeeping issues where customers are tipping waste down the wrong drain. Anything else would likely be included in this designation which covers a vast array of not so common and potentially unique defects. The one thing that they have in common is that the issue relates to a customer's private drainage. |
| 269 | **Public defects** - These relate to any defect that is identified and is Thames Waters responsibility to rectify as it has occurred to the part of the drainage system that we are responsible for. Again, just with private defects above it can relate to a very wide variety of different issues. |

Figure 7. Dual manhole (London Borough of Harrow 2016).

A 2016 investigation by London Borough of Harrow found 209 dual manholes within the 45,915m$^2$ study area, although it is believed there are many more (Figure 8). Although Thames Water do carry out remedial work on these assets such as fitting caps back on the surface water line, they can often be displaced when there is next a large rainfall event, or by rodents or when blockages are cleared (Bradshaw 2025).

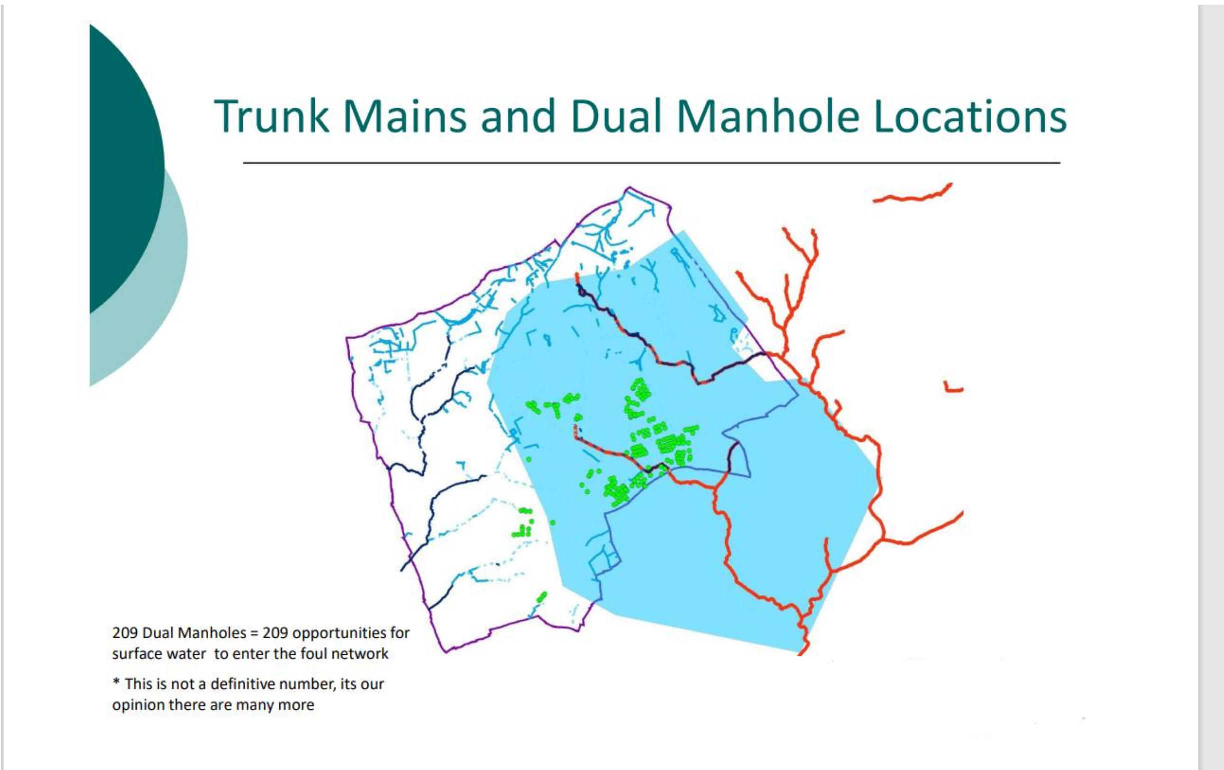

Figure 8. Screenshot from London Borough of Harrow slides referring to the 2016 project investigating pollution in the Wealdstone Brook Catchment. 209 manholes found in the study area (blue shaded area) (Bradshaw 2025).

**Thames Water have estimated that their total asset health deficit is £19.3bn** (Thames Water 2024f). The deficit was calculated as the modern equivalent asset replacement value of:

A. Assets which pose a risk that is above a defined risk threshold ('risk').
B. Assets no longer capable of reliably performing their function ('performance') and
C. Non-critical assets in very poor or failed condition and beyond their useful life ('condition'). (Thames Water 2024e).

Over 53% of the asset deficit relates to situations where the assets give rise to unacceptable risks (Thames Water 2024e). Thames Water are requesting additional funding to cover the costs of managing their accumulated asset heath deficit to start addressing it (Thames Water 2024e).

There are a concerning number of failing assets in the Thames Water region (OFWAT 2024). Wastewater and surface water drainage systems are being impacted by a combination of issues such as insufficient capacity, insufficient infrastructure and frequently inappropriate and reactive remedial methods, all of which is exacerbated by ageing infrastructure, increasing populations and the effects of climate change (Ellis *et al.* 2010).

**Surface water drain abuse**

All surface water drains lead to rivers. For example, car and bin washing on the street means that chemicals in any cleaning products used runs directly into the nearest waterway via the surface water drainage network. Lack of public awareness or indifference means the compound effect of multiple inputs in cities damages rivers. Some small-scale awareness campaigns have been carried out in some parts of the UK. For example, the 'Blue Fish Campaign' started by the Department of the Environment in Jersey, in partnership with Jersey Water and Eco-Active, aims to raise awareness by placing The Blue Fish icon next to surface water road drains (gov.je 2025).

Businesses such as commercial car washing services are required to discharge into public sewers rather than the surface water system and require permission to do so according to the Water Industry Act 1991. Pollution prevention guidance for businesses is available on the GOV.UK website and includes specific guidance for oil, petrol, silage, slurry and agricultural fuel oil, sheep dip, pesticides, biocides, herbicides and other chemicals, solvents and air pollution (GOV.UK 2016).

**Recommendations to reduce pollution from outfalls**

1. Long term investment needed to upgrade London's sewer network
2. At least a doubling of effort and increased in investment by Thames Water in tracing, identifying and fixing the causes of PSWOs.
3. Clarify or update policy and legislation related to the enforcement of misconnection rectification.
4. Develop an accurate map of outfalls in London – each outfall will have a unique identifying reference number and ownership details. Records to be kept of each outfall's pollution history to build a picture of pollution hotspots and repeat offenders across London and the targeting of remediation action and communications campaigns on sewer abuse.
5. Sufficient resourcing of the Environment Agency to support investigation and enforcement action in the cases of PSWOs that are not owned by Thames Water.
6. As a matter of urgency support enforcement of the rectification of identified misconnections. Prioritise legal pressure on the blocks of flats and other properties of multiple occupancy that have been known to be polluting for a number of years.
7. Legislation is needed to incorporate drainage checks at the point of sale of a property in Greater London to ensure they are correctly plumbed in.
8. Ensure mandated in-person checks of drainage during design and build of new developments to avoid new misconnections being added to the system.
9. Increased awareness and communications campaigns across London to stop the wrong things going down the drain and blocking sewers or being put into surface water drains.
10. Research required to review and update findings on misconnections using data from over ten years of Thames Waters SWOP.

## ROADS

40% of London's surface is impermeable (Mayor of London 2018), this area includes an estimated 40,000km of road. Abrasion between the tyre and the road surface results in tyre wear, with the resulting particulates following several pathways to the environment. 2-5% of particles become airborne, up to 75% is deposited on the road and roadsides and 25-55% gets carried away in rainwater and ends up in the surface water system (Giechaskiel *et al.* 2024). Pollutants that accumulate on these hard surfaces are washed by rainfall, via road gullies, or roadside drains into the surface water network and rivers. Road run-off is predominantly an outer London issue in areas where there is a separate sewerage system (Figure 3). Current drainage design does not adequately capture highway run-off and there is no robust process to systematically prioritise the deployment of appropriate treatment for harmful runoff (CIWEM and Stormwater Shepherds 2024).

Not all roads pollute equally and roads with higher volumes of traffic and where heavy goods vehicles regularly apply their brakes pose the highest environmental risk (Visanji 2023). Modelling has shown that road runoff from **2,415 road sections** (covering a total of 451.43km out of 3,862.3km (10%) of London's major roads that were modelled) are deemed high priority and pose a higher risk to receiving waters (Visanji 2023).

The organisations responsible for the main road networks in London are:

- National Highways, which manages the national motorway network, including the M25, M1, M4 and the M11 in Greater London.
- Transport for London (TFL), which is responsible for the main London Road Network (London's Red Routes) which makes up 5% of the city's roads but carry up to 30% of its traffic.
- City of London and the London boroughs, which are responsible for most of the smaller roads across London.

Within this section we have focussed on National Highway assets as an example of the complexity of the issue within London. The National Highways Environmental Sustainability Strategy and National Highways 2030 Water Quality Plan outline an intention for National Highways to identify opportunities to address their highest risk water outfalls by agreeing and implementing a programme of improvements from 2025 for the third road period (2025-2030), with the plan to mitigate all high risk outfalls by 2030.

National Highways high risk outfall categories 'High risk' includes outfalls with an overall risk status of category A and category B. In these locations National Highways will further consider the introduction of mitigation measures to reduce the risk. Verified category A outfalls present either:

- an unacceptable risk of a pollution incident due to spillage (acute) (the calculation of spillage risk and likelihood of subsequent pollution incident is described in the Design Manual for Roads and Bridges (LA113) - drainage and the water environment; or
- a likelihood that the receiving watercourse would fail Environmental Quality Standards (EQSs) as a result of the discharge.

Verified category B outfalls present a risk that soluble (acute) and sediment-bound (chronic) thresholds would be exceeded in the receiving watercourse." (CIWEM and Stormwater Shepherds 2024).

National Highways and other highway authorities in England have no permits in place for managing pollutants in any of their outfalls (CIWEM and Stormwater Shepherds 2024) so **there is not any routine monitoring of outfalls that convey road runoff to rivers.** The National Highways '2030 Water Quality Plan' identified 1,236 outfalls (outfall is a small surface water drain that discharges into a watercourse) and soakaways (a buried pit or trench that allows water to drain into the ground) as having a potential high risk of pollution. Of these, 145 have a verified high risk of pollution and therefore require mitigation whilst the remaining 1,091 are unverified and have been identified as having a 'potential' high risk of polluting the water environment.

In response to a 2025 Freedom of Information (FOI) request, **National Highways confirmed that they have 84 outfalls and 12 soakaways within the boundary of the GLA.** It is worth noting that although some sections of the M25 are within the GLA boundary (near Heathrow, near Waltham Cross and in Essex), most of it lies beyond the GLA boundary. National Highways outfalls that drain road-run off from major roads can be viewed here on the Watershed Pollution Map (2024) (Figure 9).

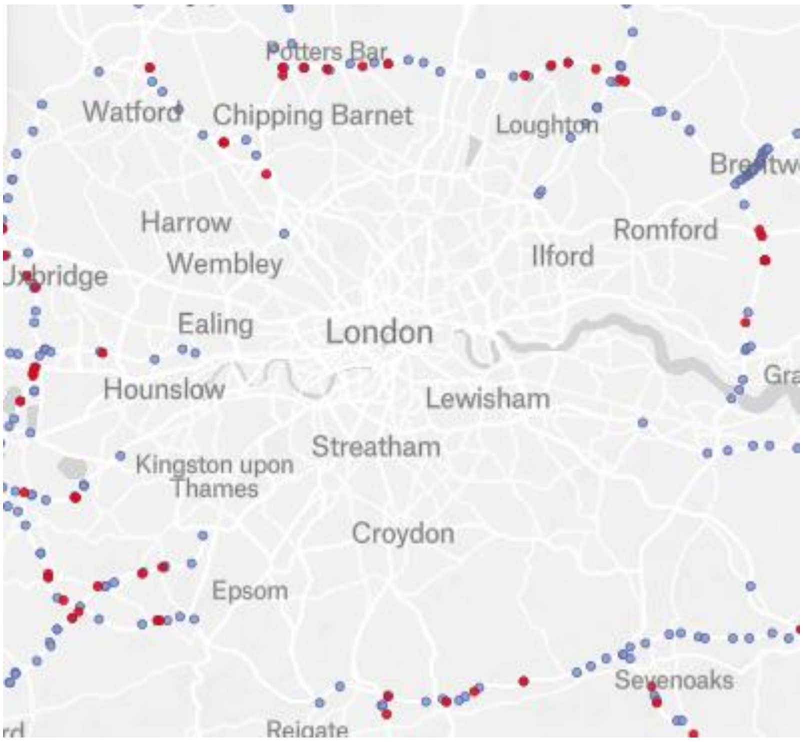

Figure 9. National Highways outfalls or soakaways that drain road run-off from major roads. (Red = high risk outfalls; blue = outfalls). Screenshot taken from the Watershed Pollution Map (2024).

**10 outfalls and 0 soakaways are within the GLA and are part of the 145 outfalls/soakaways which, at the time the Water Quality Plan 2030 (WQP) was prepared, were considered at high risk of pollution** (Table 4). National Highways are currently reviewing the pollution risk status of all outfalls and soakaways in the WQP (including the 145) and are undertaking a verification and assurance exercise to ensure consistency. Therefore, the risk status of those outfalls and soakaways may change. This process should be complete by the end of March 2025. Once the verification and assurance processes are complete, National Highways will look to determine both the priority order for addressing high risk outfalls and the action required at each. Outfalls and soakaways which have a confirmed high risk will be part of a mitigation programme from 2025 to 2030.

**Table 4. Number of National Highways outfalls and soakaways nationally and within the GLA boundary (National Highways 2023; National Highways EIR 2025).**

| STATUS | NO. OF OUTFALLS | NO OF SOAKAWAYS |
| --- | --- | --- |
| Total No. of National Highways outfalls within GLA boundary | 84 | 12 |
| Outfalls within WQP that are **verified** as being at high risk of pollution within the GLA boundary | 10 | 0 |
| Outfalls within WQP that are **unverified** but identified as having a potential high risk of pollution | 4 | 1 |

The current system used by National Highways to calculate the risk of a pollution event, the Highways England Water Risk assessment Tool (HEWRAT) assesses the catchment area, traffic volume, river dimensions and the proximity to sensitive waterways to categorise the outfall. HEWRAT does not include predictions of total concentrations of PAHs cadmium, fluoranthene and pyrene and whether they exceed Environmental Quality Standards thresholds (CIWEM and Stormwater Shepherds 2024). A 2024 report by

CIWEM and Stormwater Shepherds calls for the HEWRAT system to be reviewed and the results compared with risk assessments undertaken by the Environment Agency.

As part of the FOI, we asked for the number of outfalls that were retrofitted with measures to trap and process pollutants, rather than discharging to a water course, in the last AMP 2020 to 2025. The response was that, since 2020, no outfalls within the GLA boundary have been retrofitted to reduce the risk of pollution. Discussions regarding treatment solutions for the M4 Frog's Ditch outfall in Hillingdon are ongoing. Beyond the GLA boundary, but within the M25, a series of outfalls along the M3 near Thorpe Park are currently being mitigated where they discharge directly to St Ann's Lake (which is designated Ramsar, SAC and SSSI). Also, beyond the GLA boundary but along the M25, an outfall to Brookhouse Brook (near the M11/M25 interchange) is currently being retrofitted with treatment measures.

Although we have focussed on National Highways assets within this section, it is worth emphasising that in addition to these larger drains, smaller drains from the minor road network, which have a wide range of ownership between the 32 local authorities and cover an extensive area of London, are likely to collectively have impact.

Multiple treatment technologies and devices exist for managing highway run-off in the UK. These include proprietary devices that can separate suspended solids and soluble pollutants from rainwater run-off, as well as treatment devices such as ponds and swales which can capture and retain pollutants. However, more information is needed to understand the efficiency of these treatments (CIWEM and Stormwater Shepherds 2024). Each intervention to trap and process pollutants will need bespoke engineering and can include a combination of both technical and nature-based solutions. The Thames21 decision support tool to identify which broad type of nature-based solutions can help remediate road pollutants is not a design tool and further detailed investigation would need to be undertaken as well as development of designs based on flow and pollutant load.

**Recommendations to reduce pollution from roads**

1. National Highways and Transport for London and local highways authorities to initiate an intensive retrofit of roadside interventions that trap pollutants at sources, before they enter rivers.
2. Development of consistent approaches between the wide range of outfall owners across London.
3. Reduce traffic volumes and move to cleaner forms of transport.

## OTHERS

### Fly-tipping

According to Webb *et al.* (2006) fly-tipping at the side of waterways is one of the lesser targeted locations for fly-tipping, averaging at a mean of 5 events per month (per million population) compared to the highest of a mean of 798 events per month (per million population) for highway fly-tipping. However, it is possible that these results are under-estimated and even if not directly, fly-tipping can increase the risk of litter being swept into waterways which can contaminate the water and impact wildlife (Williams and Simmons

1999; Webb *et al*. 2006). Fly tipping can contaminate the water by the leaching of toxic chemicals from hazardous materials such as batteries (Guo *et al.* 2017).

Considering that fly-tipping in London accounts for a third of all fly-tipping in England (Cooper 2018), it is possible that it is a major contributor of litter into London's waterways, even if rivers are generally a lesser directly targeted location. However, the extent of the issue in London's rivers is unknown (McConville *et al*. 2019).

### Contaminated land

Contaminated land is land that is determined as contaminated under part 2A of the Environmental Protection Act 1990. It can be caused by historical pollution incidents such as accidents, spills or deposits from the air, contamination from historical industrial land use, historical mine workings, contaminant migration overland or by infiltration into the ground, high levels of naturally occurring substances or historical waste deposits such as former landfills (GOV.UK 2023; SEPA 2012). Contaminated land can contribute to water pollution when pollutants from the land wash into nearby rivers and streams (Göransson *et al.* 2014; SEPA 2012). Land contamination can harm human health, drinking water supplies, soils, ecosystems and property (GOV.UK 2014).

Under Part 2A of the Environmental Protection Act (1990), Local Authorities have a duty to keep a Contaminated Land Register of sites within their jurisdiction. However, it is worth noting that not all contaminated sites will have been designated under Part 2A despite being contaminated.

Certain types of contaminated land are required to be designated as special sites. As a result, the Environment Agency becomes the enforcing authority (rather than the Local Authority) and assumes responsibility for requiring remediation to be carried out under section 78E of Part 2A of the Environmental Protection Act 1990 (Part 2A). Only one of these 'special sites' falls within the GLA boundary: New Years Green Landfill site in Ickenham (data.gov.uk 2024a).

### Airports

Airports can also be a source of pollution through activities such as vehicle washing, maintenance (including painting and metal work), fuelling operations, engine test cell operations and de-icing (Sulej *et al.* 2012). Sewage fungus growth in the River Crane has been linked to the use of de-icers at Heathrow airport (Exton et al. 2024). In 2020 Heathrow Airport Ltd built a new wastewater treatment plant to treat the glycol runoff from the airport runways prior to its discharge into the river Crane (Citizen Crane, 2024).

### Pesticides

In the UK, 80% of cats and dogs now receive at least one routine treatment of an ectoparasiticide product per year (PSDA 2019). In a study by Perkins *et al*. 2021, it was found that sites downstream of sewage treatment works had higher concentrations of these ectoparasiticide, suggesting that significant quantities of these chemicals are entering waterways via household drains. A study to understand the pathways of these chemicals into rivers found that bathing pets, pet bed washing and washing of owners' hands all resulted in the presence of ectoparasiticides chemicals within the drainage system (Perkins *et al*. 2024). Pesticides can also directly contaminate waterways when pets swim in rivers or ponds etc (Perkins *et al.* 2021). In a study of Hampstead Heath ponds, ponds where dogs swim were found to have exceeded environmental toxicity thresholds for imidacloprid and fipronil (Yoder *et al.* 2024).

### Agriculture and use of herbicides by landowners

There are over 200 farms within Greater London, covering about 11,000 hectares of London's Green Belt area (London Assembly 2018). This means that some rivers within London are also impacted by agricultural pollution. It is essential that land managers maintain buffer strips between worked land and rivers to reduce the potential for silt and chemicals such as herbicides and pesticides to run off the land into rivers. The **Agricultural Land Environmental Risk and Opportunity Tool (ALERT)** is a free mapping tool created by the Environment Agency on behalf of Catchment Sensitive Farming to help farmers and our local advisers analyse the landscape and reduce pollution from agriculture (Farming Advice Service 2024).

## POLLUTION INVESTIGATION AND ENFORCEMENT

The Environment Agency does not have the resource to respond to reports of pollution unless they are Category 1, i.e. Is there evidence of wildlife impact such as dead fish (Table 5). This approach is inadequate in London and will not support an improvement agenda as many rivers and streams are in degraded state and have limited fish populations.

**Table 5. Environment Agency categories of pollution. Effects of pollution include harm to amenity, aquatic life, drinking water abstraction, ecology, fisheries and human health (GOV.UK 2024c).**

| POLLUTION CATEGORY | DESCRIPTION |
|---|---|
| Category 1 | A category 1 incident has a serious, extensive or persistent impact on the environment, people or property and may, for example, result in a large number of fish deaths. |
| Category 2 | incidents have a lesser, yet significant impact. |
| Category 3 | incidents have a minor or minimal impact on the environment, people or property with only a limited or localised effect on water quality. |

### Recommendations to improve pollution investigation and enforcement

1. Review Environment Agency policy and practice in London to ensure they are adequately resourced and have the mandate to respond to both Category 1 and 2 pollution incidents and where necessary, investigate sources of pollutions and take enforcement action against polluters.

## HOW NATURE RECOVERY CAN CONTRIBUTE TO CLEAN WATER

Over 90% of wetland habitat has been lost from the UK in the last 100 years (Mayor of London 2025a) and around 1000 freshwater species are listed as rare or threatened in the UK, a quarter of those assessed (Freshwater Habitats Trust 2025). Water quality and habitat loss have contributed to this decline, and this is particularly evident in the heavily urban landscape of London, where most waterways have been separated from their natural floodplains and heavily modified by being straightened, widened or lined with concrete and bisected with weirs (Mayor of London 2025a; Mayor of London 2018). Information on the rivers that have been classified as Heavily Modified Water Bodies under the Water Framework Directive (WFD) in London and the physical modifications that resulted in the classifications can be found here (data.gov.uk 2024b).

Urbanisation and infrastructure developments have reduced the ability of rivers to perform natural processes, including the processing of pollutants. River restoration and the creation of NBS such as constructed wetlands will improve water quality and in addition benefit Londoners through restored ecosystem service provision such as flood resilience, cooling effects and improved well-being and recreation. A plan that works with nature for clean and healthy waterbodies will support The London Nature Recovery Strategy and can be an important component of the rewilding of our city through the return of charismatic species (Rewilding our cities by ZSL - Issue).

We have listed below some of the evidence on nature-based approaches to improving water quality such as river restoration and daylighting, constructed wetlands, re-naturalisation of artificial waterbodies such as canals and docks and the return of keystone species.

### River restoration

River restoration refers to the process of returning a degraded or modified river system to a more natural state to enhance its ecological, hydrological, and social functions. Over-widening and straightening of rivers has been a particular issue through the 20th century. This widespread modification of rivers means that there are plenty of opportunities to restore them to a more natural state in London. Restoration opportunities are listed in each catchment partnerships catchment plan and in 2025, River Partnerships in London (RiPL) will be releasing the **London River Restoration Opportunity Map** which collates key river restoration opportunities across the capital. Significant river restoration work has already taken place in London in recent years; a 2020 review of work river restoration in London showed that **40 km of river was restored between 2000 and 2019** (Catchment Partnerships in London 2020). However, we can and must do more and faster if we are to realise a vision of clean and health waterbodies in London.

There are opportunities, particularly where rivers flow through open spaces, to re-meander and restore natural courses. Putting meanders back slows water flow through increased water-sediment interaction and enhances nutrient cycling, which contributes to the processing and removal of pollutants (Wohl *et al.* 2005). In a study by Mrozińska *et al*. (2018), river restoration using various hydraulic structures resulted in reductions of $NO_3^-$-N and $NH_4^+$-N, by 70% and 50% respectively and increased dissolved oxygen concentration by 65%. In-stream improvements such as riffles, pools, woody debris, aquatic vegetation increases oxygenation and in turn, promotes organic pollutant breakdown, improves sediment deposition and pollutant trapping and provides habitats for aquatic organisms that contribute to pollutant processing (Wohl *et al.* 2015). In-river restoration techniques, such as installation of berms and gravels to alter flows, can be useful in areas where larger scale changes are not possible due to flood risk.

Changing artificial riverbanks to natural functioning riparian zones is an important form of river restoration. This can include the planting of reedbeds which can oxygenate water and create vital habitat. Restoring natural riverbanks and the widespread use of sustainable drainage approaches reduces the velocity of water running off land and into rivers. This reduces the amount of silt bound with other pollutants from being washed into rivers and allows trapped pollutants to be processed and broken down by microbial and native plant communities (Dosskey *et al.* 2010; Wenger 1999).

An example of a river restoration project in London is the re-meandering of the river Wandle at Butter Hill led by the Southeast Rivers Trust (Figure 10). As well as the removal of fish barriers along the Carshalton stretch of the river, 500 metres of river was re-meandered with a low flow channel, berms, riffles, pools and marginal wetlands created along the length. To restore geomorphology, 300 tonnes of gravel was added to the river. To improve habitat, volunteers planted 2000 plants and coppiced trees to increase the amount of light (SERT 2015).

Figure 10. Before and after river restoration the River Wandle (Credit: South East Rivers Trust)

## Daylighting rivers and streams

The process of uncovering rivers that were previously buried or culverted, known as daylighting or de-culverting, can result in several significant benefits to water quality and nature recovery. Many years spent burying rivers means that London is rich in daylighting opportunities and with vision and investment could become the daylighting capital of the world. The 'Finding and Managing Culverted Watercourses report' (Thames Water 2019), identified a total of 444km of lost river and 386km of culverted watercourses in the London area. However, it should be noted that a lack of historical map coverage in some areas means that some lost rivers may not be accounted for in these numbers.

Daylighting is a form of river restoration. New, daylighted channels interact with the air and ultraviolet light which prevents stagnation, increases oxygen levels and supports the breakdown of organic pollutants more effectively, promoting nature recovery (Pinkham 2000).

A London example of the successful daylighting and remeandering is the Ravensbourne through Norman Park in Bromley (Figure 11). For 300 metres, the Ravensbourne flowed through a 1m diameter concrete culvert. As well as boosting nature recovery the works have provided a recreational facility for local people, reduced the cost needed to maintain the culvert and an increased the capacity for flood storage (The River Restoration Centre 2013).

Figure 11. Daylighting the river Ravensbourne through Norman Park. Left photo shows the severed culvert still visible. Right photo shows an aerial view of the re-meandered course (Photos taken from The River Restoration Centre 2013).

### Constructed wetlands

Constructed wetlands have an inlet and an outlet and are integrated into drainage catchments. They use natural processes to treat polluted water (Russell *et al.* 2021). Often constructed wetlands include the use of reeds, most notably the Common Reed (*Phragmites australis*), and are therefore sometimes referred to as reedbeds, which also occur naturally. Constructed wetlands are increasingly being used as a NBS for improving the management of surface water in urban areas. Constructed wetlands clean polluted water through four key mechanisms (Russell et al. 2021):

- Nutrient uptake - Wetland plants use nutrients such as nitrogen and phosphorus to grow.
- Ultraviolet irradiation - Exposure to light helps to remove pathogens and breakdown organic pollutants.
- Sedimentation - Wetland plants increase hydraulic resistance and reduce velocity; suspended solids drop out together with attached pollutants such as metals and non-soluble phosphorus.
- Microbial action - The wetland plant root structure creates a large oxygen rich surface area for microbial biofilms. These microbes break down organic pollutants, such as hydrocarbons, and transform nutrients, this process is assisted by the large surface area of shallow water provided by wetlands which further improves oxygenation.

Constructed wetlands have already been implemented in some areas of London and are successfully improving water quality. An example of successful constructed wetlands already implemented in London is Firs Farm Wetlands (Figure 12). After this constructed wetland was established, there was a drop in mean concentrations of Ammonia, Biological Oxygen Demand (BOD), Phosphate and Faecal coliform between the inlet and the outlet (Table 6).

Figure 12. Firs Farm Wetlands (Credit: Thames21)

**Table 6. Differences in measured parameters between the inlet and outlet of the constructed wetland at Firs Farm (Gilbert 2016).**

| MEASAURED PARAMETER | DIFFERENCE IN PARAMETERS BETWEEN INLET AND OUTLET |
|---|---|
| Ammonia | 68.7% decrease (WFD classification "Moderate" to "High") |
| $BOD_5$ | 28% decrease (WFD classification "Poor" to "Moderate") |
| Phosphate | 67.9% decrease (WFD classification "Poor" to "Moderate") |
| Faecal coliform bacteria including E. coli and other coliforms such as Salmonella spp., and Campylobacter spp. | 78% decrease |

Constructed wetlands are also being more commonly used to convey polluted airport run off containing contaminants such as glycol based de-icing fluids. In a study at Heathrow Airport, the efficiency of reedbeds as a treatment for glycols was tested over two years. The average reductions in runoff BOD concentrations achieved by pilot scale surface flow and sub-surface flow reedbeds were 30.9% and 32.9%, respectively. The corresponding average glycol removal efficiencies were 54.2% and 78.3% (Revitt *et al.* 2001).

Constructed wetlands can also be used to capture road run-off, reducing the concentrations of pollutants entering rivers (Visanji 2023). For example, a study by Cooper *et al*. (2019) demonstrated that three roadside constructed wetlands were able to intercept road run-off into the river Wensum and reduced turbidity and sediment load by 14% and 82% downstream of the wetlands, capturing 7253kg of sediment within the first 12 months.

The long-term efficiency and sustainability of constructed urban wetlands is critically dependent on an integrated understanding of their biological, chemical and hydrological processes and subsequent design and maintenance, and it is essential that they are maintained and managed correctly to sustain their benefits (Ellis *et al.* 2003). There is often a trade-off between benefits, for example the biodiversity of a constructed wetland will be compromised by excessive pollution loadings (Zhang *et al.* 2020). While they can reduce pollutants monitored by the Environment Agency, such as ammonia and phosphate, and contribute to WFD requirements, only certain amounts of pollution load can be processed by constructed wetlands, and incoming pollution loads must be considered upon design. If pollution loads are too extreme, the amount of wetland needed to process these are not always possible to accommodate in the heavily urban setting of London . In addition, accumulated chemicals such as microplastics can hinder the effectiveness of constructed wetlands in uptake of nitrogen and phosphorus and negatively impacts the growth of plants and microorganisms that help break down organic pollutants (Zhang *et al.* 2024), therefore the mixture and extent of pollutants coming into a wetland could influence their effectiveness.

## Restoration and enhancement of standing waterbodies: ponds, lakes and docks

Waterbodies such as ponds, lakes and docks each require bespoke management plans based on their current pollution inputs and loadings. Nutrient pollutants, such as phosphorus, which encourage the growth of nuisance algae, are absorbed into the sediment and have the potential to delay recovery of standing waterbodies for decades (McKercher *et al.* 2022), well after inputs may have been stopped. Riparian planting of aquatic emergent plants can help to remediate these inputs by oxygenating the water and filtering pollutants.

### Floating Treatment Wetlands

A potential solution for removing nutrient pollutants in standing waterbodies such as docks and canals, where natural solutions cannot be achieved, is the use of floating treatment wetlands (FTWs). FTWs use emergent vegetation made up of native wetland plant species, which float on a buoyant material with the plants growing above the water and the roots extending through the material into the water. Biofilm is attached on the roots and extract nutrients from the water through processes such as filtration, plant uptake and denitrification (Pavlineri *et al*. 2017; McKercher *et al.* 2022). As well as improving water quality, floating wetlands can increase nature and the aesthetic value of waterbodies. A study by Nichols *et al.* (2016) that investigated the performance of a FTW receiving stormwater runoff from a 7.46ha urban catchment, found that pollution loads of total suspended solids reduced by 76%, total phosphorus by 55%, and total nitrogen by 17%.

FTWs require regular inspection to ensure they have remained anchored and to assess factors such as plant coverage, with re-planting sometimes being required to ensure the FTW is as effective as possible. Some harvesting of vegetation may also be required to avoid any dead plants entering the water and increasing nutrients (Landon and Hunt 2024). It is important to emphasise that only native plants should be used in FTWs as non-native plants that may be efficient at water purification can pose a biosecurity risk. If FTWs are not managed properly or are left to decay they can become a source of pollution, so it is important that they are monitored and that the appropriate level of planning goes into selecting the most suitable size and materials for the location (Yeh *et al*. 2015).

An example of a FTW being implemented in London is at **Graving Docks in Canary Wharf** as part of the Canary Wharf Biodiversity Action Plan (Figure 13). The floating ecosystems provide multiple benefits including, natural waterscape amenity, water quality enhancement and a complex multi-level habitat for fish, pollinators, and invertebrates (Biomatrix Water 2022). These FTWs are a good example of how NBS can be utilised in heavily urban areas of London where there is no room for more natural solutions such as larger wetlands.

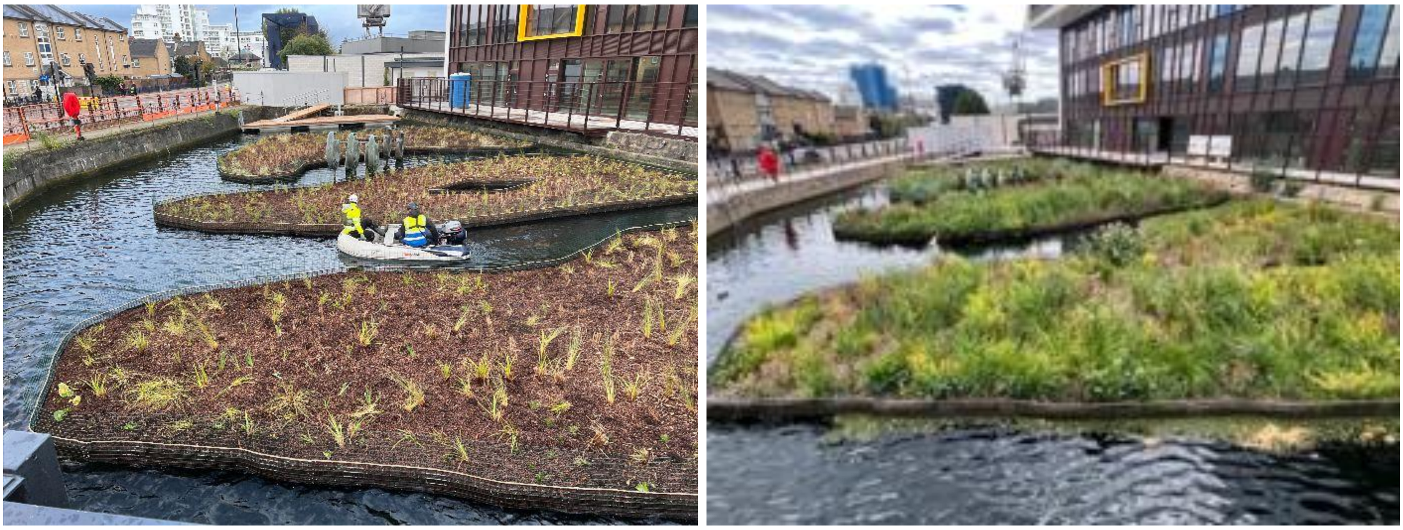

Figure 13. Floating treatment wetlands at Graving Docks (Left: November 2021, Right: July 2022) (Biomatrix Water 2022).

# PRACTICALITIES OF DELIVERING NATURE BASED SOLUTIONS

## CHALLENGES AND CONSIDERATIONS FOR IMPLEMENTING NATURE BASED SOLUTIONS

This section includes a summary of RiPL member's responses to a survey sent to them in March 2025. Representatives of three RiPL member organisations responded to the survey. Their responses have been drawn together under common themes below.

### The key considerations and challenges to delivering river restoration and constructed wetland projects in London

**Restricted Opportunities**

In built up areas, river corridors are often significantly restricted, with buildings and infrastructure extending all the way to the banks. In addition, banks, and often beds, are reinforced for structural and flood defence reasons. This restricts restoration interventions to a limited range of in-stream enhancements.

Constructed wetlands, can take up a relatively large amount of space so they are best focused in parks or open space. The average size of a constructed wetland is likely to be around 1000-3000m$^2$ and the space required to construct it may be 2-3 times larger than this in order to allow for the slopes around the wetland and the bunds between wetland cells (Russell *et al*. 2021). The requirement of both space and water for constructed wetlands can mean that opportunities are not always straightforward, especially in the urban context where space is particularly limited and valuable (Russell *et al.* 2021) and needs to balance different uses.

Water quality is an important factor to consider when daylighting or creating a constructed wetland. Planning a project sometimes reveals serious water quality issues that need to be addressed at source before a project can continue.

**Public Perception**

River corridors are often inaccessible or fenced off because they are perceived as a hazard, rather than a potential asset. This may reduce support for restoration work from landowners and the public, because they may not know the river is nearby.

Heavily modified sections of river with very limited ecological and functional value can at the same time be perceived as aesthetically pleasing and preferred by local communities. Some restoration interventions, such as removal of weirs, require extensive engagement activities to secure public support.

**Funding**

Some funders, such as Environment Agency WEIF usually only fund one-year projects, therefore 'shovel ready' projects are preferentially funded. Multi-year funding pots that include a funded development year to conduct feasibility, designs and permissions, and ideally two years of funding for delivery would remove a major barrier to delivering large scale river restoration projects.

Catchment Partnerships are often the means to develop (and by extension deliver) large scale, complex and multi-partner river restoration projects. Funding arrangements for catchments partnerships varies across London with some recently receiving Thames Water funds through their CaPs and Smarter Water catchments Programmes. Catchment Partnerships who are reliant on DEFRA catchment partnership host funding have seen funds reduce over time, with some e.g. the London Lea receiving just £3,750 annually towards the host role. A review of each catchment partnership's funding and consideration of additional long-term funding models and sources could help poorly funded catchment partnerships achieve more impact.

Funding for ongoing maintenance and monitoring can be difficult to fundraise for but is important to evidence the performance of a NBS, to inform maintenance programmes and the design of future NBDS. Monitoring also informs volunteer work programmes so that their efforts can be targeted to where they're most effective.

There is concern that Biodiversity Net Gain will not benefit rivers within or adjacent to developments – (see ZSL report on BNG and river restoration). Several respondents also asked for guidance on securing corporate funding and access emerging markets for private finance used to secure environmental outcomes.

**Unsupportive and complex policy and regulatory environment**

A barrier to river restoration projects in London is that of applying and receiving flood risk activity permits (FRAPs) from the Environment Agency. To carry out works on London rivers, the Environment Agency has increasingly asked for evidence of no impact on flood risk, even on very minor river restoration projects. For example, removing a small (<30cm) already notched, weir on the River Roding required £6,000 of flood modelling to satisfy the Environment Agency (around a third of the capital budget for removing the weir itself). Despite it being apparent that removal of this weir would not lead to increased flood risk, there seems no flexibility for Environment Agency teams to make common sense calls on minor river restoration projects. In addition, FRAPs are now processed nationally and not by region, which has impacted how and when projects can be delivered. The Environment Agency usually only fund projects through a 12-month window, and the wait time for receiving a Flood Risk Activity Permit (FRAP) can be longer than this, effectively making delivery within the Environment Agency funding window impossible.

Other considerations for restoration projects such as weir removal, include the need to get an impoundment licence when working on a weir and then an additional licence to remove the weir. Previously negotiation with local officers has been possible, but this may change as FRAPs are to be dealt with nationally. Again, this links to the current system for approving works essentially making it very difficult/expensive to deliver even small river restoration projects, as they are expected to jump through many of the same hoops as large-scale floodplain development projects.

A perceived inconsistent approach to permissions needed for river works make it difficult to standardise approaches and speed up design and delivery, lengthening the time and cost project take to complete. Standardisation of approaches across London and exemptions for smaller works and or collation of guidance from the relevant regulatory organisations would help project planning.

Daylighting schemes require permissions from the owners of the surface water drains, often this is Thames Water or the Local Authority – in some cases the owners of the assets are unknown.

**Skills and Capacity**
A critical development for Catchment Partnerships is the amplification of their work. Consolidation of all the delivered projects and potential opportunities creates a pipeline of potential collaboration and cross funding across planning, river restoration, flood risk management. On a catchment scale this starts to provide the evidence, analysis of the ecosystem service benefits, develop the approaches into business plans and pitch them to funders and markets. This blended finance approach can realise finance for delivering at scale but needs unique skillsets which Catchment Partners often do not have. This includes Ecosystem Analysist, Blended Finance and Governance Structure Advice and Business/Funder Development.

**Guidance**
Several respondents asked for clear guidance on design and delivery of constructed wetlands and daylighting. For instance, 'constructed wetlands are still seen as an emerging tool for managing surface water. Further guidance and support on where, how and what they deliver and how they can be integrated into developments is needed'.

**Maintenance and Ownership**
Constructed wetland projects can create new and ongoing maintenance requirements, for example they require sediment removal from the forebay every 2-4 years and from the secondary pond every 2-10 years. local authorities may not have the resource or skills to deliver some specific maintenance requirements.

## Timelines for delivering projects in London
Delivery of a medium sized river restoration project, including feasibility, design and permitting can take 3-5 or more years.

Constructed wetlands can take from around 4 years to 10 years for a more complex project.

All the funding for delivery is rarely secured at the beginning of a project and often requires a combination of funding streams. Sourcing multiple funders can cause significant delays and barriers, particularly to larger more impactful projects. This needs to be addressed to ensure those developing and delivering projects can focus on maximising benefits as opposed to cutting costs and fundraising through the projects to enable their delivery.

**Recommendations on recovering nature for cleaner water**

1. Focus on re-naturalising and restoring rivers by working with catchment partnerships to a) identity engineered river reaches in each catchment that can be restored, and b) prioritise at least five locations for constructed wetlands in each catchment.
2. Ensure adequate support for hosting organisations to deliver catchment-based improvements through a partnership approach – this support being both financial and through engagement by all interested parties.
3. Review Thames Water's data on buried watercourses and make it available to the public via the river restoration map. Identify and prioritise river and stream daylighting opportunities across London and set up a task force to make these projects happen in the next five years.
4. Resource an officer to develop and facilitate links between RiPL members and local authorities. Local authorities that need extra capacity and skills will be supported to develop river restoration and wetland creation schemes.
5. Local authorities to prioritise river recovery and nature-based solutions in local plans. Local plans should reference catchment plans.
6. Establish and manage a significant long term blended funding stream to support waterway recovery and the creation of nature-based solutions.
7. Work with Government to ensure that any fines (including through prosecution) are directed back to the catchment that was damaged. Focusing fines on NBS would help ensure the ecosystem recovers and is more resilient to future pollution.

## RESTORATION OF SPECIES

In this section we differentiate between keystone or functional species, which are species which have an impact on their surrounding environment, including improving water quality, and species that are indicators of the success of improved water quality. This report focuses on the main species that are already being used as indicator and functional species within London, however, with habitat and water quality improvements there could be the opportunity to see more iconic freshwater species that have previously suffered major declines reappear across London. Improving water quality in London will benefit freshwater species across the food web and enable recovery of what, when in good condition, are disproportionately biodiverse habitats (Balian *et al.* 2008).

### Keystone species or functional species

**European Beaver**

European Beavers are classed as keystone species due to their ability to significantly alter the wetland environment that they inhabit and their positive influence on biodiversity. Purely vegetarian, their feeding and damming behaviour is known to have positive impacts on local biodiversity and water quality (Willby *et al.* 2018; Stringer and Gaywood 2016).

Damming of smaller water bodies by beavers promotes the processes described in the constructed wetland section of this report. Slowing flows through damming of water channels and creating smaller, lower energy side channels produces a low energy environment in the water, where suspended sediment and other pollutants are deposited. This process filters the water as it moves through a beaver wetland. During times of flooding, beaver dams can move water onto the connected flood plains. These new flow pathways allow sediment to be deposited onto the flood plains, removing them from the water column (Howe and Crutchley 2020). The second route is via the richer assemblages of aquatic and riparian vegetation that process and remove pollutants (Brazier *et al.* 2021).

Photo: Beaver at Paradise Fields. Credit: Abhilesh Dhawanjewar, Ealing Beaver Project 2025.

**Aquatic plants**

Functional species also include aquatic plants. One of the main species used in restoration for water quality improvements is the common reed (*Phragmites australis*). Reeds are often used in constructed wetlands to process water through nutrient uptake, sedimentation and microbial action, as outlined in the constructed wetlands section of the report. Reeds can accumulate high levels of nutrients and heavy metals in their tissues, survive in disturbed areas and initiate riparian growth by creating substrate that can support other plant species (Packer *et al.* 2017). They can stabilise riverbanks which can lead to reduced velocity of water running off land and into rivers, reducing the amount of silt bound with other pollutants from being washed into rivers and allowing trapped pollutants to be processed and broken down by microbial and native plant communities (Dosskey *et al.* 2010; Wenger 1999). This increased riparian growth provides shelter from predators for important native species such as watervole (Carter and Bright 2003) and provides habitat for a range of other aquatic species (Packer *et al.* 2017). The ability of reeds to alter their environment makes them an important species across river restoration, restoration of standing waterbodies and constructed wetlands.

## Indicator Species

**Aquatic invertebrates as indicators of water and habitat quality**

Invertebrates are used as indicators of water quality and general ecosystem health due to their different sensitivities to pollution levels and habitat availability (Buss *et al.* 2015). For example, groups such as mayflies are abundant in areas of suitable habitat and easily sampled, but are sensitive to change, responding to a range of factors including temperature, metals, pesticides, nitrates and phosphorus, making their presence a good indicator of higher water quality (Jacobus *et al*. 2019).

Invertebrates are the basis for multiple methods which provide an index of river water quality in the UK, for example RIVPACS (River Invertebrate Prediction and Classification System) is a system used by UK agencies that model an estimate of river health based on expected macroinvertebrate levels in pristine conditions compared to the actual conditions of a site (UKCEH). RIVPACS is used to contextualise WHPT (Walley Hawkes Paisley Trigg) scores. WHPT is a system that superseded the original BMWP (Biological Monitoring Working Party) method and uses a scoring system based on presence and abundance of different scoring taxa based on their pollution sensitivity (Environment Agency 2019; WFD-UKTAG 2021). Invertebrate sensitivity to pollution is also the basis of the Riverfly Partnerships national river citizen science monitoring scheme which is discussed further in the monitoring recovery section.

**Water voles as indicators of habitat quality and extent**

Water voles are an iconic species and due to their reliance on healthy and restored river habitats, they can be a good indicator of recovered river habitat. Water voles were once widespread across London but by 1997 had disappeared from 72% of their previously occupied sites. ZSL's 2023 review of water vole data in London shows they are hanging on in just **11 sites.** Through Mayor of London funding, ZSL initiated the London Water Vole Recovery Programme (LWVRP) in 2022. The programme brings together 41 partners, with the vision of restoring resilient and self-sustaining water vole populations to all rivers in Greater London. Although they don't in themselves drive water quality improvements water vole are an iconic species and their future is reliant on clean, healthy and restored river habitats.

Photo: ZSL

**Recommendations on species**

1. Work with the London Beaver Working Group to identify additional suitable sites and associated organisations capable of introducing and managing Beaver releases.
2. Sustain the existing Riverfly Monitoring schemes, that uses invertebrates as indicators of river condition, and support spread of the method, to all rivers in London and, linked to the monitoring plan, integrate invertebrate data into the annual State of London Waterways report.
3. Support partners in the London Water Vole Recovery Programme to restore and monitor the return of lost populations of water vole to all rivers in London where habitat quality and connectivity will support them.

## MONITORING AND ANALYSING RECOVERY

Long term, systematic monitoring using robust methods must be a key consideration for stakeholders to understand if and how the implementation of the mayor's plan for clean and healthy waterways is working. Environment Agency monitoring, as part of WFD, of parameters such as ammoniacal nitrogen and dissolved oxygen provide important robust long-term datasets to measure change in river condition over time. In addition, as part of a London wide monitoring strategy, it will be important to monitor the impacts of individual NBS**,** such as constructed wetlands, and daylighting to help us understand their effectiveness and benefits. The data gathered on interventions can be used to inform the design of future NBS and their maintenance requirements.

The involvement of community scientists will be an important component of a monitoring strategy. Community science evidence can augment a well-resourced statutory monitoring programme led by the Environment Agency. Well-designed and coordinated community science schemes can generate robust data and support environmental literacy and stewardship in addition increased public awareness can lead to increased reporting of problems, which can increase environmental impact.

There are three community science methods that we recommend prioritising for integration into a wider monitoring strategy for London. These three methods are long established and used nationally. They are Riverfly Plus (Projects Overview — The Riverfly Partnership) methods and integrated in to the Catchment Systems Thinking Cooperative (CaSTCo) programme.

1. The Riverfly Monitoring Initiative (RMI — also known as the Anglers' Riverfly Monitoring Initiative, ARMI) has been pioneered by the Riverfly Partnership to provide a simple, standardised monitoring technique which communities can use to detect river pollution and report to the Environment Agency. In addition, Riverflies can be used as a proxy for water quality or wider ecosystem health so monitoring them allows communities to build a picture of water quality and ecosystem condition changes over times. Figure 14 shows the 2024 and 2025 Riverfly monitoring sites across London.

2. The Outfall Safari Project, which systematically surveys every river in London on a four -year rotation, surveyed 800 outfalls in 2024, of which nearly 20% were actively polluting (ZSL data). Currently approximately 64% outfalls on the Thames Water SWOP list for remediation are outfalls that were reported via the Outfall Safari Programme (Barry 2025). Over time Outfall Safari data will show trends in the number of PSWOs in London and pollution hotspots.

3. There is a substantial and growing MoRPh Rivers database (Modular River Survey) combined with some Urban River Surveys and other historical surveys, which looks at the spatial variations in hydrogeomorphological (habitat) condition for several catchments in the Thames basin but also temporal changes. These data, supplemented by new field surveys, could provide the basis for developing a standardised tool for assessing the trajectory in habitat condition in London's rivers to support multiple stakeholders working to improve river health.

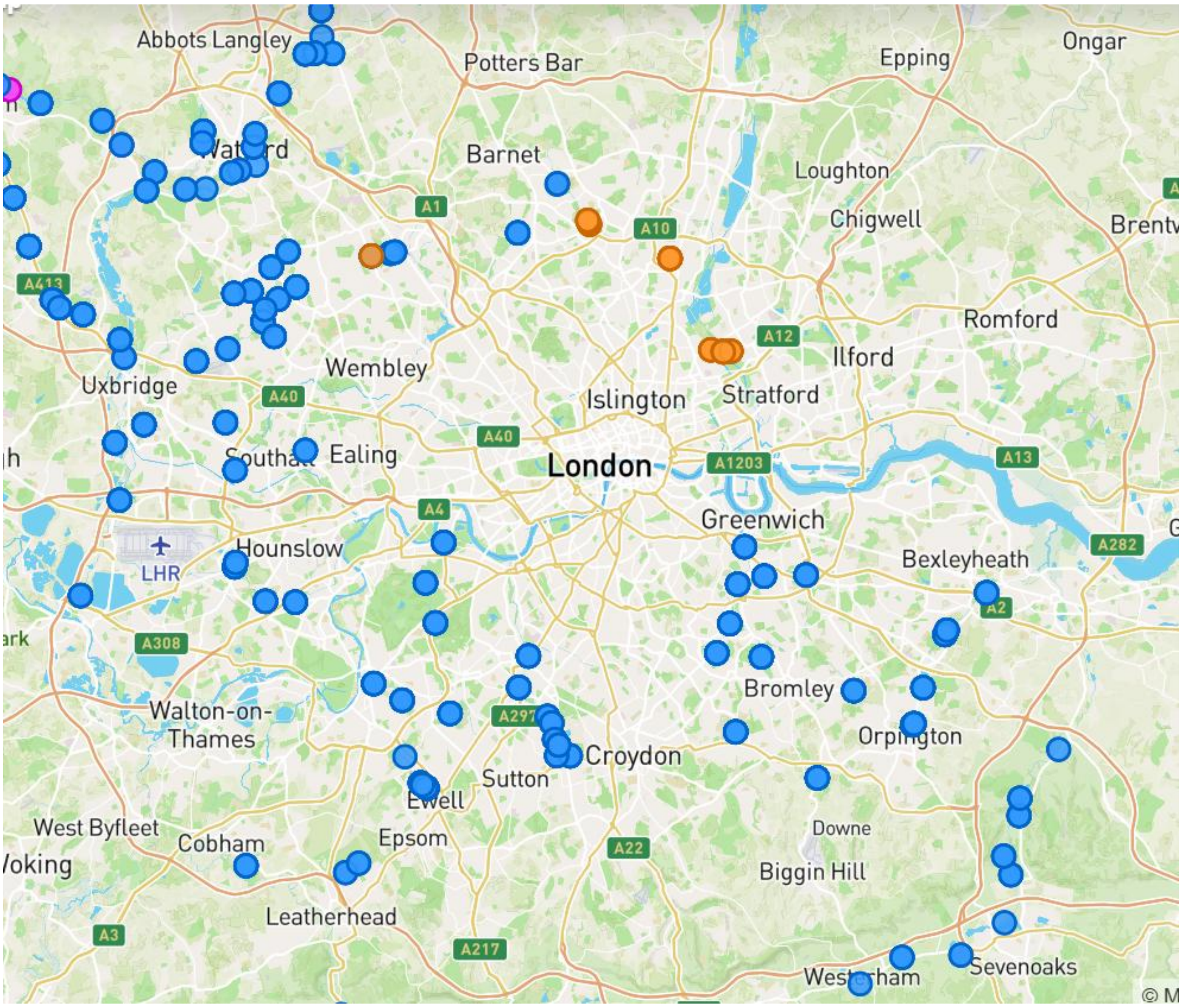


Figure 14. Map of Riverfly monitoring sites in Greater London for 2024 and 2025. (Blue = Riverfly sites, orange = Urban Riverfly sites)


Volunteers participating in Riverfly monitoring training (Photo credit: Azra Glover, ZSL)

ZSL, Environment Agency, Thames21, Southeast Rivers Trust, London Wildlife Trust and Thames water fund, help or directly manage community science schemes in London. There is a need to ensure there is coordination between organisations involved in community science to support consistent approaches, data standards and foster collaboration. These are the aims of both the annual Freshwater Citizen Science Forum at ZSL and the London Citizen Science Network.

**Recommendations on monitoring**

1. Codevelop a monitoring strategy and plan with NGOs and communities across London. The strategy, which will allow us to track progress on the delivery of the Clean and Healthy Waterways plan, must include key water quality indicators.
2. Create a funding stream to support long term, systematic delivery of the water quality monitoring plan and reporting progress against codeveloped indicators.
3. Develop a London rivers evidence dashboard and keep updated with the latest data or produce a concise and accessible annual State of London Waterways report to check the evidence and progress annually against targets in the Clean and Healthy Waterways plan.

## SOCIAL CHANGE

One of the key messages to come out of the RiPL workshop on the recommendations is the need to engage communities across London in the Clean and Healthy Waterways Plan. Positive impacts on the water environment can be gained through behaviour change, for instance what is put down home drains, and through monitoring as a citizen scientist, campaigning and volunteering to improve habitats.

**Recommendations on social change**

1. Inspire change by communicating the vision for Clean and Health Waterways and raise the profile of the opportunities and benefits of restoring waterbodies across the capital by working in partnership with catchment partnerships.
2. Increase awareness and education on how local communities can contribute to positive social catchment solutions by adapting their behaviours. Demonstrate how local communities can help through their own activities such as volunteering and monitoring.
3. *Increased awareness and communications campaigns across London to stop the wrong things going down the drain and blocking sewers or being put into surface water drains.

   *This recommendation is repeated from the recommendations on outfalls

## WHERE NATURE CAN HELP LONDONERS SAFELY ENJOY OUTDOOR SWIMMING

Many people benefit from the being in, on or near waterways, from the cooling benefits in summer to mental health.

### Where do people currently swim outdoors in London

Within London the spots with designated bathing water status are the ponds at Hampstead Heath: Ladies Pond, Men's Pond and Mixed Pond and the Serpentine at Hyde Park (GOV.UK 2024d).

There are very few bathing water sites designated on Rivers in England, two along the Thames River have bathing water status, but these are outside the Greater London boundary, at Wolvercote Mill in Oxford and Wallingford Beach. Both sites were designated poor in 2024 Bathing water classifications 2024 - GOV.UK, so current advice is against swimming in these locations.

Many of which may be suitable for applications for bathing water status are subject to further investigation and support from the local landowner.

Locations of Lido and outdoor swimming spaces like the above can be viewed on the River Health Map (Mayor of London 2025c).

Reclaim Our Rivers, a project by Thames21 is a campaign to gain bathing water designation across the Thames Basin, including several sites across London which can be viewed here. Thames21 work with communities in London who are interested in applying for bathing water status, but very few site meet DEFRA's criteria within London, which may be further impacted by the guidance and regulations which are currently being revised (see 'Water Quality Standards' section below).

### Knowing when not to go:

It is important to note that you should be prepared for any outdoor swimming and recommendations from RLSS include:

- Plan your swim
- Have the right equipment
- Know your limits
- How to stay safe and get help
- Recognise when you're too cold
- Know how to help someone in the water and in difficulty
- Know when not to go!

**Water Quality standards**

DEFRA designate bathing water status. Explaining How Bathing Waters are Monitored, Warnings Issued and Results Published – Creating a better place. Current guidance says that areas that have designated bathing water status must reach the following criteria:

- Be a coastal or inland water,
- Have at least 100 bathers a day during the bathing season (15th May to 30th September),
- Have toilet facilities bathers can use during the bathing season, within a short distance of up to about 500m from the site.

Guidance on what to include in a bathing water designation application can be found here on the government website. Once a site is designated, the Environment Agency currently monitor the water quality at the site between May and September to investigate sources of pollution and recommend measures to improve water quality (GOV.UK 2024e). However, there are limitations to this testing as it only occurs once a week and the samples sent off for the results so there is still a lack of real time monitoring to make decisions on safety of bathing.

The Environment Agency classifies designated bathing waters every year as excellent, good, sufficient or poor, with the information published here (GOV.UK 2025b). To allocate bathing waters a classification, the Environment Agency test for faecal indicator organisms (FIOs), specifically Escherichia coli or E. coli (EC) and Intestinal enterococci (IE), as outlined in The Bathing Water Regulations 2013 (DEFRA 2025). The classifications are shown in Table 7.

**Table 7. Inland Bathing Waters thresholds for classifications (DEFRA 2025).**

| CLASSIFICATION | THRESHOLDS (PERCENTILE) |
|---|---|
| Excellent | EC: ≤500 cfu/100ml ; IE: ≤200 cfu/100ml (95th percentile) |
| Good | EC: ≤1000 cfu/100ml ; IE: ≤400 cfu/100ml (95th percentile) |
| Sufficient | EC: ≤900 cfu/100ml ; IE: ≤330 cfu/100ml (90th percentile) |
| Poor | Means that the values are worse than the sufficient |

DEFRA applications for bathing water designation opens again on 12 May 2025 as the Bathing Water Regulations and application guidance have been revised. In November 2024 an open consultation was launched to invite the public, community groups, environmental groups, farmers, businesses and local authorities to share their views on modernising bathing water regulations to ensure a more flexible approach to designation and monitoring (DEFRA 2024). The response to this by government can be found here. The response shows that a large majority are in favour of expanding the definition of "bathers" to include other water users besides just swimmers which is as it is currently understood and are in favour of introducing the use of multiple monitoring points at designated bathing sites. To take these reforms forward, government are now beginning policy and development and research, including epidemiological studies to understand how best to implement them (GOV.UK 2025c).

However, some have criticised the removal of the automatic designation provision from the regulations and the addition of a required feasibility test on any waterway where a community is seeking a bathing water designation. This feasibility test means that any water bodies that are deemed too polluted to improve to at least "sufficient" water quality, will not be given a designation. When the reforms were announced, all but one of the current river bathing water status sites in England had "do not swim" advisory notices on the Swimfo map due to high levels of pollution (GOV.UK 2025b). This change will potentially reduce the chance of inland river sites achieving designated and prevent the responsible bodies being held to account in providing the necessary improvements to making polluted sites swimmable.

**General hazards when swimming outdoors**

- Cold
  The RNLI provides general safety information for Open Water Swimming which includes checking weather forecasts, dressing appropriately for cold water and wearing a bright hat or a swim float to remain visible, not entering suddenly to avoid cold water shock and ensuring that you understand how to float before going swimming (RNLI).

- Access and facilities
  Check out an appropriate access and be aware of the potential for uneven banks and beds of waterways, changes in depths of water and underwater objects and hazards and note the nearer safety equipment.
- Tidal Thames
  Powerful tides, eddies and undertows, cold water and ship movements are all other dangers to swimmers besides water quality and is therefore not an activity which is encouraged by the Port of London Authority within the tidal Thames, where these risks are of particular concern (PLA 2025). Due to other considerations besides water quality, some areas of London’s rivers, such as the tidal part of the Thames, will never be swimmable, even in areas where water quality is safe.

## REFERENCES


Albini, D., Lester, L., Sanders, P., Hughes, J., Jackson, M. (2023). The combined effects of treated sewage discharge and landuse on rivers. *Global Change Biology.* Available at: https://onlinelibrary.wiley.com/doi/10.1111/gcb.16934 [Accessed: 11th April 2025].

Aldridge, D., Fayle, T., Jackson, N. (2007). Freshwater mussel abundance predicts biodiversity in UK lowland rivers. *Aquatic Conservation: Marine and Freshwater Ecosystems* 17(6):554-564. Available at: https://doi.org/10.1002/aqc.815 [Accessed: 14th February 2025].

Arslan, P., Günal, A. (2023). Does Fipronil Affect on Aquatic Organisms? Physiological, Biochemical, and Histopathological Alterations of Non-Target Freshwater Mussel Species. *Water* 15(2):334. Available at: https://doi.org/10.3390/w15020334 [Accessed: 13th February 2025].

Baensch-Baltruschat, B., Kocher, B., Stock, F., Reifferscheid, G. (2020). Tyre and road wear particles (TRWP)—a review of generation, properties, emissions, human health risk, ecotoxicity, and fate in the environment. *Science of the Total Environment* 733. Available at: https://doi.org/10.1016/j.scitotenv.2020.137823 [Accessed: 30th January 2025].

Balian, E., Segers, H., Le´ve`que, C., Martens, K. (2008). The Freshwater Animal Diversity Assessment: an overview of the results. *Hydrobiologia* 595:627–637. Available at: https://link.springer.com/chapter/10.1007/978-1-4020-8259-7_61 [Accessed: 18th February 2025].

Banyoi, Porseryd, T.,Larsson, J., Grahn, M., Dinnétz, P. (2022). The effects of exposure to environmentally relevant PFAS concentrations for aquatic organisms at different consumer trophic levels: Systematic review and meta-analyses. *Environmental Pollution* 315. Available at: https://doi.org/10.1016/j.envpol.2022.120422 [Accessed: 17th February 2025].

Barry, S. (2024). Presentation in Connect Right meeting, 12th December.

Barry, S. (2025). Email to Elizabeth Witcombe ZSL, 9th January.

*Bathing Water Regulations 2013.* (SI 2013: 1675). Available at: https://www.legislation.gov.uk/uksi/2013/1675/contents [Accessed: 29th January 2025].

BBCNews (2017). *'Monster' fatberg found blocking east London sewer.* Available at: https://www.bbc.co.uk/news/uk-england-london-41238272 [Accessed: 7th January 2025].

BBCNews (2024). *Raw sewage from new homes being flushed into river*. Available at: https://www.bbc.co.uk/news/articles/c704l7xr3ero [Accessed: 8th April 2025].

Beech, T., Daman, J. (2024). Thames Water Environmental Newsletter Winter 2024.

Biomatrix Water (2022). *A Year of Transformation at Graving Dock in London.* Available at: https://www.biomatrixwater.com/news/gravingdocks/#:~:text=October%202022&text=Floating%20Ecosystem%20modules%20are%20a,fish%2C%20pollinators%2C%20and%20invertebrates. [Accessed: 9th April 2025].

Bradley, J., Chisholm, A., Moncrieff, C. (2024). H*ighway runoff and the water environment*. United Kingdom: Stormwater Shepherds and CIWEM. Available at: https://mcusercontent.com/69dac29721f10aed6bd8f0af2/files/013f8803-17ac-a10e-1407-4feeb54846da/Highway_runoff_and_the_water_environment_report_combined_LR.pdf [Accessed: 14th February 2025].

Bradshaw, M. (2025). Email to Elizabeth Witcombe, 9th January.

Brazier, R., Puttock, A., Graham, H., Auster, R., Davies, K., and Brown, C. (2021). Beaver: Nature's ecosystem engineers. Wiley Interdisciplinary Reviews: *Water* 8(1). Available at: https://doi.org/10.1002/wat2.1494 [Accessed: 9th April 2025].

Brierley (2013). The characterisation and quality appraisal of riverbed and road runoff sediments within the Carshalton arm of the River Wandle, London, UK.

Buss, D., Carlisle, D., Chon, T., Culp, J., Harding, J., Keizer-Vlek, H. E., Robinson, W., Strachan, S., Thirion, C., Hughes, R. (2014). Stream biomonitoring using macroinvertebrates around the globe: a comparison of large-scale programs. *Environmental Monitoring and Assessment* 187(1). Available at: doi:10.1007/s10661-014-4132-8 [Accessed: 4th February 2025].

Carter, S., Bright, P. (2003). Reedbeds as refuges for water voles (*Arvicola terrestris*) from predation by introduced mink (*Mustela vison*). *Biological Conservation* 111(3):371-376. Available at: https://doi.org/10.1016/S0006-3207(02)00305-1 [Accessed: 28th March 2025].

CaSTCo (2025). *Putting people at the heart of river recovery.* Available at: https://castco.org/ [Accessed: 28th March 2025].

Catchment Partnerships in London (2020) *River restoration in London: A 20-year review*. Available at: https://www.thames21.org.uk/wp-content/uploads/2020/10/LRW-River-restoration-report-Final.pdf [Accessed: 15th January 2025].

Citizen Crane (2025). Misconnections Citizen Crane Review Document V8.1.

CIWEM (2014). *Policy Position Statement Misconnections*. Available at: https://www.ciwem.org/assets/pdf/Policy/Policy%20Position%20Statement/Misconnections.pdf [Accessed: 6th January 2025].

CIWEM (2022). *River water quality and storm overflows: A systems approach to maximising improvement technical report.* Available at: https://www.ciwem.org/policy-reports/storm-overflows [Accessed: 19th December 2024].

CIWEM and Stormwater Shepherds (2024). *Highway runoff and the water environment report*. Available at: https://www.stormwatershepherds.org.uk/wp-content/uploads/2024/05/Highway-runoff-and-the-water-environment-report-combined-LR.pdf [Accessed: 2nd January 2025].

Cooper, L. (2018). *Unwanted goods, unwanted mess, Tackling London's fly-tipping nuisance*. London: London Assembly Labour. Available at: https://www.london.gov.uk/node/44389#:~:text=Currently%20fly%2Dtipping%20is%20increasing,all%20fly%2Dtipping%20in%20England. [Accessed: 5th February 2025].

Cooper, R., Battams, Z., Pearl, S., Hiscock, K. (2019). Mitigating river sediment enrichment through the construction of roadside wetlands. *Journal of Environmental Management* 231:146-154. Available at: https://doi.org/10.1016/j.jenvman.2018.10.035 [Accessed: 17th February 2025].

Cooper, R.J., Warren, R.J., Clarke, S.J. and Hiscock, K.M., (2022). Evaluating the impacts of contrasting sewage treatment methods on nutrient dynamics across the River Wensum catchment, UK. *Science of the Total Environment* 804. Available at: https://doi.org/10.1016/j.scitotenv.2021.150146 [Accessed: 17th January 2025].

Court, E., Chaudhuri, R., Kapoore, R., Villa, R., Pandhal, J., Biggs, C., Stafford, G. (2021). Looking through the FOG: microbiome characterization and lipolytic bacteria isolation from a fatberg site. *Microbiology* 167(12). Available at: https://www.microbiologyresearch.org/content/journal/micro/10.1099/mic.0.001117 [Accessed 6th January 2025].

Crane Valley Partnership (CVP). (2022). *State of the Environment, River Crane Smarter Water Catchment Programme.* Available at: https://www.cranevalley.org.uk/wp-content/uploads/2022/10/State-of-the-Environment-Report-River-Crane-Smarter-Water-Catchment-October-2022.pdf [Accessed: 8th January 2025].

Crane Valley Partnership (CVP). (2024). *Citizen Crane: Year Ten Report*. Available at: https://www.cranevalley.org.uk/wp-content/uploads/2024/10/Citizen-Crane-Year-10-Report.pdf [Accessed: 8th January 2025].

Data.gov.uk (2024a). *Contaminated Land Special Sites*. Available at: Contaminated Land Special Sites - data.gov.uk [Accessed: 30th January 2025].

Data.gov.uk (2024b). *Water Framework Directive Cycle 2 Heavily Modified Water Body Use and Physical Modification.* Available at: https://www.data.gov.uk/dataset/39c5484d-90ea-41fe-8119-ea699b08689a/water-framework-directive-cycle-2-heavily-modified-water-body-use-and-physical-modification [Accessed: 17th February 2025].

Department for Environment Food & Rural Affairs (DEFRA) (2023). *Our integrated plan for delivering clean and plentiful water*. Available at: https://assets.publishing.service.gov.uk/media/6492c8b35f7bb7000c7fae61/plan_for_water.pdf [Accessed: 13th February 2025].

Department for Environment Food & Rural Affairs (DEFRA) (2024). *Reforms to The Bathing Water Regulations 2013.* Available at: https://www.gov.uk/government/consultations/reforms-to-the-bathing-water-regulations-2013 [Accessed: 29th January 2025].

Department for Environment Food & Rural Affairs (DEFRA) (2025). *Bathing Water Quality*. Available at: https://environment.data.gov.uk/bwq/profiles/help-understanding-data.html [Accessed: 29th January 2025].

Dosskey, M., Vidon, P., Gurwick, N., Allan, C., Duval, T., Lowrance, R. (2010). The role of riparian vegetation in protecting and improving chemical water quality in streams. *Journal of the American Water Resources Association* 46(2):261-277. Available at: https://doi.org/10.1111/j.1752-1688.2010.00419.x [Accessed: 17th January 2025].

Egli, M., Rapp-Wright, H., Oloyede, O., Francis, W., Preston-Allen, R., Friedman, S., Woodward, G., Piel, F., Barron, L. (2023). A One-Health environmental risk assessment of contaminants of emerging concern in London's waterways throughout the SARS-CoV-2 pandemic. *Environmental International* 180. Available at: https://www.sciencedirect.com/science/article/pii/S016041202300483X [Accessed: 17th December 2024].

Ellis, J., Shutes, R., Revitt, D. (2003). *Guidance manual for constructed wetlands*. Environment Agency. Available at: https://assets.publishing.service.gov.uk/media/603761a9d3bf7f0395252cf4/WITHDRAWN-Guidance-Manual-for-Constructed-Wetlands.pdf [Accessed: 17th January 2025].

Ellis, J., Bertrand-Krajewski, J., Revitt, M., Rieckermann, J. (2010). Chapter 1: APUSS: Assessing the significance of infiltration and exfiltration on the performance of urban sewer systems. In: Ellis, J., Bertrand-Krajewski, J. eds. *Assessing the significance of infiltration and exfiltration on the performance of urban sewer systems.* IWA publishing, pp. 1-10. Available at: https://doi.org/10.2166/9781780401652 [Accessed: 11th April 2025].

Ellis, J., Butler, D. (2015). Surface water sewer misconnections in England and Wales: Pollution sources and impacts. *Science of Total Environment* 526:98-109. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0048969715004933 [Accessed: 4th December 2024].

Ellis, J., Revitt, D., Blackwood, D., Gilmour, D. (2004). Leaky sewers: assessing the hydrology and impact of exfiltration in urban sewers. *Hydrology: Science and Practise for the 21st century 2.* Available at: https://rke.abertay.ac.uk/ws/portalfiles/portal/8493918/GilmourHydSciPract21CentPublisher2004.pdf [Accessed: 6th January 2025].

Environment Agency (2019). Walley Hawkes Paisley Trigg (WHPT) index of river invertebrate quality and its use in assessing ecological status. Available at: https://www.scambs.gov.uk/media/g3uifcfw/cd535-environment-agency-walley-hawkes-paisley-trigg-whpt-index-of-river-invertebrate-quality-and-its-use-in-assessing-ecological-status-may-2019.pdf [Accessed: 4th February 2025].

Environment Agency (2023). *Thames River Basin District, Catchment Data Explorer*. Available at: https://environment.data.gov.uk/catchment-planning/RiverBasinDistrict/6 [Accessed: 13th January 2025].

Environment Agency (2024). *Event Duration Monitoring - Storm Overflows - Annual Returns*. Available at: https://environment.data.gov.uk/dataset/21e15f12-0df8-4bfc-b763-45226c16a8ac [Accessed: 19th December 2024].

Exton, B., Hassard, F., Medina-Vaya, A., Grabowski, R. (2024). Undesirable river biofilms: The composition, environmental drivers, and occurrence of sewage fungus. *Ecological Indicators* 161. Available at: https://doi.org/10.1016/j.ecolind.2024.111949 [Accessed: 9th April 2025].

Farming Advice Service (2024). *Tools*. Available at: https://www.farmingadviceservice.org.uk/csf/tools#:~:text=ALERT%20is%20a%20free%20mapping%20tool%20created%20by,analyse%20the%20landscape%20and%20reduce%20pollution%20from%20agriculture. [Accessed: 12th March 2025].

Findlay, S., Kelly, V. (2011). Emerging indirect and long-term road salt effects on ecosystems. *The Year in Ecology and Conservation Biology* 1223(1):58-68. Available at: https://doi.org/10.1111/j.1749-6632.2010.05942.x [Accessed: 13th March 2025].

Freshwater Habitats Trust (2025). *Freshwater Species Conservation*. Available at: https://freshwaterhabitats.org.uk/our-work/conservation-and-practical-delivery/species-conservation/ [Accessed: 28th March 2025].

Giakoumis, T., Voulvoulis, N. (2023). Combined sewer overflows: relating event duration monitoring data to wastewater systems' capacity in England. *Environmental Science: Water Research & Technology* 9:707-722. Available at: https://pubs.rsc.org/en/content/articlehtml/2023/ew/d2ew00637e [Accessed: 19th December 2024].

Gibbons, D., Morrissey, C., Mineau, P. (2015). A review of the direct and indirect effects of neonicotinoids and fipronil on vertebrate wildlife. *Environmental Science and Pollution Research* 22:103-118. Available at: https://link.springer.com/article/10.1007/S11356-014-3180-5 [Accessed: 13th February 2025].

Giechaskiel, B., Grigoratos, T., Mathissen, M., Quik, J., Tromp, P., Gustafsson, M., Franco, V., Dilara, P. (2024). Contribution of Road Vehicle Tyre Wear to Microplastics and Ambient Air Pollution. *Sustainability* 16(2):522. Available at: https://doi.org/10.3390/su16020522 [Accessed: 9th April 2025].

Gilbert, N. (2016). Improvements in water quality by integrated constructed wetlands in the Moore Brook catchment. Available at: https://www.thames21.org.uk/wp-content/uploads/2017/07/Enfield-Spot-sampling-Final-Report_DRAFT.pdf [Accessed: 29th January 2025].

Glover, A., Pecorelli, J. (2023). *Evidencing the Impact of Constructed Wetlands: Headstone Manor Park*. Available at: https://www.cranevalley.org.uk/wp-content/uploads/2023/04/Evidencing-the-Impact-of-Constructed-Wetlands-Headstone-Manor-Park-March-2023.pdf [Accessed: 2nd January 2025].

Glüge, J., Scheringer, M., Cousins, I., DeWitt, J., Goldenman, G., Herzke, D., Lohmann, R., Ng, C., Trier, X., Wangj, Z. (2020). An overview of the uses of per- and polyfluoroalkyl substances (PFAS). *Environmental Science Processes and Impacts* 22: 2345. Available at: https://pubs.rsc.org/en/content/articlepdf/2020/em/d0em00291g [Accessed: 23rd January 2025].

Gov.je (2025). *Blue Fish Campaign: protecting streams, ponds and reservoirs*. Available at: https://www.gov.je/Environment/Water/pages/bluefishcampaign.aspx [Accessed: 23rd January 2025].

GOV.UK (2014). *Land contamination: technical guidance*. Available at: https://www.gov.uk/government/collections/land-contamination-technical-guidance [Accessed: 27th January 2025].

GOV.UK (2016). *Guidance – Pollution Prevention for Businesses.* Available at: https://www.gov.uk/guidance/pollution-prevention-for-businesses [Accessed: 27th January 2025].

GOV.UK (2023). *LCRM: Before you start.* Available at: https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm/lcrm-before-you-start#defining-the-term-land-contamination [Accessed: 27th January 2025].

GOV.UK (2024a). *Surface Water Status*. Available at: https://www.gov.uk/government/statistics/england-biodiversity-indicators/21-surface-water-status [Accessed: 24th January 2025].

GOV.UK (2024b). *Government response to the Office for Environmental Protection report on the implementation of the Water Framework Directive Regulations and River Basin Management Planning in England*. Available at: https://www.gov.uk/government/publications/government-response-to-oeps-report-on-the-implementation-of-the-water-framework-directive-regulations-and-river-basin-management-planning/government-response-to-the-office-for-environmental-protection-report-on-the-implementation-of-the-water-framework-directive-regulations-and-river-bas#:~:text=It%20concludes%20that%20the%20government,be%20introduced%20into%20the%20current [Accessed: 13th February 2025].

GOV.UK (2024c). *Water and sewerage companies in England: EPA metric guide for 2023.* Available at: https://www.gov.uk/government/publications/water-and-sewerage-companies-in-england-environmental-performance-report-2023/water-and-sewerage-companies-in-england-epa-metric-guide-for-2023 [Accessed: 24th January 2025].

GOV.UK (2024d). *List of current bathing waters*. Available at: https://www.gov.uk/government/publications/bathing-waters-list-of-designated-waters-in-england/list-of-current-bathing-waters [Accessed: 29th January 2025].

GOV.UK (2024e). *Designate a bathing water: guidance on how to apply*. Available at: https://www.gov.uk/government/publications/bathing-waters-apply-to-designate-or-de-designate/designate-a-bathing-water-guidance-on-how-to-apply [Accessed: 29th January 2025].

GOV.UK (2025a). *State of the water environment indicator B3: supporting evidence*. Available at: https://www.gov.uk/government/publications/state-of-the-water-environment-indicator-b3-supporting-evidence/state-of-the-water-environment-indicator-b3-supporting-evidence#surface-waters-ecological-and-chemical-classification [Accessed: 13th February 2025].

GOV.UK (2025b). *Swimfo: Find a bathing water*. Available at: https://environment.data.gov.uk/bwq/profiles/ [Accessed: 29th January 2025].

GOV.UK (2025c). *Summary of responses and government response*. Available at: https://www.gov.uk/government/consultations/reforms-to-the-bathing-water-regulations-2013/outcome/summary-of-responses-and-government-response [Accessed: 28th March 2025].

Guo, X., Song, Y., Nan, J. (2017). Flow evaluation of the leaching hazardous materials from spent nickel-cadmium batteries discarded in different water surroundings. *Environmental Science and Pollution Research* 25: 5514-5520. Available at: 10.1007/s11356-017-0923-0 [Accessed: 13th March 2025].

Hintz, W. Relyea, R. (2019). A review of the species, community and ecosystem impacts of road salt salinisation in freshwaters. *Freshwater Biology* 64:1081–1097. Available at: https://doi.org/10.1111/fwb.13286 [Accessed: 17th January 2025].

Howe, C., Crutchley, S. (2020). The River Otter Beaver Trial: Natural England's assessment of the trial and advice on the future of the beaver population. Natural England Evidence Review NEER018. Peterborough: Natural England. Available at: https://publications.naturalengland.org.uk/publication/6537677127286784 [Accessed: 17th January 2025].

Huber, M., Welker, A., Helmreich, B. (2019). Critical review of heavy metal pollution of traffic area runoff: occurrence, influencing factors, and partitioning. *Science of the Total Environment* 541:895–919. Available at: DOI:10.1016/j.scitotenv.2015.09.033 [Accessed: 17th January 2025].

Jacobus, L., Macadam, C., Sartori, M. (2019). Mayflies (Ephemeroptera) and Their Contributions to Ecosystem Services. *Insects* 10(170). Available at: https://doi.org/10.3390/insects10060170 [Accessed: 4th February 2025].

Johnson, A., Jürgens M., Edwards F., Scarlett P., Vincent H., von der Ohe, P. (2019). What Works? the Influence of Changing Wastewater Treatment Type, Including Tertiary Granular Activated Charcoal, on Downstream Macroinvertebrate Biodiversity Over Time. *Environmental Toxicology and Chemistry* 38(8):1820-1832. Available at: DOI:10.1002/etc.4460. [Accessed: 17th January 2025].

Kemp, P., Sear, D., Collins, A., Naden, P., Jones, I. (2011). The impacts of fine sediment on riverine fish. *Hydrological Processes* 25: 1800-1821. Available at: https://doi.org/10.1002/hyp.7940 [Accessed: 17th January 2025].

Kent, R., Anderson, D., Caux, P., Teed, S. (1999). Canadian water quality guidelines for glycols–An ecotoxicological review of glycols and associated aircraft anti-icing and deicing fluids. *Environmental Toxicology* 14(5):481-522. Available at: https://doi.org/10.1002/(SICI)1522-7278(199912)14:5<481::AID-TOX5>3.0.CO;2-8 [Accessed: 13th March 2025].

Landon, M., Hunt, W. (2024). *Installation and Maintenance of Floating Treatment Wetlands: A Guide to Retrofitting Stormwater Retention Ponds in North Carolina*. North Carolina State University: NC State Extension. Available at: https://content.ces.ncsu.edu/show_ep3_pdf/1738325702/25613/ [Accessed: 30th January 2025].

London Assembly (2018). *Farming in London's Green Belt*. Available at: https://www.london.gov.uk/sites/default/files/farminginlondonsgreenbelt.pdf [Accessed: 14th March 2025].

London Borough of Harrow (2016). Wealdstone Brook Catchment Flooding and Pollution Investigation.

London Borough of Harrow, Barnet London Borough, Environment Agency and Department for Environment, Food & Rural Affairs. (2023). DEFRA Policy Challenge – Retrofitting drainage and water management arrangements in urban areas. Available at: https://www.harrow.gov.uk/downloads/file/31740/Policy_Challenge_Paper_FINAL.pdf [Accessed: 27th March 2025].

Markiewicz, A., Björklund, K., Eriksson, E., Kalmykova, Y., Strömvall, A-M., Siopi, A (2017). Emissions of organic pollutants from traffic and roads: Priority pollutants selection and substance flow analysis. *Science of the Total Environment* 580:1162–1174. Available at: https://doi.org/10.1016/j.scitotenv.2016.12.074 [Accessed: 17th January 2025].

Mayor of London (2018). *London Environment Strategy*. Available at: https://www.london.gov.uk/sites/default/files/london_environment_strategy_0.pdf [Accessed: 3rd December 2024].

Mayor of London (2025a). LRNS: unpublished.

Mayor of London (2025b). *River Health*. Available at: https://www.london.gov.uk/programmes strategies/environment-and-climate-change/climate-change/climate-adaptation/river-health [Accessed: 24th January 2025].

Mayor of London (2025c). *River Health Map.* Available at: https://apps.london.gov.uk/river-health/ [Accessed: 29th January 2025].

McConville, A., Hall, A., Harrington, E., Downer, K. (2019). *Plastic Pollution in the River Thames.* Available at: https://www.thames21.org.uk/wp-content/uploads/2020/06/FINAL-Plastic-pollution-in-the-tidal-Thames-v10.pdf [Accessed: 17th January 2025].

McKercher, L., Messer, T., Mittelstet, A., Comfort, S. (2022). A biological and chemical approach to restoring water quality: A case study in an urban eutrophic pond. *Journal of Environmental Management* 318. Available at: https://doi.org/10.1016/j.jenvman.2022.115463 [Accessed: 17th January 2025].

Mrozińska, N., Glińska-Lewczuk, K., Burandt, P., Kobus, S., Gotkiewicz, W., Szymańska, M., Bąkowska, M., Obolewski, K. (2018). Water Quality as an Indicator of Stream Restoration Effects—A Case Study of the Kwacza River Restoration Project. *Water* 10(9). Available at: https://doi.org/10.3390/w10091249 [Accessed: 17th February 2025].

National Highways (2023). *National Highways 2030 Water Quality Plan Mitigating high risk outfalls and soakaways*. Available at: https://nationalhighways.co.uk/media/shhf0vbo/national-highways-water-quality-plan-2030-published-aug-23.pdf [Accessed: 14th February 2025].

National Highways (2023). *National Highways Environmental Sustainability Strategy.* Guildford: National Highways. Available at: https://nationalhighways.co.uk/media/0gcnefrm/nh-environmental-sustainability-strategy_final_020523.pdf [Accessed: 28th March 2025].

National Highways EIR (2025). *Environmental Information Request (EIR) #EIR2025/00004: Information regarding outfalls and soakaways within the Greater London boundary*. Requested from ZSL, 2nd January 2025.

Nayak, S., Sahoo, G., Das, I., Mohanty, A., Kumar, R., Sahoo, L., Sundaray, J. (2023). Poly- and Perfluoroalkyl Substances (PFAS): Do They Matter to Aquatic Ecosystems? *Toxics* 11(6):543. Available at: https://doi.org/10.3390/toxics11060543 [Accessed: 13th February 2024].

Nichols, P., Lucke, T., Drapper, D., Walker, C. (2016). Performance Evaluation of a Floating Treatment Wetland in an Urban Catchment. *Water* 8(6). Available at: https://doi.org/10.3390/w8060244 [Accessed: 17th February 2025].

Ofwat (2024). Notice of Ofwat's proposal to issue an enforcement order and impose a financial penalty on Thames Water. Available at: https://www.ofwat.gov.uk/wp-content/uploads/2024/08/Notice-of-Ofwats-proposal-to-issue-an-enforcement-order-and-impose-a-financial-penalty-on-Thames-Water.pdf [Accessed: 19th December 2024].

Ollard, I., Aldridge, D. (2022). Declines in freshwater mussel density, size and productivity in the River Thames over the past half century. *Journal of Animal Ecology* 92(1):112-123. Available at: https://doi.org/10.1111/1365-2656.13835 [Accessed: 14th February 2025].

Packer, J., Meyerson, L., Skálová, H., Pyšek, P., Kueffer, C. (2017). Biological Flora of the British Isles: *Phragmites australis*. *Journal of Ecology* 105(4):1123-1162. Available at: https://doi.org/10.1111/1365-2745.12797 [Accessed: 1st April 2025].

Pavlineri, N., Skoulikidis, N., Tsihrintzis, V. (2017). Constructed Floating Wetlands: A review of research, design, operation and management aspects, and data meta-analysis. *Chemical Engineering Journal* 308: 1120-1132. Available at: https://doi.org/10.1016/j.cej.2016.09.140 [Accessed: 9th April 2025].

PDSA (People's Dispensary for Sick Animals) (2019). PDSA Animal Wellbeing (PAW) report. Available at: https://www.pdsa.org.uk/media/7420/2019-paw-report_downloadable.pdf [Accessed: 9th April 2025].

Perkins, R., Barron, L., Glauser, G., Whitehead, M., Woodward, G., Goulson, D. (2024). Down-the-drain pathways for fipronil and imidacloprid applied as spot-on parasiticides to dogs: Estimating aquatic pollution. *Science of The Total Environment* 917. Available at: https://www.sciencedirect.com/science/article/pii/S0048969724003103 [Accessed: 17th December 2024].

Perkins, R., Whitehead, M., Civil, W., Goulson, D. (2021). Potential role of veterinary flea products in widespread pesticide contamination of English rivers. *Science of The Total Environment* 755. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0048969720370911 [Accessed: 17th December 2024].

PFAS Scientific Advisory Panel (PSAP*). Second Report of the Independent PFAS Scientific Advisory Panel for Jersey – An Assessment of the Impact on PFAS Exposure on Health*. Jersey: PSAP. Available at: https://www.gov.je/SiteCollectionDocuments/Health%20and%20wellbeing/Report%202%20Health%20impacts%20of%20PFAS.pdf [Accessed: 17th February 2025].

Pinkham, R. (2000). *Daylighting: new life for buried streams*. Colorado: Rocky Mountain Institute. Available at: https://secure.wetlandstudies.com/resources-regulations/documents/Daylighting_NewLifeForBuriedStreams.pdf [Accessed: 10th January 2025].

Port of London Authority (PLA) (2025). *Swimming in the tidal Thames is not an activity which the Port of London Authority encourages.* Available at: https://pla.co.uk/swimming-tidal-thames [Accessed: 29th January 2025].

Ramírez Carnero, A., Lestido-Cardama, A., Vazquez Loureiro, P., Barbosa-Pereira, L., Rodríguez Bernaldo de Quirós, A., Sendón, R. (2021). Presence of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Food Contact Materials (FCM) and Its Migration to Food. *Foods 10*(7): 1443. Available at: https://doi.org/10.3390/foods10071443 [Accessed: 23rd January 2025].

Revitt, M., Worral, P., Brewer, D. (2001). The integration of constructed wetlands into a treatment system for airport runoff. Water Science & Technology 44(11-12):469-476. Available at: DOI:10.2166/wst.2001.0868 [Accessed: 9th April 2025].

RICS (2024). *RICS Home surveys A clear, impartial guide*. Available at: https://www.rics.org/content/dam/ricsglobal/documents/surveying/home-surveys_consumerguide_23.pdf [Accessed 2nd January 2025].

RNLI. *Open Water Swimming.* Available at: https://rnli.org/safety/choose-your-activity/open-water-swimming# [Accessed: 29th January 2025].

Royal Society of Chemistry (2023). Evidence report PFAS in UK waters – presence, detection, and remediation. London: RSC. Available at: https://www.rsc.org/globalassets/04-campaigning-outreach/policy/environment-health-safety-policy/pfas-evidence-report.pdf [Accessed: 9th April 2025].

Russell, I., Glover, A., Pecorelli, J. (2021). *Urban Wetland Design Guide*. Available at: https://cms.zsl.org/sites/default/files/2022-09/2021_Urban%20Wetlands_FINAL%5B125594%5D.pdf [Accessed: 3rd December 2024].

Scottish Environment Protection Agency (SEPA) (2012). Water Pollution Arising from Land Containing Chemical Contaminants second edition. Scotland: SEPA. Available at: https://www.sepa.org.uk/media/28315/water-pollution-arising-from-land-containing-chemical-contaminants.pdf [Accessed: 9th April 2025].

Skinner, A., Young, M., Hastie, L. (2003). Ecology of the Freshwater Pearl Mussel. Conserving Natura 2000 Rivers Ecology Series No. 2 English Nature, Peterborough. Available at: https://www.google.com/url?sa=i&url=https%3A%2F%2Fpublications.naturalengland.org.uk%2Ffile%2F121017&psig=AOvVaw28DdZsM2quURpplZJyJfwj&ust=1744290753772000&source=images&cd=vfe&opi=89978449&ved=0CAcQr5oMahcKEwjA3sHHg8uMAxUAAAAAHQAAAAAQBA [Accessed: 9th April 2025].

Soltaninia, S., Eskandaripour, M., Ahmadi, Z., Ahmadi, S., Eslamian, S. (2024). The hidden threat of heavy metal leaching in urban runoff: Investigating the long-term consequences of land use changes on human health risk exposure. *Environmental Research* 251. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0013935124005723#:~:text=Human%20health%20impacts%20of%20runoff,carcinogenic%20health%20risks%20from%20runoff. [Accessed: 22nd November 2024].

South East Rivers Trust (SERT) (2015). *Butter Hill Phase 3 Project Summary.* Available at: https://wandlevalleypark.co.uk/wp-content/uploads/2015/10/H.-Butter-Hill-Restoration-Case-Study.pdf [Accessed: 17th February 2025].

Spurgeon, D., Wilkinson, H., Civil, W., Hutt, L., Armenise, E., Kieboom, N., Sims, K., Besien, T. (2022). Worst-case ranking of organic chemicals detected in groundwaters and surface waters in England. *Science of The Total Environment* 835. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0048969722021945 [Accessed: 17th December 2024].

Stringer, A., Gaywood, M. (2016). The impacts of beavers Castor spp. on biodiversity and the ecological basis for their reintroduction to Scotland, UK. *Mammal Review* 46(4). Available at: https://doi.org/10.1111/mam.12068 [Accessed: 18th February 2025].

Taylor, K., Owens, P. (2009). Sediments in urban river basins: a review of sediment–contaminant dynamics in an environmental system conditioned by human activities. *Journal of Soils and Sediments* 9:281-303. Available at: https://link.springer.com/article/10.1007/s11368-009-0103-z [Accessed 17th December 2024].

Thames Water (2019). *Finding and Managing Culverted Watercourses.* Available at: https://content.tfl.gov.uk/twu-culverted-watercourses-lane-rental-industry-publication.pdf [Accessed: 15th January 2025].

Thames Water (2024a). *TMS08 Our AMP8 Water Outcomes Delivery Strategy*. Available at: https://www.thameswater.co.uk/media-library/home/about-us/regulation/our-five-year-plan/pr24-2023/water-outcomes.pdf [Accessed: 19th December 2024].

Thames Water (2024b). *Pollution Incident Reduction Plan*. Available at: https://www.thameswater.co.uk/media-library/home/about-us/regulation/pollution-incident-reduction/pollution-incident-reduction-plan.pdf [Accessed: 4th December 2024].

Thames Water (2024c). *Our turnaround Thames Water Annual Report 2023/24*. Available at: https://www.thameswater.co.uk/media-library/home/about-us/investors/our-results/2024-reports/thames-water-annual-report-2023-24.pdf [Accessed: 3rd January 2025].

Thames Water (2024d). *A fatberg the weight of three double decker buses is unblocked from east London*. Available at: https://www.thameswater.co.uk/news/abbey-mills-fatberg [Accessed: 3rd January 2025].

Thames Water (2024e). *PR24 Our Business Plan 2025-2030*. Available at: https://www.thameswater.co.uk/media-library/home/about-us/regulation/our-five-year-plan/pr24-2023/our-business-plan.pdf [Accessed: 3rd January 2025].

Thames Water (2024f). *TMS15 Asset Health Deficit*. Available at: https://www.thameswater.co.uk/media-library/home/about-us/regulation/our-five-year-plan/pr24-2023/asset-deficit.pdf [Accessed: 3rd January 2025].

Thames Water (2025a). *Bin it don't block it*. Available at: https://www.thameswater.co.uk/help/water-and-waste-help/blockages/bin-it Accessed 6th January 2025].

Thames Water (2025b). *TMS-DD-057 WINEP7 Carryover*. Available at: https://www.thameswater.co.uk/media-library/home/about-us/regulation/our-five-year-plan/draft-determination-2024/supporting-documents/enhancement-cases/TMS-DD-057-WINEP7-Carryover-Redacted.pdf [Accessed: 2nd April 2025].

Thames Water EIR (2024). *Environmental Information Request (EIR) #EIR-24-25-428: Information related to drainage misconnections and sewage pollution.* Requested from Thames21, 11th November 2024.

Thames Water. *London's wastewater future. London 2100: The case for change.* Available at: https://www.thameswater.co.uk/media-library/home/about-us/london-2100-a-case-for-change.pdf Accessed: 19th December 2024].

Thames21 (2020). *Road Pollution Solutions*. Available at: https://mapapps.bgs.ac.uk/road-pollution-solutions/ [Accessed: 19th December 2024].

The Building Regulations 2010. Available at: https://www.legislation.gov.uk/uksi/2010/2214/schedule/1/2024-10-01 [Accessed: 20th December 2024].

The Ealing Beaver Project (2025). *The Ealing Beaver Project: Bringing Beavers Back to London*. Available at: https://theealingbeaverproject.com/ [Accessed: 30th January 2025].

The Environmental Permitting (England and Wales) Regulations 2016. Available at: https://www.legislation.gov.uk/uksi/2016/1154/contents [Accessed: 7th January 2025].

The River Restoration Centre (2013). *Restoring Meanders to Straightened Rivers*. Available at: https://www.therrc.co.uk/assets/archive/MOT/Final_Versions_(Secure)/1.6_Ravensbourne.pdf

The Riverfly Partnership (2025). *Riverfly Monitoring Initiative (RMI).* Available at: https://www.riverflies.org/riverfly-monitoring-initiative-rmi [Accessed 2nd January 2025].

The Riverfly Partnership. *Projects Overview*. Available at: https://www.riverflies.org/projects-overview [Accessed: 28th March 2025].

The Riverfly Partnership. *Riverflies Overview*. Available at: https://www.riverflies.org/riverflies-overview [Accessed: 29th January 2025].

The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. (2017/407). Available at: https://www.legislation.gov.uk/uksi/2017/407/regulation/13 [Accessed: 13th February 2025].

Thellmann, P., Kuch, B., Wurm, K., Köhler, H., Triebskorn, R. (2017). Water quality assessment in the "German River of the years 2014/2015": how a case study on the impact of a storm water sedimentation basin displayed impairment of fish health in the Argen River (Southern Germany). *Environmental Sciences Europe* 29(10). Available at: https://link.springer.com/article/10.1186/s12302-017-0108-y [Accessed 6th January 2024].

Trach, Y., Trach, R., Kuznietsov, P., Pryshchepa, A., Biedunkova, O., Kiersnowska, A. and Statnyk, I., (2024). Predicting the influence of ammonium toxicity levels in water using fuzzy logic and ANN models. *Sustainability* 16(14): 5835. Available at: https://doi.org/10.3390/su16145835 [Accessed: 17th January 2025].

UKCEH. *RIVPACS reference database*. Available at: https://www.ceh.ac.uk/data/software-models/rivpacs-reference-database [Accessed: 4th February 2025].

Van Biervliet, O., Gilbert, N., Collins, L., Davies, B. (2015). London Total Suspended Solids Project.

Vaughn, C., Hakenkamp, C. (2001). The functional role of burrowing bivalves in freshwater ecosystems. *Freshwater Biology* 46:1431-1446. Available at: file:///C:/Users/Elizabeth.Witcombe/Downloads/VaughnHakenkamp.FWBiol.2001.pdf [Accessed: 14th February 2025].

Vereycken, J., Aldridge, D. (2023). Bivalve molluscs as biosensors of water quality: state of the art and future directions. *Hydrobiologia* 850:231-256. Available at: https://link.springer.com/article/10.1007/s10750-022-05057-7 [Accessed: 14th February 2025].

Visanji, Z. (2023). *Road Pollution Solutions Tool Technical Summary*. Available at: https://www.thames21.org.uk/improving-rivers/road-run-off/ [Accessed: 21st November 2024].

Webb, B., Marshall,. B., Czarnomski, S., Tilley, N. (2006). *Fly-tipping: Causes, Incentives and Solutions.* London: UCL Jill Dando Institute of Crime Science. Available at: https://www.researchgate.net/publication/238523261_Fly-tipping_Causes_Incentives_and_Solutions [Accessed: 11th April 2025].

Wenger, S. (1999). A review of the scientific literature on riparian buffer width, extent and vegetation. Available at: https://www.researchgate.net/publication/252178206_A_Review_of_the_Scientific_Literature_on_Riparian_Buffer_Width_Extent_and_Vegetation [Accessed 16th January 2025].

WFD-UKTAG (2021). UKTAG River Assessment Method Benthic Invertebrate Fauna. https://wfduk.org/sites/default/files/River%20Invertebrates%20WHPT%20UKTAG%20Method%20Statement%20-%20updated%20May%202021.pdf [Accessed: 4th February 2025].

Whitehead, P., Bussi. G., Hughes, J., Castro-Castellon, A., Norling, M., Jeffers, E., Rampley, C., Read, D., Horton, A. (2021). Modelling Microplastics in the River Thames: Sources, Sinks and Policy Implications. *Water* 13(6):861. Available at: https://doi.org/10.3390/w13060861 [Accessed: 8th April 2025].

Wildfish (2017). The impact of excess fine sediment on invertebrates and fish in riverine systems. Available at: https://wildfish.org/wp-content/uploads/2022/05/WildFish-Sediment-Literature-Review-2017.docx-1.pdf [Accessed: 8th January 2025].

Willby, N., Law, A., Levanoni, O., Foster, G., Ecke, F. (2018). Rewilding wetlands: beaver as agents of within-habitat heterogeneity and the responses of contrasting biota. *Philosophical Transactions of the Royal Society B: Biological Sciences* 373(1761). Available at: http://doi.org/10.1098/rstb.2017.0444 [Accessed: 18th February 2025].

Williams, A., Simmons, S. (1999). Sources of riverine litter: The River Taff, South Wales, UK. *Water Air and Soil Pollution* 112(1):197-216. Available at: DOI:10.1023/A:1005000724803 [Accessed: 9th April 2025].

Wohl, E., Angermeier, P., Bledsoe, B., Kondolf, G., MacDonnell, L., Merritt, D., Palmer, M., Poff, N., Tarboton, D., (2005). River restoration. *Water Resources Research* 41(10). Available at: https://doi.org/10.1029/2005WR003985 [Accessed 17th January 2025].

Wohl, E., Lane, S., Wilcox, A. (2015). The science and practice of river restoration. *Water Resources Research* 51(8): 5974-5997. Available at: https://doi.org/10.1002/2014WR016874 [Accessed 17th January 2025].

Yeh, N., Yeh, P., Chang, Y. (2015). Artificial floating islands for environmental improvement. *Renewable and Sustainable Energy Reviews* 47: 616-622. Available at: https://www.sciencedirect.com/science/article/abs/pii/S1364032115002439 [Accessed: 9th January 2025].

Yoder, L., Egli, M., Richardson, A., Brooker, A., Perkins, R., Collins, T., Cardwell, J., Barron, L., Waage, J. (2024). Dog swimming and ectoparasiticide water contamination in urban conservation areas: A case study on Hampstead Heath, London. *Science of The Total Environment* 955. Available at: https://doi.org/10.1002/2014WR016874 [Accessed: 17th December 2024].

Zhang, C., Wen, L., Wang, Y., Liu, C., Zhou, Y., & Lei, G. (2020). Can Constructed Wetlands be Wildlife Refuges? A Review of Their Potential Biodiversity Conservation Value. *Sustainability* 12(4): 1442. Available at: https://doi.org/10.3390/su12041442 [Accessed: 17th January 2025].

Zhang, S., Shen, C., Zhan, F., Wei, K., Shan, S., Zhao, Y., Man, Y., Wong, M., Zhang, J. (2024). Microplastics removal mechanisms in constructed wetlands and their impacts on nutrient (nitrogen, phosphorus and carbon) removal: A critical review. *Science of the Total Environment* 918. Available at: https://doi.org/10.1016/j.scitotenv.2024.170654 [Accessed: 17th February 2025].

ZSL (2021). *The State of the Thames 2021: Environmental trends of the Tidal Thames*. McCormick, H., Cox, T., Pecorelli, J., and Debney, A. (Eds). ZSL, Regent's Park, London, UK. Available at: https://cms.zsl.org/sites/default/files/2022-10/ZSL_TheStateoftheThamesReport_Nov2021_0.pdf [Accessed: 8th April 2025].

ZSL (2021a). *Frogs Ditch Water Quality Assessment, Impacts and Recommendations for Improvement*. Available from ZSL.

# APPENDICES

## Appendix A

### Table 1. Water Framework Directive Priority Substances (Official Journal of the European Union 2013)

| NUMBER | NAME OF PRIORITY SUBSTANCE | IDENTIFIED AS PRIORITY HAZARDOUS SUBSTANCE | USE |
|---|---|---|---|
| (1) | Alachlor | | Herbicide |
| (2) | Anthracene | X | (PAH) used to make dyes, plastics and pesticides |
| (3) | Atrazine | | Herbicide |
| (4) | Benzene | | Solvent in the chemical and pharmaceutical industries, as a starting material and an intermediate in the synthesis of numerous chemicals, and in gasoline |
| (5) | Brominated diphenylethers | X | Flame retardants in polyurethane foams in upholstery and in polymer resins and plastics used as components in electrical equipment. |
| (6) | Cadmium and its compounds | X | used as pigments in a wide variety of applications, including engineering plastics, glass, glazes, ceramics, rubber, enamels, artists colours, and fireworks. |
| (7) | Chloroalkanes, C 10-13 | X | polymers, adhesives and sealants and coating products |
| (8) | Chlorfenvinphos | | Insecticide |
| (9) | Chlorpyrifos (Chlorpyrifos-ethyl) | | Insecticides |
| (10) | 1,2-dichloroethane | | mainly used in the production of vinyl chloride monomer which is used to make PVC. |
| (11) | Dichloromethane | | Used as an aerosol solvent, in the production of pharmaceuticals and as a degreasing agent in electronics and manufacturing industries. |
| (12) | Di(2-ethylhexyl)phthalate (DEHP) | X | (PVC) plastic products like toys, vinyl upholstery, shower curtains, adhesives, and coatings. |

| | | | |
|---|---|---|---|
| (13) | Diuron | | Herbicide |
| (14) | Endosulfan | X | Pesticide |
| (15) | Fluoranthene | | Used to line the interior of steel and ductile-iron water pipes and storage tanks, as an intermediate in fluorescent dye, pharmaceutical and pesticide production, and in chemical, biochemical or cancer research. |
| (16) | Hexachlorobenzene | X | Pesticides, fireworks, ammunition and synthetic rubber |
| (17) | Hexachlorobutadiene | X | Used to make rubber, it is used as a solvent and to make lubricants, in gyroscopes, as a heat transfer liquid, and as a hydraulic fluid. |
| (18) | Hexachlorocyclohexane | X | Insecticide |
| (19) | 251-835-4 | | Herbicide |
| (20) | Lead and its compounds | | Manufacture of matches, ammunition, fireworks, explosives, pottery glazes, ceramics, brake shoes, flame retardants for plastics and as catalysts for industrial production and epoxy curing agents |
| (21) | Mercury and its compounds | X | Dental industry, mining |
| (22) | Naphthalene | | Used in production of dyes, plasticisers, insecticides and some pharmaceutical products |
| (23) | Nickel and its compounds | | Chemical process equipment, food process equipment, heater elements, coins, magnets, batteries and more |
| (24) | Nonylphenols | X | antioxidant, lubricant, pesticides |
| (25) | Octylphenols | | Intermediate in the production of phenolic resins and in the manufacture of octylphenol ethoxylates |
| (26) | Pentachlorobenzene | X | Used to make fungicide |

| | | | |
|---|---|---|---|
| (27) | Pentachlorophenol | | Pesticide and wood preservative |
| (28) | Polyaromatic hydrocarbons (PAH) | X | Dyes, plastics and pesticides |
| (29) | Simazine | | Herbicide |
| (30) | Tributyltin compounds | X | Pharmaceutical manifacture |
| (31) | Trichlorobenzenes | | Dye carrier |
| (32) | Trichloromethane (chloroform) | | Industrial solvent |
| (33) | Trifluralin | X | |
| (34) | Dicofol | X | Pesticide |
| (35) | Perfluorooctane sulfonic acid and its | X | PFAS |
| (36) | Quinoxyfen | X | Fungicide |
| (37) | Dioxins and dioxin-like compounds | X | By-product of smelting, chlorine bleaching of paper pulp and the manufacturing of some herbicides and pesticides |
| (38) | Aclonifen | | Herbicide |
| (39) | Bifenox | | Herbicide |
| (40) | Cybutryne | | Herbicide |
| (41) | Cypermethrin | | Insecticide |
| (42) | Dichlorvos | | Insect/parasite control |
| (43) | Hexabromocyclododecanes (HBCDD) | X | Flame retardant |
| (44) | Heptachlor and heptachlor epoxide | X | Insecticide |
| (45) | Terbutryn | | Herbicide |

## Appendix B

**Table 8. Total number of unresolved misconnections in each of the London boroughs (Thames Water EIR 2025)**

| LONDON BOROUGH | NUMBER OF OUTSTANDING MISCONNECTION CASES (PROPERTIES)* |
|---|---|
| **Barking and Dagenham** | 33 |
| **Barnet** | 103 |
| **Bexley** | 4 |
| **Brent** | 79 |
| **Bromley** | 9 |
| **Camden** | 0 |
| **Croydon** | 14 |
| **Ealing** | 133 |
| **Enfield** | 23 |
| **Greenwich** | 1 |
| **Hackney** | 2 |

| | |
|---|---|
| **Hammersmith and Fulham** | 0 |
| **Haringey** | 161 |
| **Harrow** | 56 |
| **Havering** | 6 |
| **Hillingdon** | 23 |
| **Hounslow** | 21 |
| **Islington** | 0 |
| **Kensington and Chelsea** | 0 |
| **Kingston upon Thames** | 24 |
| **Lambeth** | 2 |
| **Lewisham** | 0 |
| **Merton** | 14 |
| **Newham** | 3 |
| **Redbridge** | 29 |
| **Richmond upon Thames** | 4 |
| **Southwark** | 0 |
| **Sutton** | 17 |
| **Tower Hamlets** | 0 |
| **Waltham Forest** | 51 |
| **Wandsworth** | 0 |
| **Westminster** | 0 |

## SUGGESTED CITATION

ZSL (2025). Working with nature to improve water quality in London. Witcombe, E., Facey, S., Glover, A., Pecorelli, J. (Eds). ZSL, Regents Park, London, UK.

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