Highway runoff and the water environment

May 2024

STORMWATER SHEPHERDS

CIWEM

Front cover image: Shows a highway outfall to the Massey Brook from the M6

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We would like to thank David Brydon of Blackwell Water Consultancy Ltd for the analysis and modelling carried out for this report. We would also like to thank the following people for their review and contributions: Lian Lundy (Middlesex University), Bridget Woods-Ballard (HR Wallingford), Peter Bide (CaBA), Rob Collins (The Rivers Trust), John Brydon (Thames21), Paul Shaffer (CIWEM), Mark Charlesworth (Natural Resources Wales), Andrew Hemingway (SEPA) and Ian Titherington (Welsh Government).

This work was generously supported by Rees Jeffreys Road Fund.

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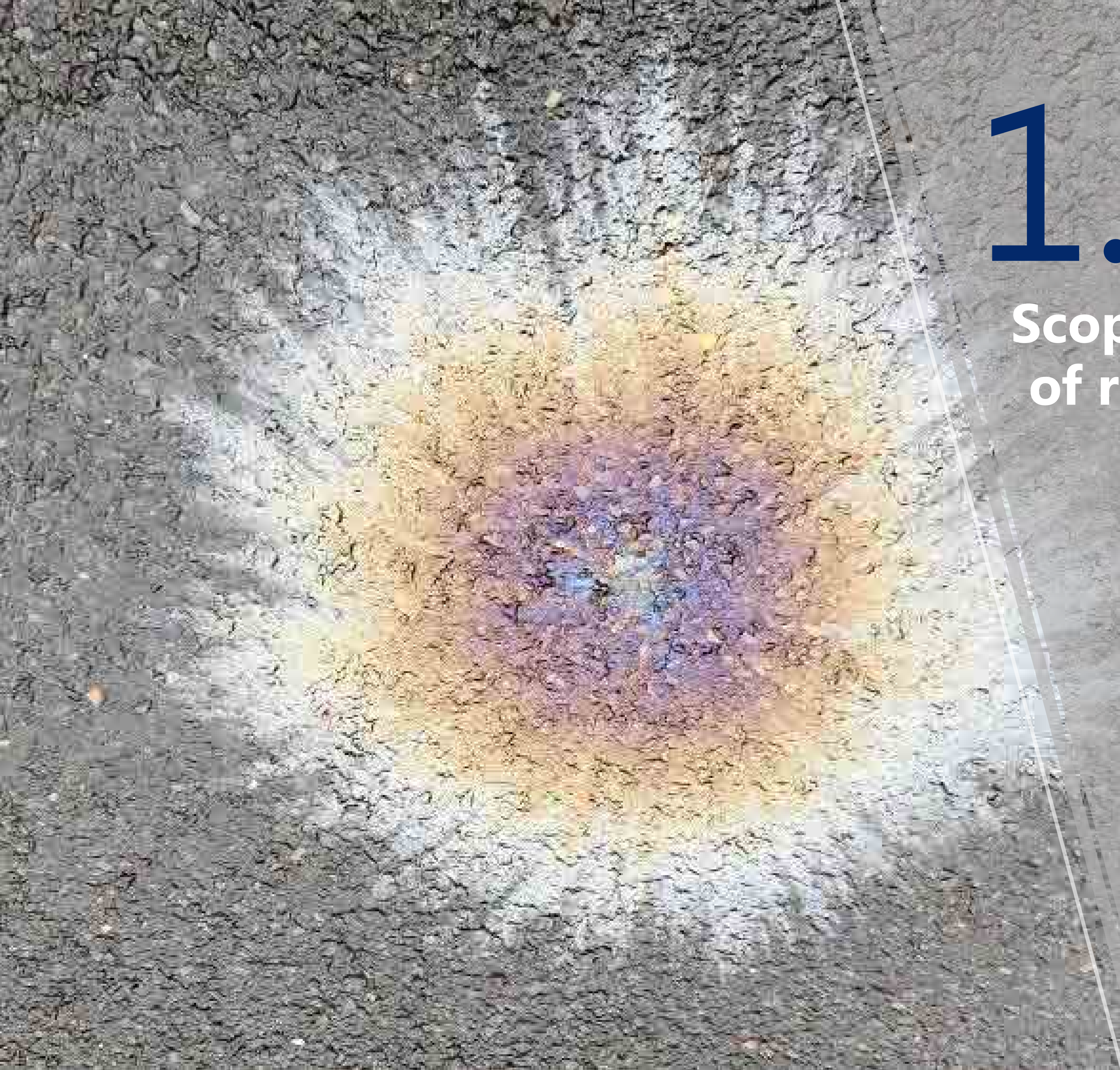
Contents



1. Scope of report

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Across the UK's road network, highway runoff washes into the environment every time it rains. The runoff is polluted with microplastics, trace metals, hydrocarbons and other organic pollutants which enter our rivers; yet treatment of this pollution is too often absent or inadequate.

Appreciation of the nature and extent of highway pollution is very low despite pollution from towns, cities and transport officially contributing to 18 per cent of water body failures to achieve good status under the Water Framework Directive[1] , and rapidly growing public concern around river health.

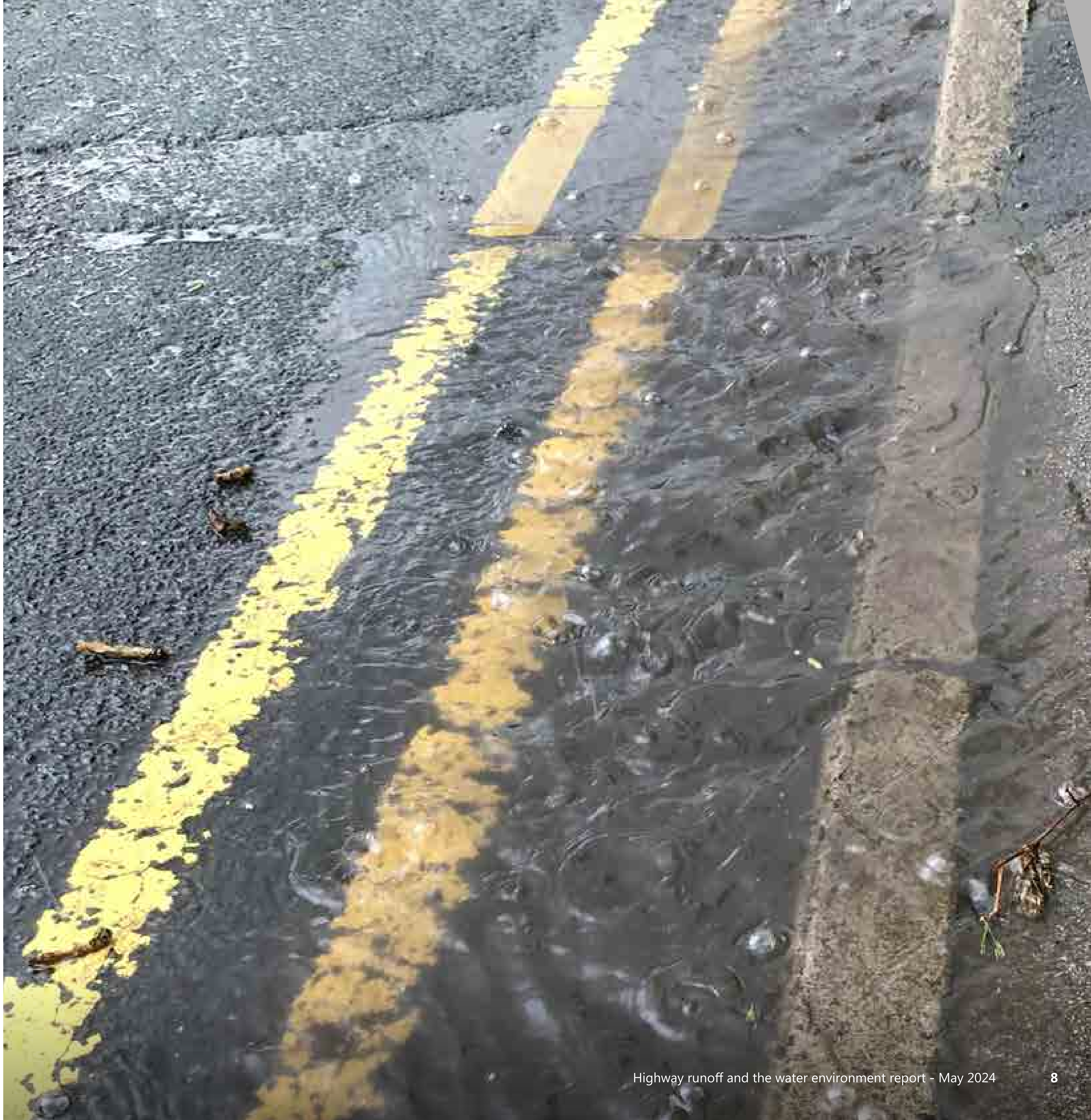
Although an understanding exists of the presence and toxicity of substances in highway runoff and the ease with which they can enter watercourses, there is very limited data on runoff discharge volumes and pollutant concentrations. Further investigation is also needed into the impacts of these polluted discharges on ecological and human health.

Potential solutions do exist, as do experienced designers who can create effective treatment schemes. But we need to find a way to pay for many such schemes to be delivered.

This report identifies the problem caused by pollution from highway outfalls, estimating its scale, nature and cumulative impact, and considers the potential solutions through environmental permitting, funding streams and remediation. It seeks to raise the profile of highway runoff with highway authorities, the public and decision-makers, and ultimately significantly reduce its harm on the environment.

The report's focus is England given the research presented was undertaken in England.

1. HM Government. Environmental Improvement Plan. 2023



2. Executive summary

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Highway runoff is a widespread pollution problem which causes harm to rivers and streams, but is lightly managed

Across England's road network, surface water runoff washes into the environment every time it rains. This is polluted with microplastics, trace metals, hydrocarbons and other organic pollutants which enter our rivers through outfalls from the road network.

Nationally, there are more than 18,000 known outfalls[2] associated with the motorway and trunk road network (operated by National Highways) and likely more than a million local highway drains discharging directly to watercourses (there is no reliable data on the number, location and condition of these).

This form of urban pollution frequently falls through the gaps when it comes to policy, legislation and management. It is often referred to as 'diffuse' because it originates from many widespread sources, but in many cases, it impacts receiving water in a concentrated, 'point source' way through outfalls.

This report considers samples taken by Stormwater Shepherds in the North West of England between 2021 and 2024, as well as older research. These samples provide a fuller picture than has previously existed of the extent and effects of pollution runoff from different types of roads.

Our findings show that the discharges fail the Environmental Quality Standards (EQS)[3] for several polyaromatic hydrocarbon (PAH) pollutants and that these pollutants cause harm to the waters into which they are discharged.

Whilst there is much political and media focus on pollution from sewage and farming activities, the impacts of pollution from roads are not well-understood and the data informing our understanding of the scale of the problem is not extensive.

Our findings indicate that harm caused by this pollution is likely to be greater than indicated by the Water Framework Directive figure, associating 18 per cent of reasons why waters fail to achieve good ecological quality status with 'pollution from towns, cities and transport'[4]. Our findings raise the question as to whether road runoff discharges should require permitting (as other polluting discharges would) as a mechanism to control highway pollution and drive improvements in our surface waters which are extensively failing against chemical and ecological targets[5].

M56 motorway in wet conditions

2. National Highways. Disclosure Log, Outfall pollution (FOI 5449). May 2023
3. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
4. Environment Agency, Natural England. State of the water environment indicator B3: supporting evidence. May 2023
5. Ibid

Highway runoff contains multiple poisonous and harmful substances

The pollutants in highway runoff come from multiple sources. They are deposited on the road surface as well as passing into the atmosphere around the road. They include:

- Road surface and markings worn down through use
- Microplastics particularly from vehicle tyres
- Dust containing heavy metals from brakes, clutches and other components
- Fluids from windscreens, engines, brakes and hydraulics, and fuel additives
- Combustion emissions and unburned fuel
- Spillages from accidents and leaks on vehicles
- Road salt
- Herbicides used on road verges
- Metals from road furniture
- Soils, sand and sediment from tyres or from washed or blown sediment onto the road surface from surrounding land

The combinations of these pollutants are variable due to differing road, traffic and weather conditions. The lack of data on this pollution makes it difficult to alert the relevant responsible authorities on where they should be prioritising action.

Research by the Environment Agency and Highways England (predecessor to National Highways) has identified a number of pollutants commonly found in highway runoff: Copper, Zinc, Cadmium, fluoranthene, pyrene and polyaromatic hydrocarbons (PAHs).

These are identified as specific pollutants, priority substances[6] or priority hazardous substances (substances of major concern for European waters due to their toxicity, bio-accumulating properties and/or persistence in the environment that under the Water Framework Directive and its regulations should be progressively reduced or eliminated from surface water).

PAHs express different forms of toxicity, from carcinogenic through to endocrine disrupting, immunotoxicity or oxidative stress depending on the chemical and organism, impacting growth, reproduction and function of the organism.

Metals have similar impacts on invertebrates, causing the reduction in size or absence of populations of certain species, as well as having impacts on larvae of amphibian species. Metals do not break down, meaning they accumulate in concentration up the food chain.

Microplastics, particularly tyre-wear particles dominant in road runoff samples are demonstrated to have both lethal and sub-lethal toxicity to different species of organisms, associated with chemical leachates from the particles.

Sediment can cause both physical harm to the habitats important to organisms, as well as mobilising the toxic substances present in them downstream of outfalls, impacting organisms which ingest them either when suspended in the water column or within the sedimentary layer of the bed of the water body.

The ongoing impact of these discharges of highway runoff on the water environment – and the harm that they cause to the aquatic ecosystem – is not widely measured. The Environment Agency does not have a specific monitoring programme assessing the impact of highway runoff on the water environment[7].

Likewise, National Highways and highway authorities do not routinely monitor the discharges of highway runoff entering the water environment from their network. Instead they rely on their own risk assessment tool.

Outfall from a car park, Wigan

6. Directive 2013/39/EU Priority Substances Directive
7. Environment Agency. Response to FOI request made by BBC, February 2024

Samples show evidence of exceedance of Environmental Quality Standards

Environmental Quality Standards (EQS) are limit values set by regulation to manage the concentrations of defined harmful substances. For water these have been set under the Water Framework Directive[8].

The Environmental Permitting Regulations 2016[9] dictate that any discharge of poisonous materials into a watercourse is a criminal offence, unless the discharge is made in compliance with a permit to discharge.

Samples analysed by this research from nine locations (three motorway outfalls and six local highway outfalls) show that the discharges concerned fail the EQS for several PAHs. These consistently exceeded their maximum allowable concentrations, in once case being 730 times higher. EQS levels were exceeded in samples taken at outfalls from both motorways and local roads.

Assessment undertaken against the Environment Agency's environmental permitting modelling guidance[10] on hazardous chemicals for samples taken at the Cuerden Valley Park outfall in Lancashire indicates that pollutant discharges at the levels found are such that the outfall should be considered as potentially permittable. Were the Environment Agency to agree it would then undertake a risk assessment to assign appropriate permit conditions to manage the impact of the outfall.

Moreover, the sample results from Massey Brook, which is defined as a low risk outfall by National Highways, showed the highest levels of PAHs ever recorded by Stormwater Shepherds UK in a discharge of highway runoff.

Highway runoff discharges are not currently permitted

Section 100 of the Highways Act 1980[11] gives a highway authority the power to discharge surface water from highway drains into any inland waters, or into any tidal waters.

Ordinarily a discharge of polluting matter into a watercourse would require a permit under paragraph 4 of schedule 21 to the Environmental Permitting (England and Wales) Regulations 2016.

The Environment Agency currently does not require highway authorities to apply for permits[12] for discharges from urban surfaces despite having the powers to do so, seemingly on the assumption that water running off roofs, roads and carparks is typically uncontaminated.

Therefore, National Highways and other highway authorities in England have no permits in place for managing pollutants in any of their outfalls. Water company surface water sewers that convey highway runoff into the water environment do not ordinarily have water discharge activity permits either.

However, highway authorities' powers to discharge do not allow them to cause pollution with impunity nor exempt them from enforcement action in the event of pollution from either a site or outfall[13,14]. The Environment Agency must uphold the requirements of relevant EU directives, such as the Environmental Quality Standards Directive. If highway discharges are shown to prevent compliance with these standards, then they should be controlled by the Environment Agency as necessary.

National Highways undertakes its own risk assessments of polluting highway drainage outfalls using the Highways England Water Risk Assessment Tool (HEWRAT). This assesses the combination of heavy traffic loading and sensitive receiving waters; National Highways then implements a programme of improvements where the risks are shown to be high.

Since HEWRAT identifies 1054 outfalls[15] that potentially pose a high risk of pollution, it may be argued that the Environment Agency should serve notice on them to apply for a permit.

8. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
9. The Environmental Permitting (England and Wales) Regulations 2016
10. Environment Agency, Defra. Guidance: Surface water pollution risk assessment for your environmental permit. February 2022
11. Highways Act 1980, Section 100
12. Environment Agency, Defra. Guidance: Discharges to surface water and groundwater: environmental permits. February 2024
13. Highways Agency. Memorandum of Understanding between Highways Agency and Environment Agency: Annex 1 - Water Environment. November 2009
14. Highways England, Environment Agency. Memorandum of Understanding. April 2018 (National Highways, FOI/7262)
15. National Highways. National Highways 2030 Water Quality Plan - Mitigating high risk outfalls and soakaways. August 2023

The Agency should then carry out a risk assessment to assign permit conditions that protect the environment from harm and ensure compliance with the Water Framework Directive. For the outfalls owned by local authorities and water authorities, desk-top modelling could identify the outfalls at highest risk of causing pollution and they too could be served with a notice.

This, however, is not happening and so understanding of the scale and nature of the problem is poor and there is no process to systematically prioritise the deployment of appropriate treatment for particularly harmful runoff.

Our research illustrates that the levels of pollution are sufficiently high that the discharges should – according to regulations – be controlled using the environmental permitting regime and that the voluntary agreement with National Highways is not effectively protecting rivers from pollution.

If National Highways, other highway authorities and water companies were made to apply for permits for high-risk outfalls from the road network, that would enable the Environment Agency to control them more effectively. It would also generate an income to allow the Environment Agency to resource the control of the outfalls. This would provide an incentive for highway authorities to reduce pollution at source by working with vehicle manufacturers and to develop more effective treatment devices.

Solutions

There are widespread treatment technologies and devices for managing highway runoff readily available in the UK. These range from grit and oil separators, filter and sedimentation structures through to vegetative treatment features and ponds, basins and wetlands.

These treatment schemes must be appropriately maintained for them to remain functional. Vortex Grit Separators can easily accumulate over 5 tonnes of contaminated sediment each year and if this is not removed, the separator becomes ineffective. Equally, oil/water separators must have their filters checked and exchanged regularly or they cease to work properly.

Removing the water pollutants from cars on the roads in the UK is complex and challenging. It is essential that new schemes include good drainage design and that they are properly maintained, so that newly built highway outfalls are not adding to the pollution caused by existing highway outfalls.

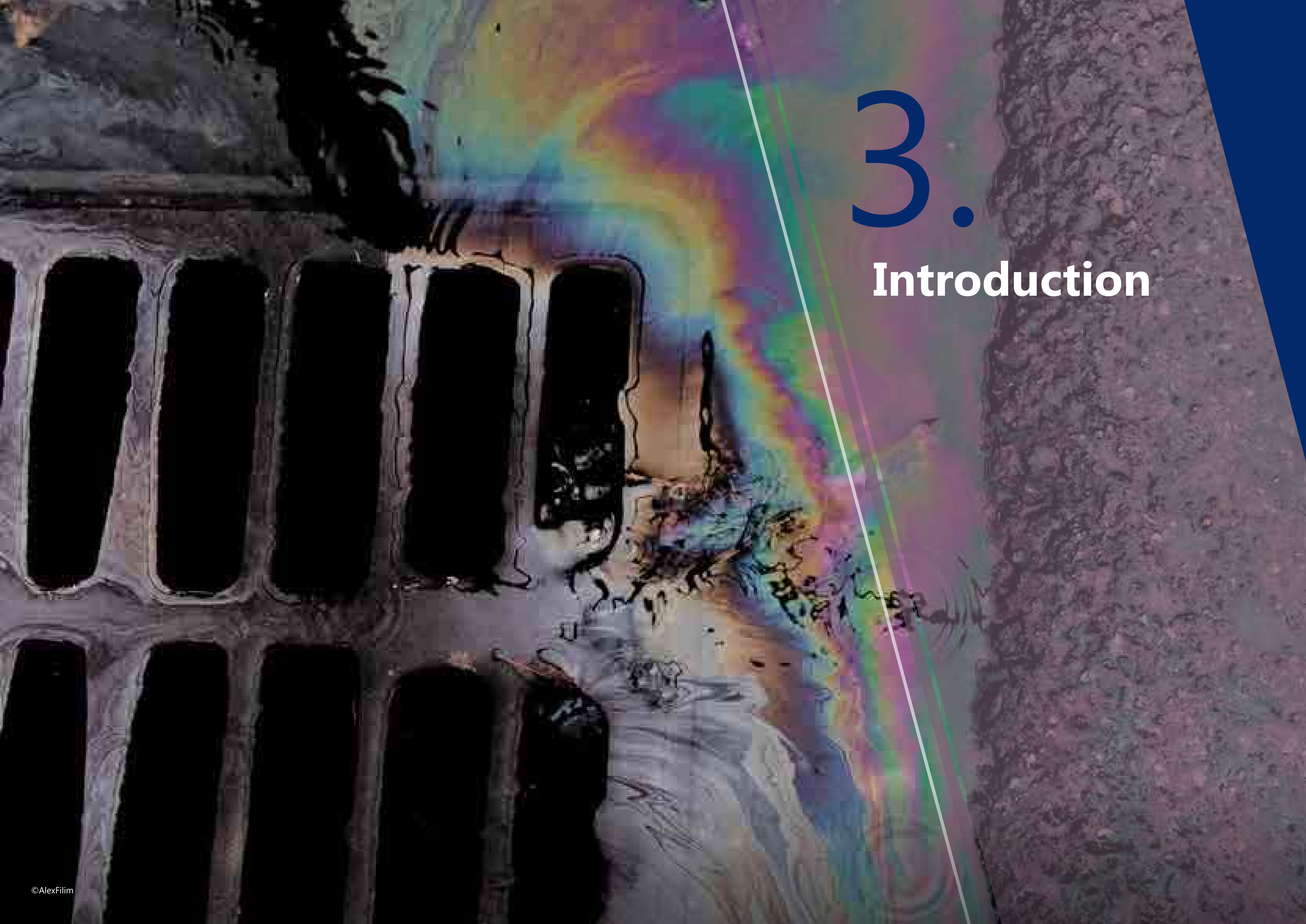
Likewise, we argue that there should be far greater emphasis on the control of pollutants at their source. There are a range of interventions in progress aimed at reducing levels of PAHs in fuel oils and tyres. These control mechanisms are slowly reducing pollution from roads and vehicles, but they cannot eradicate it. Even with the advent of electric cars, there will still be pollution from tyre-wear particles and brake dust, so effective pollution control must continue to be pursued.

Recommendations

We call on the Government to deliver the following actions to improve the management of harmful road runoff:

- The Department for Transport must look beyond other important issues such as road safety and be ambitious on wider issues that are of increasing importance to the public, such as managing the considerable environmental impact of roads.
- There must be far greater emphasis on the control of pollutants at their source, including enforcing legislation to control use of PAHs in the manufacture of tyres, and ensuring new Euro 7 Emissions Standards on tyre abrasion limits are properly adopted by manufacturers when they come into force in 2025.
- All new road schemes should include good drainage design, and crucially provision for effective monitoring, operation and maintenance of drainage and treatment schemes.
- The HEWRAT model should be reviewed and its outputs compared with the risk assessments undertaken by the Environment Agency; we are concerned that there is currently no robust process to systematically prioritise the deployment of appropriate treatment for harmful runoff.
- A catchment-based approach to assessing risk of harm from highway outfalls should be adopted, so that the most polluting outfall sources can be prioritised for remedial action and the most cost-effective solutions developed.
- The control of pollution from National Highways' network is a statutory duty, and should be paid for from their core budget. An ambitious settlement for environmental protection should be included within National Highways' next road budget agreed with the Department for Transport.
- The introduction of extended producer responsibility levies on products such as tyres, fuel oils and brake pads should be introduced. This could provide the Department for Transport with greater budget to allow National Highways to install remediation schemes at high risk outfalls.
- Alternatively, or in addition, the introduction of a Stormwater Utility Levy should be considered (as used in Germany). Under this mechanism, each household pays a monthly fee into a central or regional fund to pay for better management of surface water. This could be set up to give local authorities the power to prioritise and address polluting outfalls within their area, as well as delivering against wider government policy objectives, for example, storm overflows and surface water flooding.
- The Environment Agency should seriously consider issuing permits for high-risk outfalls from the road network. This would enable them to control the pollution by dictating the level of treatment that is required to protect the receiving watercourse and requiring that treatment devices be maintained and operated properly. It would also generate an income to allow the Environment Agency to resource the control of the outfalls.

Filter drain on the A66 in Cumbria



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3. Introduction

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a) Highway runoff and the water environment

Water pollution is currently a high-profile topic as politicians, activists and local people have increased the focus on river health[16], the risks associated with swimming in rivers and seas, and the impact on the quality of our local environment.

The narrative across the British press focusses primarily on sewage pollution from water companies, along with increasing amounts of coverage about pollution from agriculture. Pollution from highways and urban surfaces is under-reported and is not attracting the same level of scrutiny, interrogation and investment as other sources.

The Office of Environmental Protection reported[17] on the progress in improving the natural environment in England in 2022 to 2023. They noted that policies to address pollution from towns, cities and transport are notably absent from the government's environmental improvement plan.

Across the UK, highway runoff enters the water environment when it rains. Our findings, along with extensive published evidence show that the runoff is generally polluted and, in many situations, the pollution is unacceptable and treatment must be introduced.

Pollution from highway runoff is identified as a diffuse pollution problem because there are multiple discharges in towns and cities, but the discharges enter the water environment via pipes and outfall structures at defined locations so they act as 'point source' pollution, which in other contexts would commonly be regulated. Only discharges to ground, via infiltration devices, can be considered to be truly diffuse pollution from highways. The pollution that results from these discharges needs further investigation to quantify its impact.

This problem affects three main groups of asset owners in England:

1. **National Highways** is responsible for the Strategic Road Network which comprises 1,865 miles of motorway and 2,571 miles of trunk roads. It accounts for 3 per cent of all roads but carries 33 per cent of all traffic and 66 per cent of all road freight.

2. **Local Authorities** own and operate almost all of the remaining road network and the number of outfalls from this network is unknown.

3. **Water and sewerage companies** own the surface water sewers which are often the conduit from the road to the water environment. They are responsible for the discharge from their outfalls into the water environment.

The boundaries of ownership and responsibility for these drains can often be blurred, particularly between local highway authority and water company drains and sewers. Current responsibilities may not fully reflect historic ones. Current water industry guidance[18] on adoption of drains states: "Any system that only provides highway drainage is not adoptable by the water and sewerage company. A system may accept some highway drainage, but this cannot be the main purpose of the system."

Together, these three groups need to quantify the problem and identify opportunities for solutions, which are often best delivered in partnership, using the various skill sets of all three groups.

16. House of Commons Environmental Audit Committee. Water Quality in Rivers – Fourth Report of Session 2021-22. January 2022
17. Office for Environmental Protection. Progress in improving the natural environment in England 2022 to 2023. January 2024
18. Water UK. Sewerage Sector Guidance: A changed approach to surface water sewers. 2020

b) National Highways' outfalls

National Highways has good knowledge of its drainage infrastructure and the location of many of its outfalls and soakaways, the details of which are recorded in their drainage data management systems. There are approximately 18,000 National Highways outfalls to surface water, categorised according to the pollution risk that they represent to the receiving water. In March 2023, National Highways had categorised 1054 outfalls as posing a potential high risk of pollution and 14,301 as posing a medium or low risk.[19]

The categorisation of outfalls is carried out using the Highways England Water Risk Assessment tool (HEWRAT). In the first step of the risk assessment, this risk is quantified using four factors:

- Catchment area (of carriageway)
- Traffic volume
- River dimensions, and
- Proximity to sensitive areas.

In the second step of the risk assessment, this risk category is verified using a process of desk-based and field-based checks and further application of HEWRAT. Once the risk type is verified, the results are fed into the National Highway's Priority Outfalls Programme which establishes further prescribed courses of action, which may include, for example, identifying and implementing mitigation actions (see Section 7). Since there are over 18,000 outfalls on the Strategic Road Network, this approach was developed to provide a robust and systematic approach to target limited resources in an efficient manner.

Alongside the Priority Outfalls Programme there is a similar programme for Priority Soakaways. These are structures which enable water to infiltrate into the ground rather than being discharged into a watercourse. The sites where highway runoff soaks into groundwater are of particular concern as the Environmental Permitting Regulations 2016[20] require discharges of priority hazardous substances such as benzo-a-pyrene into groundwater to be limited and prevented.

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.

19. National Highways. National Highways 2030 Water Quality Plan - Mitigating high risk outfalls and soakaways. August 2023
20. Environmental Permitting Regulations 2016

c) Local authority outfalls

Local authorities own and operate most of the roads that are not part of the Strategic Road Network. This includes some trunk roads, but also arterial routes into towns and cities, residential roads and rural roads. The roads that local authorities own are very varied and each local authority has its own particular issues to deal with, including the nature of the local water environment, the type of drainage infrastructure favoured by planners, and the type of traffic in their area. These factors will affect the load and nature of the pollution from its road network, and its influence the road drainage design and standards that the authority adopts.

Many local authorities have the location of all their gully-pots (used to collect surface water) mapped for operational planning, but they often do not know where their drainage network discharges to the water environment. For example, the South Gloucestershire Council Highways Asset Management Framework numbers and describes the gully pots and the risk of flooding associated with blockages, but does not identify discharges to the water environment or assess the risk of pollution [21].

This situation is better for new-build roads where the location of outfalls are known and treatment devices are often included to capture and treat the runoff, both to alleviate flood risk and to reduce pollution. For example, the Preston West Distributor Road in Lancashire has recently been completed and has treatment ponds along its length.


Outfall from the M61 to the River Yarrow

d) Water company surface water sewers

All water companies in the UK have asset records that identify and map their surface water sewers, including the location of outfalls to the water environment where known (though often this data is of limited quality). These surface water sewers convey runoff from urban and rural surfaces, including roads. In towns and suburbs, the carrier pipes from the roadside gully pots often connect to a surface water sewer within the road. The runoff is then conveyed to the bottom of the hill and discharged to a river or stream. Where the discharge is to a water environment, the water company is responsible for the quality of that discharge and its impact on the environment. In areas of chalk or limestone geology, with few surface waters, the runoff can soak into the ground at designated locations.

An element of the bills that customers pay to water companies is designated for the conveyance and treatment of surface water and highway runoff. However, surface water sewer outfalls do not normally include any pollution treatment devices at all.

21. South Gloucestershire Council Highways Asset Management Framework

Outfall from the M6 to the River Lostock

4. Pollution of the water environment

4.Pollution of the water environment

a) Sources of pollution from highway runoff

The pollutants in highway runoff come from multiple sources; they are deposited on the road surface as well as passing into the atmosphere around the road:

- Attrition of the road surface itself, including road markings[22] and sacrificial non-slip surfaces.
- Microplastic particles created as tyres wear down.
- Dust from brake and clutch components created as the vehicle manoeuvres and as the driver changes gear and brakes.
- Fluids from the windscreen, engine and the exhaust, including washing products, hydraulic fluids, brake fluids and fuel additives.
- Exhaust emissions and unspent fuels emitted from the exhaust pipe.
- Spillages on the road surface, from accidents and leaks – these may be flushed into the drains by emergency responders.
- Road salt applications to reduce ice in the winter.
- Dissolved metals from road furniture.
- Herbicides used for vegetation management around the road and its verges.
- Litter from road users, local areas and people parking in laybys, as well as wind-blown litter from nearby sites.
- Soil, sand and other sediments deposited on the road surface from dirty tyres on commercial vehicles, farm vehicles and similar.
- Sediment blown or washed onto the carriageway from surrounding land or neighbouring fields.

The levels of these pollutants in the runoff are infinitely variable. They are affected by the nature and frequency of the rain event, the activities on the carriageway, the behaviour of the traffic, the time since the last rain event, the geology of the local area, the maintenance of the drainage infrastructure, the ambient temperature and many other factors.

We suggest there has been too little research into the levels of pollution in highway runoff across the UK and this lack of data is making it difficult to alert relevant responsible bodies and the public to the risk of pollution.

“There has been too little research into the levels of pollution in highway runoff across the UK and this lack of data is making it difficult to alert relevant responsible bodies and the public to the risk of pollution.

22. Alice A. Horton, Claus Svendsen, Richard J. Williams, David J. Spurgeon, Elma Lahive, Large microplastic particles in sediments of tributaries of the River Thames, UK – Abundance, sources and methods for effective quantification, Marine Pollution Bulletin, Volume 114, Issue 1, 2017, Pages 218-226, ISSN 0025-326X

Eaves Brook downstream of the M6

Sources of pollution from highway runoff
Sediment from dirty vehicles and surrounding land
Attrition of road surface
Road salt applications to reduce winter ice
Exhaust emissions and unspent fuels
Fluids from windscreen, engine and exhaust
Dissolved metals from road furniture
Herbicides used for vegetation management
Microplastic particles created as tyres wear down
Dust from brake and clutch components
Highway outfall

b) Pollutants of interest in highway runoff

Discharges of highway runoff contain an array of pollutants including suspended solids, microplastic tyre-wear particles, toxic organic compounds and toxic metals.

To improve the reliability and extent of data on pollutant concentrations in highway runoff, the Highways Agency (the predecessor to National Highways) and Environment Agency undertook collaborative research in the early 2000s[23]. The focus was on pollution from non-urban trunk roads and motorways in England.

The results were used to identify a list of significant pollutants routinely found in highway runoff which pose a risk of short-term acute impacts (from soluble pollutants) and/or long-term chronic impacts (from sediment-bound pollutants) on ecosystems. The study also identified those site characteristics that influence pollutant concentrations.

These 'significant' pollutants were agreed with the Environment Agency and were Copper, Zinc, Cadmium, pyrene and polyaromatic hydrocarbons (PAHs) including fluoranthene.

- Copper and Zinc are classified as 'specific pollutants' which are substances that may have a harmful effect on biological quality and which have been identified by UKTAG[24] (UK Technical Advisory Group) as being discharged to the water environment in significant quantities in the UK.
- Fluoranthene is a priority substance[25].
- Cadmium and PAHs are identified as priority hazardous substances under the Water Framework Directive, which identifies them as substances shown to be of major concern for European waters due to their toxicity, bio-accumulating properties and/or persistence in the environment.

This pollution isn't limited to the Strategic Road Network. Research carried out in Preston[26] also showed that samples of highway runoff exceeded the Environmental Quality Standard for 13 pollutants. This was a local authority road crossing over the River Ribble towards Preston town centre, carrying approximately 35,000 vehicles per day, indicating that many busy local authority roads pose a risk of pollution too.

Research acknowledges that there is a relationship between the pollutant level and the traffic density on the road. The Highways England report, 'Effects of soluble pollutants on the ecology of receiving water'[27], showed that there was a relationship between the number of times that pollution thresholds were exceeded and traffic density bands. There were marked increases in the percentage exceedances when the traffic density was between 120,000 and 200,000 vehicles per day. There is also a complex relationship between the time since the last rain event, the intensity of the rain and the pollutant load for some pollutants.

These studies and others highlighted the risk of pollution from highway runoff, but did not fully unpick the mechanisms by which the pollutants cause harm to the water environment, nor the extent of treatment that is needed to reduce that harm to an acceptable level.

c) Modelling the impact

National Highways operate their water risk assessment tool, HEWRAT, to identify those outfalls that pose the highest risk of pollution. The model predicts the concentrations of selected metals and suspended solids in the discharge and the risk of the sediment being deposited in the river. It then identifies the extent of treatment that the discharge requires, if any, before it discharges to the water environment, or to ground.

Other highway authorities also use the HEWRAT model to estimate the level of pollution that they might expect from outfalls on their new-build road schemes.

HEWRAT makes predictions of Polyaromatic Hydrocarbon (PAH) concentrations bound to sediment in highway runoff but the model does not make predictions of dissolved concentrations of PAHs.

During the research for the development of the HEWRAT model, no exceedances of the proposed thresholds for cadmium, fluoranthene and pyrene were found, suggesting that releases of these substances in the dissolved phase did not represent a risk to receiving water bodies. As a result, total concentrations of these substances are not considered in HEWRAT[28].

Yet analysis of highway outfalls in this report (Section 6) reveal levels of PAHs that significantly exceed EQS under the Water Framework Directive[29]. This indicates that the HEWRAT model should include predictions of total PAH concentrations and whether or not they exceed the Environmental Quality Standards.

23. Highways Agency, 2008. Crabtree, R.W., Dempsey, P., Moy, F., Brown, C. and Song, M. UC 7697, Improved Determination of Pollutants in Highway Runoff - Phase 2: Final Report, WRc Plc, Report: UC 7697
24. UK Technical Advisory Group on the Water Framework Directive. Updated Recommendations on Environmental Standards - River Basin Management (2015-21). Final Report. November 2013
25. Directive 2013/39/EU of the European Parliament and of the Council. As regards priority substances in the field of water policy. 2013
26. Webster, R.J., 2014, Highway Pollution & Remediation: A Study into Highway Pollution and Potential Outfall Treatment in Lancashire (Masters Dissertation)
27. Highways Agency; Effects of soluble pollutants on the Ecology of Receiving Waters, WRc Plc, Report No.: UC 7486/1, May 2008

d) Impact on the water environment

The ongoing impact of these discharges of highway runoff on the water environment, and the harm that they cause to the aquatic ecosystem, is not widely measured.

In response to a Freedom of Information request made by the BBC in 2024, the Environment Agency stated that it didn't have any specific monitoring programme assessing the impact of highway runoff on the water environment[30]. Neither do National Highways and highway authorities routinely monitor the discharges of highway runoff entering the water environment from their network.

In response to a Freedom of Information request, National Highways said that they do not consider routine monitoring of even a small percentage of their outfall locations to be either practical or good value. They rely instead upon their HEWRAT model to predict the risk of pollution from their outfalls[31].

Sample results shown in Section 6 of this report indicate that highway outfalls cause pollution.

Since the advent of the Water Framework Directive in 2000, all improvements to discharges to rivers should be driven by the River Basin Management Plans. Yet these plans rarely cite specific highway outfalls as sources of pollution because there is an absence of comprehensive river water quality data for the pollutants described.

Furthermore, due to the distance between these highway outfalls and the Environment Agency's river monitoring points, there is little definitive linkage between the pollutants in highway runoff and Water Framework Directive failures. This doesn't mean that the linkage doesn't exist; just that it is not identified or measured.

However, the HEWRAT model was developed to indicate a risk of failure of water quality thresholds and it is this model that suggests that 1054 highway outfalls from the Strategic Road Network potentially pose a very high or high risk of pollution[32]. Assuming the model results are reliable, the risk of water pollution is arguably significant.

> "The ongoing impact of these discharges of highway runoff on the water environment, and the harm that they cause to the aquatic ecosystem, is not widely measured.

28. Highways Agency; Effects of soluble pollutants on the Ecology of Receiving Waters, WRc Plc, Report No.: UC 7486/1, May 2008
29. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
30. Environment Agency; Response to FOI request made by BBC, February 2024
31. National Highways; Response to FOI request FOI/5614, June 2023
32. National Highways. National Highways 2030 Water Quality Plan - Mitigating high risk outfalls and soakaways. August 2023

There is also evidence from research across the world that pollution from urban runoff affects aquatic ecosystems and the wildlife that live in rivers and streams. Research by Beasley and Kneale[33] in 2001 showed reduced macroinvertebrate numbers at sites below road runoff outfalls. Luker and Montague[34] identified possible impacts of pollution from highway runoff including direct toxic effects on stream biota due to soluble pollutants or ingestion of particulate pollutants. They also noted that although the cause of pollution might be short-lived, the impact itself may have a longer duration because of the time needed for recovery of the stream ecosystem.

When highway runoff discharges are sampled, they are found to be polluted, but the cumulative impact of numerous highway outfalls on the receiving water bodies is not widely understood. The Environment Agency's national monitoring programme includes some sample points to address this and there is a large amount of British and international research underway, especially into the effects of microplastic tyre wear particles on the environment.

The harm to the water environment caused by highway outfalls must be measured and better understood so that effective treatment systems can be installed where necessary and properly operated.

The pollutants are known to affect the health, the growth and the reproductive success of organisms so it is not enough to simply count the number of organisms. Research must also measure their health, size and lifespan and include a range of species from microscopic organisms and invertebrates to fish and plants.

In particular, more research and monitoring are needed of the impacts on the benthic macroinvertebrates that live at the bottom of rivers and in the layers of sediment. These macroinvertebrates are subject to prolonged exposure to the pollution and toxins attached to sediment.

The types of harm that are caused by the various pollutants have been summarised.

i. Polyaromatic Hydrocarbons (PAHs)

PAHs are chemical compounds with two or more aromatic rings. They occur as a by-product of incomplete combustion from multiple sources, including the internal combustion engines of road traffic. They are also released from tyres and spillages of oils onto the highway.

PAHs are widespread and toxic environmental pollutants. They have low water solubility, and when they enter the environment, they are adsorbed onto particulate matter.

Hoffman et al[35] found that the petroleum hydrocarbons were largely associated with particulate material, and the particulate fraction of the hydrocarbons accounted for 83 to 93 per cent of the total. This highlights the importance of sediments as the principal sources of PAH exposure to freshwater plants and animals.

PAHs express toxicity in a number of ways. Some, such as benzo(a)pyrene, are prominent and strong carcinogens. They are degraded by photodegradation, biodegradation by microorganisms and by metabolism in higher biota. It is the metabolism of PAHs in biota that leads to the formation of carcinogenic metabolites[36].

PAHs can also cause immunotoxicity, oxidative stress and endocrine disruption. They enter aquatic organisms by a variety of routes, including respiration, the ingestion of food, the ingestion of sediments and suspended particles and dermal absorption from the surrounding water, especially through the gills. Different aquatic invertebrates have different sensitivities to the same PAHs so it is important to measure toxicity using many different species[37].

Some of the toxic effects of PAHs are photoactivated, so they are expressed when the invertebrate is exposed to sunlight. This causes damage to cells and membranes. The carcinogenic effects of PAHs can lead to tumour initiation and development, and other toxicities can lead to narcosis which disturbs the vital membrane functions.

The toxicity of these substances is complex and in combination they affect the growth, the reproductive success, the function and ultimately the survival of freshwater invertebrates. The creatures fail to thrive and population numbers are suppressed causing harm to the river ecosystem.

33. Beasley, G. and Kneale, P. (2001) Macroinvertebrates, Heavy Metals and PAHs in Urban Watercourses. Working Paper. School of Geography , University of Leeds. School of Geography Working Paper 01/07
34. Luker, M. and Montague, K. Control of pollution from highway drainage discharges. CIRIA. K. (1994)
35. Eva J. Hoffman, James S. Latimer, Gary L. Mills and James G. Quinn, 1982, Petroleum Hydrocarbons in Urban Runoff from a Commerical Land Use Area, Journal (Water Pollution Control Federation), Vol. 54, No. 11 (Nov., 1982), pp. 1517-1525 (9 pages)
36. Douben, Peter E. T. PAHs: An Ecotoxicological Perspective, pp. 1-6, Introduction, 9780471560241, https://doi.org/10.1002/0470867132.ch1, https://doi.org/10.1002/0470867132.ch1, 2003, Summary
37. Den Besten, P.J., Ten Hulscher, D., Van Hattum, B., (2003) Bioavailability, Uptake and Effects of PAHs in Aquatic Invertebrates in Field Studies, Institute for Inland Water Management and Waste Water Treatment (RIZA), Lelystad, The Netherlands, Institute for Environmental Studies, Vrije Universiteit, Amsterdam, The Netherlands

ii. Metals

Many of the metals found in highway runoff are toxic to aquatic life. They can inhibit growth, suppress reproductive success and therefore populations, impair functions such as swimming and avoiding predators and ultimately lead to the death of some fish and invertebrates.

Their toxicity is complex and is made more so by the mixture of metals in the runoff, and the effects of environmental factors on the level of bioavailability of the metals to the organisms. Nonetheless, they are known to be toxic and to cause the absence, or the reduction in size, of populations of certain species of invertebrate, which affects the overall 'score' of river health.

Mayflies and Stoneflies are particularly sensitive to metal pollution, so high levels of pollution can change the make-up of the macroinvertebrate population in streams, eradicating the sensitive species and allowing the proliferation of those that are more tolerant, such as midge larvae[38]. Toxic metals also cause an adverse effect on growth and development rates of the larvae of green toads, and can also lead to increased rates of morphological deformations[39].

The chemical forms of heavy metals are governed by many factors that include their concentration including water hardness, presence and concentration of other metal ions, and organic ligands such as carbonates, and iron and manganese hydroxides[40].

Pollution from metals is of significant concern because they don't degrade or break-down in the water environment and therefore become concentrated in the bodies of organisms and can accumulate in the food chain. They can have sub-lethal effects on some predators of aquatic species including birds and mammals, so the pollution persists beyond the watercourse itself[41].

Although lead was eliminated from petrol many years ago, Stormwater Shepherds UK found elevated levels of it in some of the samples taken (Section 6). Low concentrations of soluble lead may affect tadpoles, frogs, and fish such as minnows, stickleback and trout[42]. Fish are also particularly sensitive to dissolved copper and zinc at very low levels and the samples detailed in Section 6 contain levels above the published standard.

In summary, the metals found in highway runoff are toxic to aquatic organisms and the animals that feed on them, with a range of harmful impacts on the aquatic life in our rivers and streams.

Mayfly ©Diane Isabel

38. Kiffney, P. M. and Clements, W. H. (1994a) Effects of heavy metals on a macroinvertebrate assemblage from a rocky mountain stream in experimental microcosms. Journal of the Northern American Benthological Society, 13, 4, 511-523
39. A. Dorchin, U. Shanas, Assessment of pollution in road runoff using a Bufo viridis biological assay, Environmental Pollution, Volume 158, Issue 12, 2010, Pages 3626-3633, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2010.08.004
40. Beasley, G. and Kneale, P. (2001) Macroinvertebrates, Heavy Metals and PAHs in Urban Watercourses. Working Paper. School of Geography , University of Leeds. School of Geography Working Paper 01/07
41. Beasley, G. and Kneale, P. (2001) Macroinvertebrates, Heavy Metals and PAHs in Urban Watercourses. Working Paper. School of Geography , University of Leeds. School of Geography Working Paper 01/07
42. Luker, M. and Montague, K. (1994) Control of pollution from highway drainage discharges. CIRIA

iii. Microplastic tyre wear particles

Tyre-wear particles are created as cars and other vehicles drive along roads, and they are thought to be the largest terrestrial source of microplastics in our oceans[43].

There is a wealth of research underway internationally into the effects of these particles on humans and on wildlife. There is increasing evidence that the effects are far-reaching and affect many different species in many ways. For the purposes of this document, we focus on the effects of the micro-plastic tyre-wear particles on the wildlife and organisms that live in the rivers and streams where discharges of highway runoff take place.

National Highways commissioned research into Microplastics and Contaminants of Concern in the Strategic Road Network[44]. Their findings support the suggestion that surface water runoff is a significant source of anthropogenic debris - including microplastics - to aquatic ecosystems, with tyre-wear particles contributing a greater mass than other forms of microplastics.

Research by a group of international universities in 2024[45] concluded that that tyre particles are hazardous pollutants of particular concern as they are close to or possibly above chronic environmental safety limits in some locations. The study provides critical evidence that tyre particles can release chemicals that are known to be toxic, and many unknown or insufficiently characterised chemicals. It also showed that tyre-wear particles can be extensively ingested by organisms at the base of the food chain.

The highest environmental concentrations of these particles were demonstrated to induce massive mortality to water fleas. Even at lower concentrations, tyre particles and their leachates were demonstrated to strongly impact the reproduction and morphological development of the fleas. Other research has also found that leachate from tyre wear particles and highway runoff is acutely lethal to the water flea.[46]

Considerable research has been carried out to understand the effects of one particular substance reported to leach from tyre-wear particles, 6PPD-quinnone. This has been found to be extremely toxic to some species of fish. This research continues and the impacts on fish in British rivers is, as yet, unknown. Sub-lethal effects are equally important to widespread fish mortalities. Research carried out in Spain[47] showed that 6PPD-quinnone had sub-lethal effects on zebrafish larvae, affecting their behaviour associated with, for example, movement and sleep patterns.

More research and an improved understanding are required on the effects of micro-plastic tyre-wear particles on the aquatic environment. However, we cannot afford to wait for the results of decades of research before any action is taken. There is sufficient evidence that the particles are harmful and we should deliver solutions now in parallel with the continued research.


Tyre crumb on road surface ©nikolay100

43. Hann, S., Darrah, C., Sherrington, C., Blacklaws, K., Horton, I. and Thompson, A., 2018. Reducing Household Contributions to Marine Plastic Pollution. Eunomia
44. Atkins, Jacobs for National Highways. Microplastics and Contaminants of Concern in the Strategic Road Network Appendix A: Quantifying tyre wear particles and other microplastics from the Strategic Road Network. 2023
45. Paul Boisseaux, Cassandra Rauert, Pradeep Dewapriya, Marie-Laure Delignette-Muller, Robyn Barrett, Lee Durndell, Florian Pohl, Richard Thompson, Kevin V. Thomas and Tamara Galloway, Deep dive into the chronic toxicity of tyre particle mixtures and their leachates, Journal of Hazardous Materials, (2024) doi:https://doi.org/10.1016/j.jhazmat.2024.133580
46. Jianan Li, Jiale Xu, Xiaodong Jiang, Urban runoff mortality syndrome in zooplankton caused by tire wear particles, Environmental Pollution, Volume 329, 2023, 121721, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2023.121721
47. Marina Ricarte, Eva Prats, Nicola Montemurro, Juliette Bedrossiantz, Marina Bellot, Cristian Gómez-Canela, Demetrio Raldúa, Environmental concentrations of tire rubber-derived 6PPD-quinone alter CNS function in zebrafish larvae, Science of The Total Environment, Volume 896, 2023, 165240, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2023.165240

> “We cannot afford to wait for the results of decades of research before any action is taken. There is sufficient evidence that the particles are harmful and we should deliver solutions now in parallel with the continued research.

iv. Sediment

The Environment Agency states “Sediment is an important part of a healthy functioning aquatic environment. However, excess sediment generated by human pressures can cause problems, ranging from damage to the health of aquatic ecosystems, to poor quality water for abstraction in drinking water protected areas.

“Sediment can also act as a source, and ‘transport’ other pollutants and chemicals. The effects of siltation can impact rivers by clogging up the spaces between gravels in river beds. This prevents or reduces fish spawning and egg survival especially for sensitive species such as salmon, trout and shad”[48].

Where highway runoff is entering a water environment the problems associated with the sediment pollution are worse because the sediment has harmful substances sorbed to the particles, and some of the particles leach out damaging substances too, over time. Thus, the impact of sedimentary pollution from highway runoff is twofold; the physical properties of the sediment cause harm, and the toxic nature of the leachates and associated substances also cause harm.


Tadpoles ©skrcenyz

48. Environment Agency. Fine sediment: challenges for the water environment. October 2021

This harm is experienced particularly by invertebrates that live on the riverbed, above and within the sediment layer, and all the organisms that feed on the particles, both as they are suspended in the water column, and once they have settled on the riverbed. Fine sediment particles are ingested by microscopic organisms and invertebrates so the toxic effects of metals and PAHs described above affect them, and to some extent, the wildlife that eat them.

There are insufficient data on the sediment load from highway runoff to inform a clear picture of how much is washed off roads into watercourses. However, National Highways CD 523[49] provides some estimates and calculations for annual loads. It estimates the sediment load to be 2 tonnes per hectare per year. Appendix E/B of the same report also highlights the extreme differences in annual sediment load that are possible from different roads in different regions, depending on variables such as local land use.

A further problem with sediment pollution is that it conveys the pollutants adhered to the sediment down the river and into estuaries and marine environments. Many estuarine habitats around the UK coast support protected species and their habitats. Since HEWRAT relies on the ability of a river to 'disperse' the polluted suspended solids and to wash them downstream, the risks of accumulated sediment in rivers and estuaries needs further investigation. Yet there is little research into the conveyance of pollutants in the water environment associated with sediment.

Research along the Dutch coast found that the spatial distribution of PAHs in sieved sediment fractions revealed the highest concentrations adjacent to the coast, near major rivers and freshwater outlets[50].

In 2008, Gaskell et al[51] found that at all the sites they sampled, highway-derived particulate material was predicted to exceed the trigger values at which toxicity is expected. Further research is needed to understand where the sediment is washed to and if the toxicity persists in downstream environments.

v. Other pollutants

Current research, including that completed by UKWIR[52] is considering other pollutants that are found in highway runoff and that cause harm in the water environment. These chemicals include 'forever chemicals' such as Perfluorooctanesulfonic acid (PFOS), and the research has found levels in excess of the Environmental Quality Standards. This research also examines chemicals of emerging concern such as insecticides.

Sediment removed from a Vortex Grit Separator

49. CD 523 Determination of pipe roughness and assessment of sediment deposition to aid pipeline design (HE, 2019). DMRB 4.2.4. Design manual for roads and bridges (DMRB)
50. Bioavailability, Uptake and Effects of PAHs in Aquatic Invertebrates in Field Studies Pieter J. Den Besten, Dorien Ten Hulscher, Bert Van Hattum (2003). Institute for Inland Water Management and Waste Water Treatment (RIZA), Lelystad, The Netherlands, Institute for Environmental Studies, Vrije Universiteit, Amsterdam, The Netherlands
51. Gaskell, P. N.; Guymer, I.; Maltby, L. Accumulation and dispersal of suspended solids in watercourses: Final Report, 2008
52. UKWIR, 2022, 22/WW/02/15 – Urban Runoff (including Road Runoff) And Atmospheric Deposition – How to Apportion Pollution Load Especially Chemical of Emerging Concern. Prepared by Atkins

vi. Summary of effects of pollution

These harmful effects on the organisms that live in our rivers and streams are poorly understood, and the predictive model HEWRAT used to assess the risk of pollution from highway runoff does not properly reflect these complex and far-reaching effects.

The pollutants affect the behaviour of the organisms so that they cannot feed properly, or escape from predators. They cause deformities and mutations that affect their scope for growth and ability to thrive.

Some of the substances interfere with reproduction success, causing deformities of embryos or abortion. Others cause carcinogenic tumours to develop and some bioaccumulate in the flesh of organisms that ingest them. Although they don't all bio-magnify up the food chain, some do, and they affect the health and success of birds and mammals that feed in rivers.

It is important to consider the effect of these pollutants as they mix together in the environment. Research on the effects of heavy metals and PAHs in urban watercourses on the population of macroinvertebrates[53] found that when PAH data is included in the analysis, the most significant controls on macroinvertebrate community composition were zinc, followed by nickel, naphthalene, iron and benzo(b)fluoranthene.

To date, there has been no consideration of the effects of mixtures of these pollutants on river health, so the potential extent of harm is unknown.

Further, there is no information about the effects of these pollutants on recreational river-swimmers and water-users who enter rivers and seas that are affected by this pollution. Additionally, there is insufficient information on the effects of this pollution on groundwater and potential water supply, with little or no monitoring in place.

The impact of these highway runoff pollutants is wide-ranging. More investigation and monitoring of these effects, and the extent of this harm, is essential.

However, we cannot wait to start to reduce highway pollution whilst the research continues. Enough is known about the harm to justify investment in treatment schemes at highway outfalls at a fast pace, whilst further research is completed. In Section 7, we outline some of the solutions that can be included in potential treatment schemes.

“ The pollutants affect the behaviour of the organisms so that they cannot feed properly, or escape from predators. They cause deformities and mutations that affect their scope for growth and ability to thrive.

53. Beasley, G. and Kneale, P. (2001) Macroinvertebrates, Heavy Metals and PAHs in Urban Watercourses. Working Paper. School of Geography , University of Leeds. School of Geography Working Paper 01/07

5. Regulatory control of pollution in England

5. Regulatory control of pollution in England

There are two elements to the control of pollution from highway runoff.

Firstly, the discharges themselves cause pollution; this should be controlled using discharge permits under the Environmental Permitting Regulations 2016. Secondly, the impact of highway runoff on the compliance of a watercourse with the requirements for good ecological status and good chemical status is considered under the Water Framework Directive.

a) Environmental Permitting Regulations

Section 100 of the Highways Act 1980[54] gives a highway authority the power to discharge surface water from highway drains into any inland waters, or into any tidal waters.

Ordinarily, a discharge of polluting matter into a watercourse would require a permit under paragraph 4 of schedule 21 to the Environmental Permitting (England and Wales) Regulations 2016[55].

However, the Environment Agency currently does not require highway authorities to apply for permits[56] for discharges from urban surfaces despite having the powers to do so, seemingly on the assumption that water running off roofs, roads and carparks is typically uncontaminated.

However, highway authorities' powers to discharge do not allow them to cause pollution with impunity nor exempt them from enforcement action in the event of pollution from either a site or outfall[57,58].

The environmental regulator must uphold the requirements of relevant EU directives, such as the Environmental Quality Standards Directive[59] and pollution from highway discharges that prevents compliance with the standards should be controlled by the Environment Agency as necessary.

If a person is operating a highway drain that may cause pollution, the regulator has the power to serve notice requiring them to cease the activity or to hold an environmental permit authorising the carrying on of that activity. To our knowledge, such notice has never been served by the Environment Agency.

Further, paragraph 11 of schedule 22 to the Environmental Permitting Regulations states that if a groundwater discharge made by a highway authority might lead to the direct or indirect input of a pollutant to groundwater, the Environment Agency may serve notice on the authority requiring that they apply for a permit for that groundwater activity.

“The Environment Agency currently does not require highway authorities to apply for permits[56] for discharges from urban surfaces despite having the powers to do so, seemingly on the assumption that water running off roofs, roads and carparks is typically uncontaminated.

54. Highways Act 1980, Section 100
55. The Environmental Permitting (England and Wales) Regulations 2016. Schedule 24
56. Environment Agency, Defra. Guidance: Discharges to surface water and groundwater: environmental permits. February 2024
57. Highways Agency. Memorandum of Understanding between Highways Agency and Environment Agency: Annex 1 - Water Environment. November 2009
58. Highways England, Environment Agency. Memorandum of Understanding. April 2018 (National Highways, FOI/7262)
59. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015

> The permitting process is not applied to highway outfalls because National Highways has a voluntary Memorandum of Understanding (MoU) arrangement with the Environment Agency.

Currently, National Highways and other highway authorities in England have no permits in place for any of their outfalls. Water company surface water sewers that convey highway runoff into the water environment do not ordinarily have water discharge activity permits either.

When the owner or operator of a discharge to the water environment considers the need to apply for a permit in England, they are required by the Environment Agency to carry out a risk assessment[60] if they are applying for a bespoke permit that includes discharging hazardous chemicals and elements to surface water. This includes four screening tests to assess whether or not the discharge is liable to cause failures of environmental standards in the receiving watercourse. For discharges to groundwater, separate groundwater risk assessments are required[61].

Because discharges of highway runoff are not being controlled by permits, these risk assessments are not being carried out by anyone.

Since the National Highways HEWRAT identifies 1054 outfalls[62] that potentially pose a high risk of pollution, it could be argued that the Environment Agency should serve notice on them to apply for a permit. The Environment Agency would then carry out a risk assessment to assign permit conditions that protect the environment from harm and ensure compliance with the Water Framework Directive (see Section 5b).

For the outfalls owned by local authorities and water authorities, desk-top modelling could identify the outfalls at highest risk of causing pollution and they too could be served with a notice to apply for a permit.

The permitting process is not applied to highway outfalls because National Highways has a voluntary Memorandum of Understanding (MoU) arrangement with the Environment Agency[63,64] originally established with its predecessor the Highways Agency. This allows National Highways to undertake risk assessments of polluting highway drainage outfalls and implement a programme of improvements where the risks are high because of a combination of heavy traffic loading and sensitive receiving waters. The parties consider the agreement ensures that knowledge is shared and risks are understood and addressed[65].

However, the results of analysis shown in Section 6 illustrate that the levels of pollution are sufficiently high that the discharges should be controlled using the permitting regime. Furthermore, that the voluntary agreement is not protecting rivers from pollution despite the MoU[66] stating that both parties will "seek to minimise pollution from highway run off to prevent deterioration of and where possible enhance surface waters and groundwater".

Section 5 of the MoU does not preclude a more regulatory approach, stating "This Memorandum of Understanding will not affect the statutory duties, regulatory responsibilities or legal rights, responsibilities of either party. It doesn't preclude enforcement action by the Environment Agency where appropriate."

60. Environment Agency, Defra. Guidance: Surface water pollution risk assessment for your environmental permit. February 2022
61. Environment Agency, Defra. Guidance: Groundwater risk assessment for your environmental permit. April 2018
62. National Highways. National Highways 2030 Water Quality Plan - Mitigating high risk outfalls and soakaways. August 2023
63. Highways Agency. Memorandum of Understanding between Highways Agency and Environment Agency: Annex 1 - Water Environment. November 2009
64. Highways England, Environment Agency. Memorandum of Understanding. April 2018 (National Highways, FOI/7262)
65. Defra. Tackling water pollution from the urban environment – consultation. 2012
66. Highways England, Environment Agency. Memorandum of Understanding. April 2018 (National Highways, FOI/7262)

b) Water Framework Directive

The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017[67] states "This directive is to contribute to the progressive reduction of emissions of hazardous substances to water. The ultimate aim of this directive is to achieve the elimination of priority hazardous substances and contribute to achieving concentrations in the marine environment near background values for naturally occurring substances. Pollution through the discharge, emission or loss of priority hazardous substances must cease or be phased out."

The Priority Substances Directive[68] states: "As a matter of priority, causes of pollution should be identified and emissions should be dealt with at source, in the most economically and environmentally effective manner."

The directive provides for the identification of priority substances which are the water pollutants of greatest concern across Europe. The regulations require progressive reduction of discharges, emissions and losses of these substances and, for a subset of priority hazardous substances, cessation or phasing-out of discharges, emissions and losses within 20 years.

It also requires EQS to be used as criteria for the assessment of good chemical status for surface water bodies. The initial list of priority substances was agreed in 2001; It includes many substances that are found in highway runoff as discussed in previous sections[69].

Further, the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 state that where a potential risk to the aquatic environment from acute exposure to one of the priority substances has been identified as a result of measured or estimated environmental concentrations or emissions, the Environment Agency must monitor surface waters and, where such standards have been established, apply the maximum allowable concentration set out in Table 1 of Schedule 3 Part 3 of the directions.

The Environment Agency must also maintain an inventory of emissions, discharges and losses of all priority substances and pollutants listed in Table 1 of Schedule 3 Part 3, for each river basin district.

Discharges of highway runoff are not included in any inventory of emissions, but they should be. Table 1 of Schedule 3 Part 3 includes a number of chemicals that are known to be present in highway runoff, including benzene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k) fluoranthene, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, and mercury.

As discussed above, total concentrations of PAHs are not considered in the HEWRAT model. However, the EQS maximum allowable concentrations are based on toxicity to aquatic life and were retained for the individual PAHs when the EQSs were reviewed[70]. This highlights an important mis-match between the HEWRAT model and the EQS allowable concentrations for PAHs. It also reveals a failure of regulation by the Environment Agency, allowing these discharges to continue without the application of a robust risk assessment.

The Water Framework Directive was introduced as an 'umbrella' directive that guided the regulators as they applied their regulatory frameworks to restore the health of river ecosystems. By allowing National Highways to use compliance with the directive's aims to assess the effect of pollution from their outfalls, instead of by applying the Environmental Permitting Regulations upon these outfalls themselves, the Environment Agency appears to have allowed this long-term, toxic pollution to have a gradual and cumulative effect on river health and to continue and worsen for a decade.

Surcharging surface water manhole

67. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017
68. Directive 2013/39/EU of the European Parliament and of the Council. As regards priority substances in the field of water policy. 2013
69. Environment Agency. River basin management plans, updated 2022: summary programmes of measures – mechanisms. 12, Chemicals and priority substances. January 2024
70. Environment Agency. Polycyclic aromatic hydrocarbons (PAHs); background data and predicted future emissions. September 2015

c) Is the regulatory control of outfalls and soakaways from the strategic road network working?

National Highways published their '2030 Water Quality Plan' in August 2023[71]. This identifies that "There are 1,236 outfalls and soakaways identified by National Highways 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."

The plan goes on to state "We have robust assessment tools for determining water quality impacts of highway runoff from the Strategic Road Network (SRN) based on extensive research which was, in part, funded by the Environment Agency. The pollutants of concern and associated thresholds which were agreed with the Environment Agency, and adopted by us in the Design Manual for Roads and Bridges in 2009[72], help us to determine if the pollution risk from highway runoff is acceptable or unacceptable, and inform the nature of any mitigation required. All road schemes designed and built since 2009 on the SRN therefore have been subject to robust assessments and, where necessary, include mitigation measures for known pollution risks."

The Defra Plan for Water states that there has been improved water quality through the Road Investment Strategy 2020 to 2025 because, so far, National Highways has delivered over 30 water quality initiatives, improving almost 20 miles of water bodies[73].

However, apart from specific research programmes, there has been no measurement of the routine pollution from the SRN since the introduction of the Road Investment Strategy, and no evidence that the 30 water quality initiatives have delivered any improvement in water quality.

National Highways do not measure the level of pollution in their outfalls before they design or install a treatment system, nor do the Environment Agency measure the pollution either before or after the installation of the treatment system. Therefore, it is impossible to say how far pollution persists, how far any improvement has extended, or if any improvement has been made at all.

> "There has been no measurement of the routine pollution from the Strategic Road Network since the introduction of the Road Investment Strategy, and no evidence that the 30 water quality initiatives have delivered any improvement in water quality.

71. National Highways. National Highways 2030 Water Quality Plan - Mitigating high risk outfalls and soakaways. August 2023
72. Highways England. Design Manual for Roads and Bridges LA 113 Road Drainage and the Water Environment. March 2020
73. Defra. Plan for Water: our integrated plan for delivering clean and plentiful water. April 2023

The conveyance of contaminated sediment from any highway outfall down the receiving watercourse means that the toxic effects of that sediment may be felt by the aquatic organisms all the way down the catchment and out into the estuary and the sea.

In light of these gaps in our knowledge, the measurement of the pollution from these outfalls and the preparation of a permit that details the amount of treatment that is required to achieve compliance with the EQS in the receiving watercourse would be far more objective.

Knowledge and information on pollution from soakaways to ground is even more sparse. There is no specific monitoring of groundwater near highway runoff soakaways and the location of many of the soakaways is unknown. These discharges should also be controlled by groundwater discharge permits, but there are no such permits in place and neither National Highways nor the Environment Agency are measuring the discharges and the level of pollution in them.

d) Regulation of outfalls and soakaways from local authority roads and water company surface water sewers

There has been very little consideration of pollution from local authority roads and water company surface water sewers to date, beyond the work undertaken by charity Thames21[74]. Drainage and Wastewater Management Plans produced by water and sewerage companies pay no attention to the urban pollution that the surface water sewers convey into the water environment from highways.

Whilst the water companies' bills include a small component for the conveyance and treatment of highway runoff, this is assigned to the treatment of the runoff that reaches wastewater treatment works and there are few, if any, specific treatment schemes in place for surface water sewer discharges. However, the data from London Road included in Section 6 suggests that highway runoff conveyed into the River Ribble via a water company surface water sewer causes pollution. There is no monitoring or assessment of the pollutant load in these discharges.

Similarly, the local authority highway discharges to watercourse and to groundwater are unmonitored and unregulated. Indeed, the location of many of them is unknown. However, the results of our sampling in Section 6 show that the discharges contain hazardous substances that cause harm to aquatic wildlife.

A report published by the Mayor of London in 2019 set out the results of a study into road runoff water quality. The Mayor partnered with the Environment Agency and the Zoological Society of London to fund Thames21 to develop a new model, using numbers and types of vehicles to predict the amount of pollution deposited on roads and the degree of damage to rivers. The project was also in partnership with Middlesex University, Transport for London, Thames Water and South East Rivers Trust[75].

In 2023, the second phase of the project produced a decision support tool. This tool was created to show varying levels of pollution, and identifies the best locations for nature-based solution interventions to address this issue of road runoff pollution.

> "There has been very little consideration of pollution from local authority roads and water company surface water sewers to date.

74. Greater London Authority. Road Runoff Water Quality Study. 2019
75. Greater London Authority. Road Runoff Water Quality Study. 2019

e) The regulatory controls in Scotland, Wales and Northern Ireland

Pollution from highway runoff is a problem across the UK, although the busiest roads are mostly in and around cities in England. Nonetheless, the roads around Glasgow and Cardiff have very high traffic densities and pose the same risk of pollution to the water environment. Across the more rural areas of Scotland and Wales, although the traffic densities are far lower, the rivers and streams are far cleaner, and support populations of rare and sensitive aquatic species, so the risk of pollution in these areas cannot be overlooked.

The regulatory framework in Wales is very similar to that described for England, and discharges of highway runoff can be regulated using the Environmental Permitting Regulations 2016, but there are currently no permits applied to highway outfalls and no notices have been served to require permit applications. The outfalls from the trunk roads and motorways in Wales have been assessed for their risk of pollution using the National Highways HEWRAT model, and Welsh Government have used the outputs from the model to identify those outfalls that pose the greatest risk of pollution.

In Scotland, the regulatory framework is different. All discharges of water runoff from roads are authorised under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)[76]. Low-risk discharges are authorised by General Binding Rules (GBR) 10 with existing discharges (from developments constructed before 2007) authorised by GBR10A, and new discharges by GBR10B.

Both sets of rules require that the discharge causes no pollution and that any treatment facilities are maintained. Critically, GBR10B also requires that a sustainable drainage system (SuDS) is used for the treatment of the runoff from any discharges from developments that were completed after 2007.

Highway authorities that are creating discharges of highway runoff from new roads that pose a higher risk of pollution need to apply for a licence under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended). This is defined as "motorways and trunk roads where any one outfall serves a length of road greater than 1km."

The difference in these regulatory approaches is striking and it would be interesting to examine the extent of pollution from roads in Scotland to see if the application of General Binding Rules is an effective mechanism to control pollution.

Motorway outfall in high flow

76. The Water Environment (Controlled Activities) (Scotland) Amendment Regulations 2021

6. Sampling results

6. Sampling results

In this section we show results of samples taken by Stormwater Shepherds UK from three motorway outfalls in northwest England between 2021 and 2024. The samples were tested for a range of highway runoff pollutants.

We also provide analysis of the same pollutants in runoff from local authority managed roads in and around Preston, Lancashire. Although these data are taken in 2015, the results are important because they provide a fuller picture of the impacts from a wide range of roads.

Results are summarised in the following tables with the Environmental Quality Standards for the relevant pollutants. Compliance with the annual average concentration standards for copper and zinc is not assessed because it would be inappropriate to consider if a discharge complies with an annual average from a single sample.

Map showing approximate sampling locations

- M6 motorway outfalls
- Local authority outfalls

Notes for all tables:

- Samples were taken using a polythene container attached to a telescopic fibreglass handle. The samples were then transferred to bottles provided by the laboratory and conveyed to the refrigerated storage depot. Samples were analysed by ALS Laboratories UK who are UKAS accredited to ISO 17025.
- Anthracene, benzo(a)pyrene, benzo(b) fluoranthene, benzo(g,h,i)perylene, benzo(k) fluoranthene, fluoranthene and naphthalene are Polyaromatic Hydrocarbons (PAHs).
- Orange shading of the results in the table denotes a failure to comply with the EQS.
- The EQS for cadmium is dependent on the hardness of the water in the river, so it differs from site to site. The EQS shown in the tables is accurate for each site.

a. Motorway samples

Massey Brook, Cheshire

A sample was taken from an M6 motorway discharge into Massey Brook near Warrington in Cheshire during significant and persistent rainfall in January 2024. This sample point is of interest because it is classified as an outfall that poses a low risk of pollution according to the National Highways Water Risk Assessment Tool. The levels of polyaromatic hydrocarbons (PAHs) found in this sample are the highest that Stormwater Shepherds UK have ever recorded in a discharge of highway runoff.

> “The levels of polyaromatic hydrocarbons (PAHs) found in the Massey Brook sample are the highest that Stormwater Shepherds UK have ever recorded in a discharge of highway runoff.

Table 6.1 Results of analysis for sample of highway runoff discharge from the M6 to Massey Brook, Cheshire

Analyte	Units	Results	Environmental Quality Standard	
		Motorway outfall to Massey Brook	Maximum allowable concentration µg/l	Annual average concentration µg/l
Dissolved cadmium	µg/l	0.09		
Dissolved copper	µg/l	26		1 bioavailable
Dissolved lead	µg/l	0.38	14	
Dissolved zinc	µg/l	90		10.9 bioavailable
Anthracene	µg/l	<0.025	0.1	
Benzo(a)pyrene	µg/l	5.77	0.27	0.00017
Benzo(b)fluoranthene	µg/l	8.08	0.017	
Benzo(g,h,i)perylene	µg/l	5.99	0.0082	
Benzo(k)fluoranthene	µg/l	3.05	0.017	
Fluoranthene	µg/l	14.5	0.12	
Naphthalene	µg/l	0.253	130	
Mercury	µg/l	Not sampled	0.07	

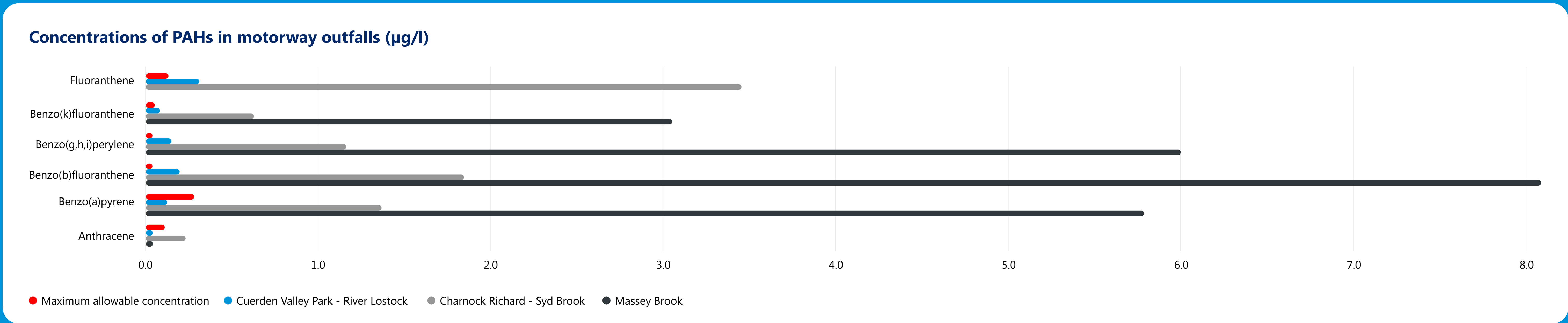
Charnock Richard, Lancashire

A sample was taken from an M6 motorway discharge into Syd Brook, near Chorley in Lancashire during rainfall in September 2023. This discharge goes into a section of the brook that 'pools' behind a culvert under an access road and the entire pool is black in colour and thick with black sediment.

"This discharge goes into a section of the brook that 'pools' behind a culvert under an access road and the entire pool is black in colour and thick with black sediment.

Table 6.2 Results of analysis for sample of highway runoff discharge from the M6 to Syd Brook, near Chorley, Lancashire

Analyte	Units	Results	Environmental Quality Standard	
		Motorway outfall to Syd Brook	Maximum allowable concentration µg/l	Annual average concentration µg/l
Total suspended solids	mg/l	78		
Dissolved cadmium	µg/l	0.07	1.5 (Class 5)	
Dissolved copper	µg/l	25		1 bioavailable
Dissolved lead	µg/l	0.42	14	
Dissolved zinc	µg/l	92		10.9 bioavailable
Anthracene	µg/l	0.217	0.1	
Benzo(a)pyrene	µg/l	1.35	0.27	0.00017
Benzo(b)fluoranthene	µg/l	1.83	0.017	
Benzo(g,h,i)perylene	µg/l	1.15	0.0082	
Benzo(k)fluoranthene	µg/l	0.629	0.017	
Fluoranthene	µg/l	3.44	0.12	
Naphthalene	µg/l	0.26	130	
Mercury	µg/l	Not Sampled	0.07	



Cuerden Valley Park, Lancashire

Since 2021, Stormwater Shepherds UK have been working as part of a partnership project to measure the pollution load from an M6 motorway outfall into the River Lostock near Bamber Bridge, Cuerden Valley Park, south of Preston in Lancashire.

The project was initiated and supported through the River Douglas Catchment Valley Partnership, with partners including Lancashire County Council, the Environment Agency, National Highways, United Utilities, the Cuerden Valley Park Trust and Groundwork CLM. This site was chosen as the outfall can be safely accessed and easily monitored, and there is space in the park to deliver a solution to address the river's failure of Good Ecological Status in the longer-term.

As part of this project, samples have been taken on five occasions from the motorway outfall and the river above and below the discharge:

1. The first sampling event was on September 23rd 2021. The sample of the motorway outfall was a composite sample taken across the duration of the rain event. A composite sample provides an indication of the average concentration of pollutants..
2. & 3.The second and third sampling events were on the same day in June 2023, one at the very beginning of the day and one at the end of the day. For these two events, the samples of motorway runoff were spot samples taken 30 minutes apart. Due to extreme weather conditions, it wasn't safe enough to take composite samples. Three spot samples of the outfall were taken during the morning event, and two spot samples during the evening event.
4. The fourth sampling event was taken in October 2023, and was a composite sample taken through a rainstorm.
5. The fifth and final set of samples were taken on December 7th 2023 and have higher levels of pollutants, including a level of cadmium above the Environmental Quality Standard which hasn't appeared in any of the other motorway samples.

This final set of samples were taken in a rainstorm after a period of snow and when salt had been applied to the motorway, which may have mobilised more of the pollutants. The weather had also been dry for a number of days before the snowfall.

The high levels of suspended solids in the discharge illustrate that not all the high readings can be attributed to dissolved pollutants being mobilised by the application of road salt.

Table 6.3 Results of analysis for samples of highway runoff discharge from the M6 to the River Lostock, Lancashire

Analyte	Units	September 2021			June 2023 - Morning				June 2023 - Evening			October 2023			December 2023				Environmental Quality Standard	
		Outfall composite sample	River Lostock downstream	River Lostock upstream	Outfall sample 1	Outfall sample 2	Outfall sample 3	River Lostock downstream	Outfall sample 1	Outfall sample 2	River Lostock downstream	Outfall composite sample	River Lostock downstream	River Lostock upstream	Outfall spot sample	Outfall composite sample	River Lostock downstream	River Lostock upstream	Maximum allowable concentration µg/l	Annual average concentration µg/l
Total suspended solids	mg/l	149	28	28	40	50	38	28	246	167	108	66	20	8	490	478	114	2		
Dissolved cadmium	µg/l	<0.02	<0.02	<0.02	0.04	0.04	0.04	0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	0.11	0.08	0.05	<0.02	0.9 (Class 4)	
Dissolved copper	µg/l	12	8.1	<4.0	43	42	44	20	9.1	15	5.2	12	6	<4.0	12	12	11	<4.0		1 bioavailable
Dissolved lead	µg/l	0.38	<0.30	<0.30	0.41	0.37	0.39	0.43	0.47	0.32	0.48	0.54	0.51	0.32	<0.30	<0.30	0.45	0.34	14	
Dissolved zinc	µg/l	42	18	<5.0	76	67	68	38	12	21	38	30	12	5.3	60	47	37	5.6		10.9 bioavailable
Anthracene	µg/l	0.0193	<0.005	<0.005	0.0082	<0.005	<0.005	<0.005	0.0361	0.0163	0.0079	0.0461	<0.01	<0.01	0.385	0.152	0.0456	0.00657	0.1	
Benzo(a)pyrene	µg/l	0.116	0.0294	0.0118	0.0601	0.0383	0.0322	0.0168	0.284	0.182	0.0714	0.34	<0.004	<0.004	2.6	1.62	0.353	0.0243	0.27	0.00017
Benzo(b)fluoranthene	µg/l	0.183	0.0494	0.0146	0.0951	0.0635	0.0536	0.0243	0.417	0.263	0.12	0.475	0.0732	<0.01	2.49	1.62	0.477	0.0436	0.017	
Benzo(g,h,i)perylene	µg/l	0.129	0.0444	0.0178	0.0473	0.022	0.0232	<0.005	0.239	0.185	0.0638	0.211	<0.01	<0.01	2.35	2.04	0.416	0.0188	0.0082	
Benzo(k)fluoranthene	µg/l	0.0793	0.0222	0.0079	0.0265	0.0193	0.018	0.0068	0.103	0.0718	0.037	0.238	<0.01	<0.01	1.44	0.765	0.216	0.0136	0.017	
Fluoranthene	µg/l	0.29	0.0469	0.0167	0.195	0.129	0.119	0.0648	0.687	0.414	0.228	0.663	0.0776	<0.01	6.01	3.77	0.837	0.0886	0.12	
Naphthalene	µg/l	0.0125	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.0142	<0.01	<0.01	0.027	<0.02	<0.02	0.119	0.0418	0.0158	<0.01	130	
Dissolved mercury	µg/l	0.00004	<0.00001	<0.00001	0.00002	0.00002	0.00002	<0.00001	0.00002	0.00001	0.00001	0.00002	<0.00001	<0.00001	Not sampled	0.0001	0.00006	Not sampled	0.07	

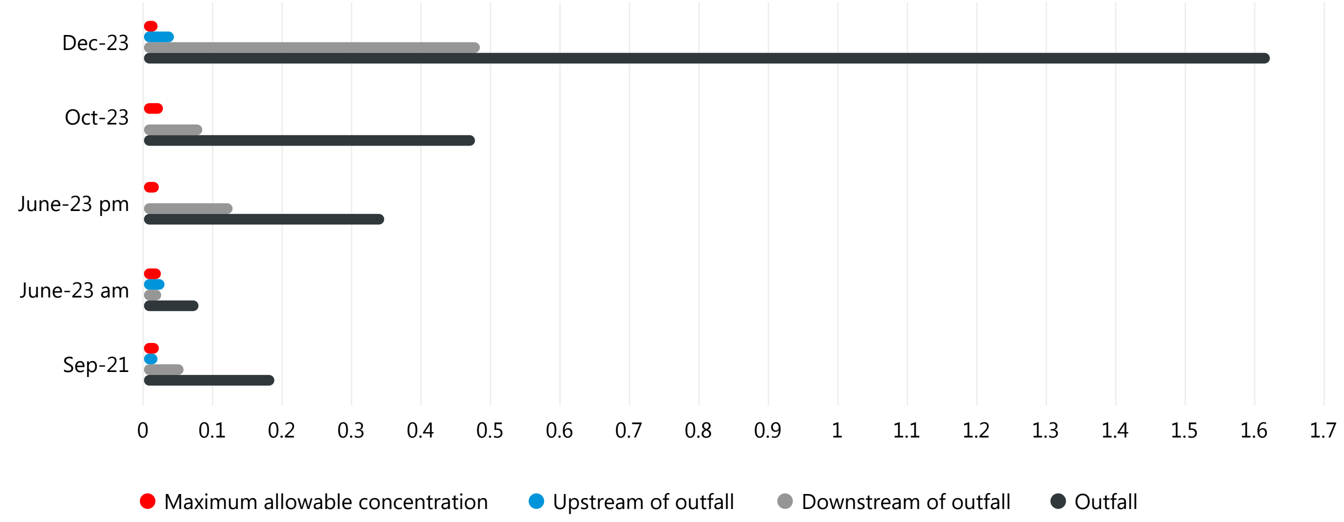
Cuerden Valley Park analysis

This outfall into the River Lostock in Cuerden Valley Park is certainly polluting, containing levels of priority hazardous substances and specific pollutants far above the standards.

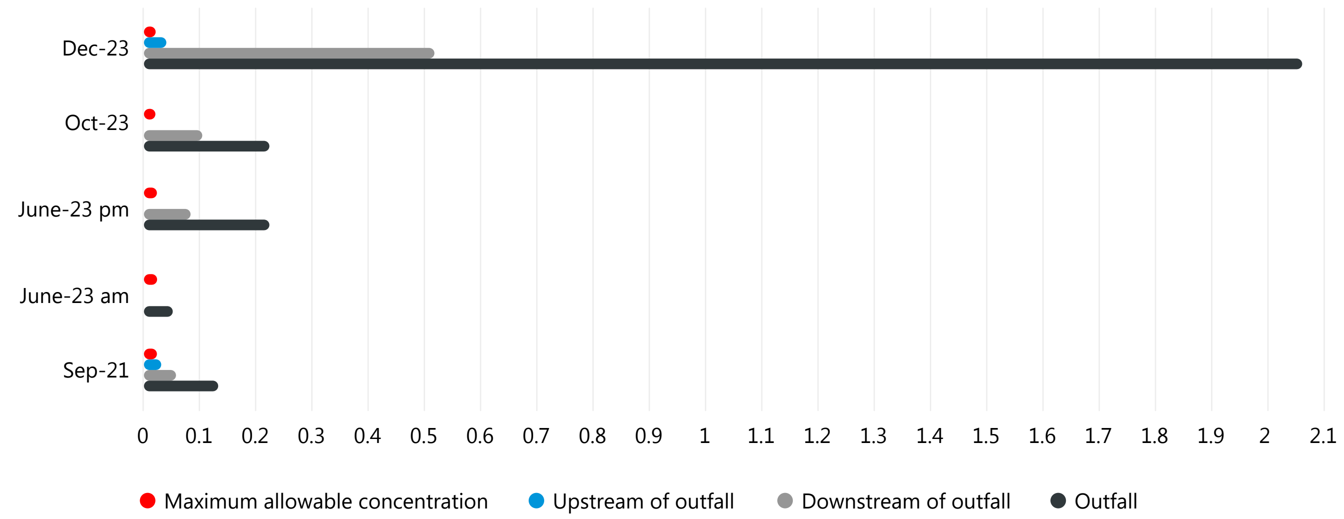
The samples taken from the River Lostock downstream demonstrate that elevated levels of PAHs and some toxic metals persist beyond the mixing zone and are not adequately diluted by the flow in the river. The outfall sampled is one of three in a short stretch, two of which are off the M6 and one off the M65. Modelling of all three outfalls would be required to quantify the contribution of the sampled outfall to river water quality deterioration.

It is worth noting that the River Basin Management Plan for this site fails to recognise these motorway outfalls as discreet sources of pollution. This means that their impact on river health goes unrecorded and no monitoring or mitigation is introduced.

Concentrations of Benzo(b)fluoranthene at M6 outfall to River Lostock, Cuerden Valley Park (µg/l)



Concentrations of Benzo(g,h,i)perylene at M6 outfall to River Lostock, Cuerden Valley Park (µg/l)



Modelling and screening tests

Water quality modelling and screening tests were carried to assess the impact of the M6 outfall on the River Lostock in Cuerden Valley Park, and therefore ascertain if this outfall, and similar outfalls, are likely causing EQS failures in the river itself and whether they should have environmental permits.

Blackwell Water Consultancy Limited were commissioned to carry out water quality modelling based on the samples taken at Cuerden Valley Park and regional water quality data sets from the Environment Agency[77]. Blackwell consultancy's model uses data about outfall discharges and upstream water quality to forecast downstream water quality.

The modelling strongly implies that the motorway outfall will have a substantial effect on a typical regional river, causing water quality to deteriorate significantly.

Further, Blackwell Water Consultancy Limited carried out the first three screening tests, required as part of the Environment Agency risk assessment for an environmental permit[78] (see box). This demonstrates that the M6 motorway outfall at Cuerden Valley Park failed the three tests and is likely causing concentrations of priority hazardous substances above EQS in the River Lostock downstream.

This should be recorded by the Environment Agency and they should serve notice on National Highways to apply for a permit. The Environment Agency should proceed with the next stage of the risk assessment, Test 4. This involves modelling to confirm whether an environmental permit is required and to establish appropriate permit conditions, including the amount of treatment that the outfall must receive in order to maintain the levels of pollutants in the river below the published standards.

As the River Lostock downstream of the outfall fails to comply with maximum allowable concentrations of priority hazardous substances and specific pollutants, this should be monitored by the Environment Agency.

> “The M6 motorway outfall at Cuerden Valley Park is likely causing concentrations of priority hazardous substances above EQS in the River Lostock downstream.

Water Pollution risk assessment for Environmental Permits

When the organisation responsible for a water discharge activity is considering whether or not they need to apply for an environmental permit, the Environment Agency provides guidance for the completion of a risk assessment if the application is for a bespoke permit that includes discharging hazardous chemicals and elements to surface water. The guidance sets out how the organisation must evaluate and assess any hazardous chemicals and elements that they plan to release into surface water.

The organisation must then carry out screening tests on the pollutants to check if they're a risk to the environment. This is called a specific substances assessment. Because highway runoff contains hazardous chemicals that are identified as specific substances, any highway authority that was instructed to apply for an environmental permit would have to carry out these screening tests.

The details of the tests are provided on the GOV.UK website at www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit

77. Blackwell Water Consultancy Ltd, April 2024. Stormwater Shepherds, Highways outfall impact on the River Lostock R0295
78. https://www.gov.uk/guidance/surface-water-pollution-risk-assessment-for-your-environmental-permit

b) Local authority road samples

Here we present analysis of runoff samples collected in 2015 from local authority roads in Lancashire with different traffic densities. Samples were only taken of the discharges of highway runoff; the river was not sampled.. This dataset was used to compose the dissertation of Mr R Webster 2015[79].

Map showing approximate sampling locations

- M6 motorway outfalls
- Local authority outfalls

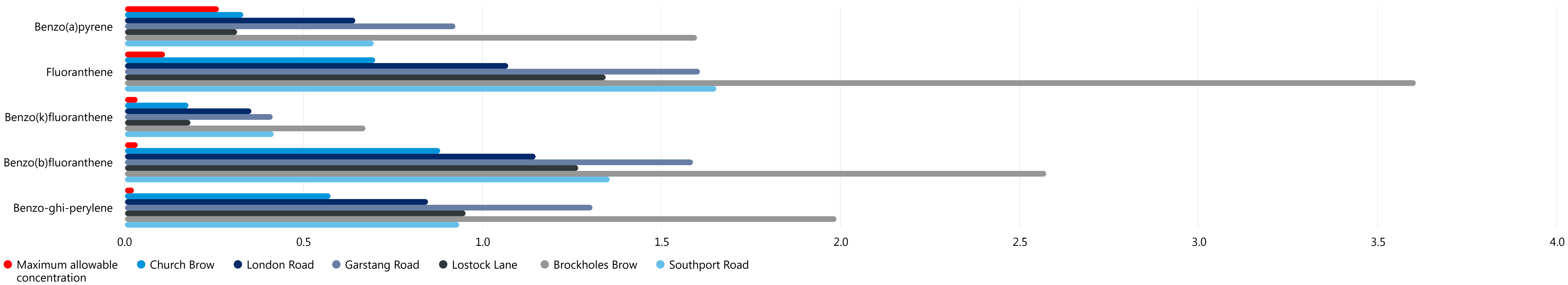
Southport Road

Southport Road is in a residential area of the small town of Ormskirk in Lancashire. It does get congested at times due to traffic lights to the south of the site, but the traffic density is about 12,000 vehicles per day (annual average daily traffic, AADT).

Table 6.4 Results of analysis for samples of highway runoff discharge from Southport Road into Hurlston Brook

Analytes	09/03/2015	11/03/2015	26/03/2015	Environmental Quality Standard	
	Southport Road – persistent rain for preceding hour	Southport Road	Southport Road – rain from 2am previous night	Maximum allowable concentration µg/l	Annual average concentration µg/l
Dissolved cadmium µg/l	< .1	0.362	< .1	0.9 (Class 4)	
Suspended Solids mg/l	257	680	40.4		
Benzo-ghi-perylene µg/l	0.241	0.951	< .02	0.0082	
Benzo-b-fluoranthene µg/l	0.357	1.32	0.0236	0.017	
Benzo-k-fluoranthene µg/l	0.102	0.375	< .02	0.017	
Fluoranthene µg/l	0.589	1.68	0.0493	0.12	
Dissolved zinc µg/l	44.7	168	23.3		10.9 bioavailable
Benzo-a-pyrene µg/l	0.198	0.72	< .02	0.27	
Dissolved copper µg/l	25.5	67.3	15.4		1 bioavailable

Concentrations of PAHs in local authority outfalls (µg/l)



79. Webster, R.J., 2014, Highway Pollution & Remediation: A Study into Highway Pollution and Potential Outfall Treatment in Lancashire (Masters Dissertation)

Brockholes Brow

Brockholes Brow is the A59 route over the River Ribble into Preston city centre from the East. The road slopes steeply up towards Preston from the river. It carries traffic off the M6 and the A59 into town and the traffic load is approximately 24,000 AADT. The road becomes congested at rush hour.

Table 6.5 Results of analysis for samples of highway runoff discharge from Brockholes Brow into the River Ribble

Analytes	09/03/2015	11/03/2015	26/03/2015	Environmental Quality Standard	
	Brockholes Brow – persistent rain for preceding hour	**Brockholes Brow**	**Brockholes Brow –** rain from 2am previous night	**Maximum allowable concentration µg/l**	**Annual average concentration µg/l**
Dissolved cadmium µg/l	< .1	0.16	< .1	0.6 (Class 3)	
Suspended solids mg/l	63.8	902	120		
Benzo-ghi-perylene µg/l	0.0249	1.99	< .02	0.0082	
Benzo-b-fluoranthene µg/l	0.038	2.57	0.0201	0.017	
Benzo-k-fluoranthene µg/l	0.0128	0.653	< .02	0.017	
Fluoranthene µg/l	0.0773	3.6	0.0695	0.12	
Dissolved zinc µg/l	62.1	119	56.3		10.9 bioavailable
Benzo-a-pyrene µg/l	0.0234	1.6	< .02	0.27	
Dissolved copper µg/l	22.1	64.4	41.7		1 bioavailable

Lostock Lane

Lostock Lane is a dual carriageway that connects the small town of Bamber Bridge to the M6 junction to the South of Preston. The road is congested at busy times as it approaches the motorway roundabout. The AADT on the road is approximately 21,000 vehicles per day.

Table 6.6 Results of analysis for samples of highway runoff discharge from Lostock Lane into the River Lostock

Analytes	09/03/2015	11/03/2015	26/03/2015	Environmental Quality Standard	
	Lostock Lane to R. Lostock – persistent rain for preceding hour but stopped at 11.30	**Lostock Lane to R. Lostock –** heavy rain for 2 hours preceding sample	**Lostock Lane to R. Lostock –** rain for preceding 2 or 3 hours, drizzle at sample time	**Maximum allowable concentration µg/l**	**Annual average concentration µg/l**
Dissolved cadmium µg/l	0.204	< .1	< .1	0.9 (Class 4)	
Suspended solids mg/l	345	443	74		
Benzo-ghi-perylene µg/l	0.398	0.964	0.139	0.0082	
Benzo-b-fluoranthene µg/l	0.62	1.26	0.159	0.017	
Benzo-k-fluoranthene µg/l	0.248	0.133	0.0515	0.017	
Fluoranthene µg/l	0.91	1.35	0.222	0.12	
Dissolved zinc µg/l	68.1	39.9	38.5		10.9 bioavailable
Benzo-a-pyrene µg/l	0.352	0.298	0.103	0.27	
Dissolved copper µg/l	28.4	19.1	16.1		1 bioavailable

Garstang Road

Garstang Road is a busy urban road to the North of Preston, linking the M55 motorway with a large residential area. The area becomes very congested at rush hour and there are multiple sets of traffic lights. The AADT is approximately 37,000 vehicles.

Table 6.7 Results of analysis for samples of highway runoff discharge from Garstang Road into a tributary of Blundel Brook

Analytes	11/03/2015	13/03/2015	26/03/2015	Environmental Quality Standard	
	Garstang Road to Woodplumpton Brook – heavy rain preceding 45 minutes	**Garstang Road –** rainfall from 2100hrs previous evening	**Garstang Road –** rain from 2am previous night	**Maximum allowable concentration µg/l**	**Annual average concentration µg/l**
Dissolved cadmium µg/l	0.201	< .1	< .1	0.9 (Class 4)	
Suspended solids mg/l	418	110	79.6		
Benzo-ghi-perylene µg/l	1.29	0.047	< .02	0.0082	
Benzo-b-fluoranthene µg/l	1.58	0.0544	< .02	0.017	
Benzo-k-fluoranthene µg/l	0.375	< .02	< .02	0.017	
Fluoranthene µg/l	1.61	0.0793	0.0534	0.12	
Dissolved zinc µg/l	87.3	34.4	33.7		10.9 bioavailable
Benzo-a-pyrene µg/l	0.927	0.0331	< .02	0.27	
Dissolved copper µg/l	37.6	10.5	15.7		1 bioavailable

London Road

London Road is an arterial route into Preston city centre from the south, crossing the River Ribble. The road is steeply inclined up into the city and the sample point is at the bottom of the hill. This outfall is a surface water sewer, owned by United Utilities, conveying the runoff from the length of London Road all the way from the river up towards the prison. When the river flow is high, the outfall can become submerged, but that was not the case for these three events.

Table 6.8 Results of analysis for samples of highway runoff discharge from London Road into the River Ribble

Analytes	09/03/2015	11/03/2015	26/03/2015	Environmental Quality Standard	
	London Road to R. Ribble – persistent rain for preceding hour	**London Road to R. Ribble – heavy rain** for preceding hour	**London Road to R. Ribble –** rain for preceding 2 or 3 hours; antecedent dry weather period	**Maximum allowable concentration µg/l**	**Annual average concentration µg/l**
Dissolved cadmium µg/l	1.29	0.469	< .1	0.6 (Class 3)	
Suspended solids mg/l	498	566	129		
Benzo-ghi-perylene µg/l	0.797	0.797	< .02	0.0082	
Benzo-b-fluoranthene µg/l	1.17	1.14	< .02	0.017	
Benzo-k-fluoranthene µg/l	0.373	0.338	< .02	0.017	
Fluoranthene µg/l	1.32	1.06	0.027	0.12	
Dissolved zinc µg/l	105	66.3	44.8		10.9 bioavailable
Benzo-a-pyrene µg/l	0.744	0.671	< .02	0.27	
Dissolved copper µg/l	36.4	38.6	14.2		1 bioavailable

Church Brow

Church Brow is a low-trafficked road in Walton-le-Dale. It is steeply sloping from river level up towards the church and there can be light congestion at busy times, due to the roundabout at the bottom of the hill. The AADT for this site is just under 5,000 vehicles per day.

Table 6.9 Results of analysis for samples of highway runoff discharge from Church Brow into the River Ribble

Analytes	11/03/2015	13/03/2015	26/03/2015	Environmental Quality Standard	
	Church Brow to R. Ribble – very heavy rain preceding half hour, heavy rain over one hour	**Church Brow –** rainfall from 2100hrs previous evening	**Church Brow to R. Ribble –** rain for preceding 2 or 3 hours, light rain at time of sample	**Maximum allowable concentration µg/l**	**Annual average concentration µg/l**
Dissolved cadmium µg/l	< .1	< .1	< .1	0.6 (Class 3)	
Suspended solids mg/l	451	199	28.5		
Benzo-ghi-perylene µg/l	0.583	0.298	0.0204	0.0082	
Benzo-b-fluoranthene µg/l	0.819	0.258	0.0268	0.017	
Benzo-k-fluoranthene µg/l	0.129	0.0737	< .02	0.017	
Fluoranthene µg/l	0.722	0.297	0.0602	0.12	
Dissolved zinc µg/l	19.6	13.1	23.5		10.9 bioavailable
Benzo-a-pyrene µg/l	0.338	0.178	< .02	0.27	
Dissolved copper µg/l	17.2	4.64	19.4		1 bioavailable

Findings

The results from these local authority roads show that the pollutant levels can also be elevated, just as those from the motorway, although they are not as high as the results seen in the sample at Massey Brook. These discharges also tended to run at lower flow rates than the motorway discharges as they take runoff from a smaller impermeable area of road surface. London Road and Lostock Lane are dual carriageways, but the rest of these roads are single carriageway. The area drained by these outfalls varies from 3,000m² at Southport Road to 13,000m² at Garstang Road.

These results illustrate that runoff from all roads can cause pollution, and that in many cases the level of pollutants is higher than the EQS. Whether or not these discharges contribute to EQS failures downstream of the mixing zone would need to be determined by the regulators. The maximum allowable concentration EQSs for PAHs are based on toxicity to aquatic life[80]. It is considered essential that the regulators uphold these Standards for all rivers.

“These results illustrate that runoff from all roads can cause pollution, and that in many cases the level of pollutants is higher than the Environmental Quality Standard.

80. Environment Agency. Polycyclic aromatic hydrocarbons (PAHs); background data and predicted future emissions. September 2015

7. Treatment and control options

Sediment trap at Stover Park, downstream of the A38

7. Treatment and control options

a) Treatment technologies that can be used to treat highway runoff

An array of treatment technologies and devices for managing highway runoff are readily available in the UK. They include proprietary devices which can remove both sediment and soluble pollutants, and many vegetative treatment devices such as ponds and swales. The installation and construction of these measures is reasonably straightforward and there are many examples of their use.

There is, however, insufficient information on their performance when treating highway runoff and far more field testing of these products and devices needs to be carried out to allow their effectiveness to be measured in a controlled way.

The Environment Agency recognises that the increasing use of SuDS has the potential to manage and mitigate risks from the PAH load in urban runoff to watercourses. However, they acknowledge that more needs to be known about the breakdown of PAHs and other hydrocarbons within these systems and any impacts through connected systems such as groundwater[81].

The treatment solution selected will depend on the traffic density, the expected pollutant load off the road and the resultant pollutant risk. The runoff from trunk roads and motorways is highly polluted and the treatment scheme must provide adequate treatment, and the capacity to capture and retain the pollutants, if it is to be effective.


Vortex grit separator being installed

“An array of treatment technologies and devices for managing highway runoff are readily available in the UK.

81. Environment Agency. Polycyclic aromatic hydrocarbons (PAHs): sources, pathways and environmental data. 2019

For less heavily trafficked roads, the use of nature-based solutions is preferred, although effective maintenance is still essential.

For trunk roads, motorways and any other high-risk roads with heavy congestion, the treatment scheme must include sediment capture and removal before additional treatment stages are included. The sediment capture and removal must be included because much of the pollution is included in the sediment in the runoff; metals in highway runoff are predominantly in, or associated with the particulate phase[82], and by effectively capturing this, the pollutant load is quickly and effectively reduced.

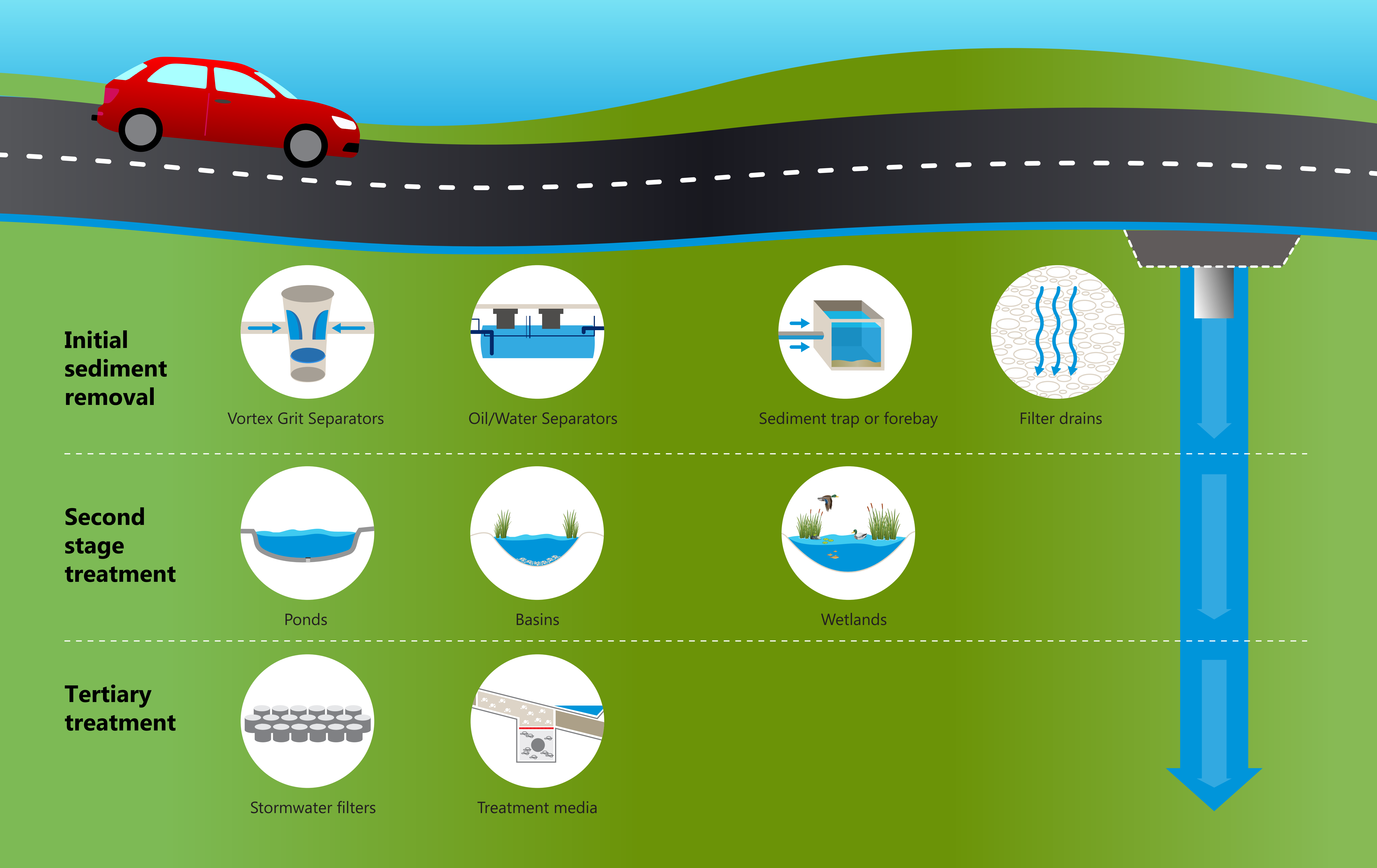
Following sediment capture and removal, it is common practice to provide further treatment for the runoff in a pond, basin or wetland. There is too little research on the effects of the residual pollution on the wildlife that live in these habitats, and there is a risk that the pollution is still sufficiently harmful that it affects the wildlife. Research has shown a harmful effect on frogs inhabiting a surface water treatment pond receiving urban runoff[83]. This potential harm warrants further research so that safe habitats for wildlife can be created.

Inlet to sediment trap

Treatment wetland near Liverpool on the A59

82. Luka, M. and Montague, K. (1994) Control of pollution from highway drainage discharges. CIRIA
83. Linking water quality with amphibian breeding and development: a case study comparing natural ponds and Sustainable Drainage Systems (SuDS) in East Kilbride, Scotland. R.J. Bird, E. Paterson, J.R. Downie & B.K. Mable. The Glasgow Naturalist (2018) Volume 27, Supplement. The Amphibians and Reptiles of Scotland

Treatment and control options to treat highway runoff



Initial sediment removal

The most common techniques for capturing sediment off heavily trafficked roads are vortex grit separators, oil/water separators and filter drains. The sediment can also be captured in a forebay in a pond or wetland.

a) Vortex Grit Separators are subsurface devices that can be made of plastic, glass-reinforced plastic or concrete. As the surface water enters the device, it is forced into a vortex-flow which creates a longer flow-path for suspended particles and encourages the deposition of those particles at the bottom of the device where they are stored. The devices can readily capture and retain up to 50 per cent of the suspended particles in the surface water. They must be regularly maintained and emptied, often once a year.

b) Oil/Water Separators are larger sub-surface devices that capture suspended particles and also capture floating oil from leaks and spillages. These devices can often remove up to 80 per cent of the suspended particles and also need to be maintained and emptied regularly.

Both of these devices are commonplace in surface water drainage systems where the pollutant load is high and downstream devices, or environments, need to be protected from the gross pollution. Because they are quick and easy to empty, and their performance can be measured and proven, they are often a good first-stage of drainage management for highway runoff.

c) Filter drains are constructed in-situ at the side of the road. They comprise a layer of stone above a perforated drainage pipe. They can also include a layer of treatment media that will capture dissolved pollutants. They have a large treatment capacity and can be an excellent option for new-build roads, although they can be more difficult to retrofit when there is little space at the carriageway edge. They don't need to be maintained as often as the separators, but the maintenance operation can be more time-consuming and expensive.

d) Sediment forebays or traps can be included near the inlet to capture sediment at the 'top' of a treatment pond or basin, or they can be built in-situ as a separate device. They capture a proportion of the sediment before it can pass forward into the pond or basin. They are designed to be easy to empty, with vehicular access, and they often have a concrete base.

Filter drain on the A66, Cumbria

Second stage of sediment removal and provision of natural processes

Once a proportion of the polluted sediment has been captured, the runoff should receive secondary treatment, where smaller solids will settle out, some organic pollutants will biodegrade and nutrients will be taken up in plant growth. These natural processes are usually delivered in ponds, basins or wetlands.

a) Ponds are deep devices with permanent pools of water where sediment can settle out and natural processes can break down organic pollutants.

b) Basins can either retain a small pool of water, or drain down completely and be dry between rain events. They fill up when it rains and hold the water back to reduce downstream flood risk. They also allow some sediment to settle out, and natural processes will take place around the basin. The wetting and drying action can be better for the biodegradation of organic pollutants. They are often unlined devices and allow runoff to infiltrate into the ground, so a groundwater protection risk assessment is essential during the design stage.

c) Wetlands are typically larger and shallower than ponds, and have vegetation across their area, with small pools of varying depth. The variety of depths, wet and dry areas and vegetation type can provide an array of natural processes to capture and break-down pollutants.

Treatment reedbed at Stover Park, downstream of sediment trap

Tertiary treatment, or treatment where space is limited

Where there is inadequate space for the nature-based solutions described above, or where there is a specific need to remove a particular pollutant effectively, additional manufactured treatment products may be included. These may be stormwater filters or treatment media.

a) Stormwater filters contain treatment media in cartridges or bags that can capture specific dissolved pollutants, including metals and pesticides. They are particularly useful when the outfall discharges to a sensitive environment or to ground where high-level pollution capture and removal is necessary.

b) Treatment media can be used as a 'loose' material, as well as in a stormwater filter. When it is used 'loose' it can be deployed as a drainage layer at the bottom of an infiltration basin, as a layer in a filter drain, or in bags/cages in bioremediation zones.

c) Novel treatment ideas are coming to international markets all the time. Some of them target particular pollutants, some of them make existing devices more efficient, and some of them work in completely new ways. It is important to consider these, especially if they can reduce costs, carbon use, or waste creation.

Roadside swale

Simple vegetative treatment devices for low trafficked roads

For low trafficked roads on residential developments and similar, it is possible to treat the highway runoff in simple vegetative solutions that form part of a sustainable drainage system (SuDS). These devices can be located at the side of the road, in the corner of carparks, and along residential roads as tree pits.

a) Swales or bioswales are linear devices at the side of the road, formed as shallow grassed channels. The runoff enters the swale as sheet-flow along its length and the pollutants are captured in the grass, are broken down by micro-organisms and are captured as they pass down through the underlying soil. Any exceedance flows can run along the swale and onwards to another device or to a watercourse. They can either be mown through the summer, presenting as a grass surface, or be left unmown in the centre and planted to create a dense habitat for wildlife.

b) Bioremediation zones are similar to swales but they are not normally linear devices; they are usually rectangular cells, planted with shrubs, flowers and sometimes trees, and the runoff usually enters them through designed inlets. The pollution is captured and treated at the surface, and as it passes down through the cell in the engineered soils. The plants and micro-organisms take up nutrients and some pollutants and micro-organic activity breaks down some of the organic pollutants.

These devices can be included upstream of ponds, basins or wetlands, as described above. If they are designed well, they can also create habitats for wildlife and pleasing green spaces for people to enjoy.

b) Design criteria for treatment devices

When treatment devices are being designed to treat polluted highway runoff, it is essential to calculate the flow rate that needs to be treated in the devices in order to properly protect the environment. If a permit were issued for the outfall, it should dictate the necessary treatment flow rate. For low and medium trafficked roads that can be designed in accordance with the Simple Index Approach in the CIRIA (C753) SuDS Manual[84] , all sub-annual flows should be treated by the device. CIRIA C753 suggests that the maximum design treatment flow rate used to specify and design treatment flow rates should be that for the 1 in 1 year, 15-minute rainfall event.

For heavily trafficked trunk roads and motorways, that are designated as high-risk surfaces in the SuDS Manual, the Simple Index Approach is not sufficiently detailed to be applied on its own. For these locations, the design process set out in the Design Manual for Roads and Bridges (DBRB) should be followed[85]. DMRB also includes guidance on the protection of groundwater from road-building projects. However, it does not specify the rainfall event or rainfall depth that should be used as the maximum design treatment flow rate or treatment volume.

It is essential to calculate the range of flow rates that must be treated by the in-line devices, including the maximum treatment flow rate, so that their capacity can be designed accordingly. For devices that rely on residence time for treatment, the treatment volume must also be calculated. There is currently a gap in the guidance for the design of treatment devices in these situations; the design is often focussed on flood risk management and the attenuation volume required to achieve adequate levels of flood protection. However, the volume required for effective pollution treatment may be higher than that, and it might be necessary to divert very high flows around ponds, basins and sediment separators to prevent the captured pollutants from being washed downstream during storms.

There is also a need to design devices to protect groundwater. The design of infiltration devices is often focussed on maximising infiltration to prevent surface water flooding without adequate consideration of pollution control. It is also unclear how designers can properly design these devices for pollution control when they do not have site-specific pollutant load information. Although the HEWRAT model is designed to consider the control of pollution, the designers do not have access to site-specific sample results and, as can be seen from the results of analysis in Section 6, pollutant levels are very variable.

Similarly, without adequate information about the sediment yield off a highway surface, the designers cannot properly assess the sediment storage capacity that must be included in a sediment capture device or a forebay. If the client dictates that the device will only be maintained once every two years, it is impossible for the designer to know how much silt will accumulate in that two-year period without site-specific sediment yield data.

These gaps in the guidance need to be filled and site-specific sampling should be included as part of the design process, especially for retrofit schemes. Without this, we are building undersized devices, risking groundwater pollution and creating unmanageable maintenance burdens for the future.

Sediment trap serving a motorway service station

84. Woods Ballard, B, Wilson, D, Udale-Clarke, H, Illman, S, Scott, T, Ashley, R, Kellagher, R (2015) The SuDS Manual, CIRIA, C753, London
85. Highways England. Design Manual for Roads and Bridges LA 113 Road Drainage and the Water Environment. 2020

c) Operation and maintenance

Whilst there is increasing emphasis on delivering new treatment schemes, maintenance of highway runoff treatment has suffered. Too many highway outfall treatment schemes are left to fall into disrepair and to fill up with contaminated sediment so that they no longer perform as they should do. This applies to schemes operated by both local authorities and National Highways.

If millions of pounds are invested in installing new treatment devices across the highway network, it is crucial that they are supported by maintenance and operation contracts or commitments and sufficient maintenance funding provision.

Vortex Grit Separators can easily accumulate over 5 tonnes of contaminated sediment each year and if this is not removed, the separator becomes ineffective. Equally, oil/water separators must have their filters checked and exchanged regularly or they cease to work properly.

The designer needs to know the expected sediment yield of the catchment so that the treatment device can be designed with adequate sediment capacity. There is also an option to include silt level alarms on many of the systems and devices, which alert the operator when the silt level reaches a prescribed level and maintenance is required.

Good design is essential so that future maintenance operations are simple and cost-effective. The designer must include tanker stands near sub-surface devices so that the vacuum tanker can readily access the devices. Similarly, ponds and basins will need to be emptied by excavators or bulldozers and safe vehicle access is essential.

Wherever possible, access for maintenance should be off the road network so that it can be done safely and without lane closures; this makes it more likely that the operation can be carried out within budget and will be done in accordance with a schedule. Failure to remove captured pollutants from these devices will render them ineffective and pollution will occur.

All highway outfall treatment schemes, both on new build schemes and on retrofit schemes on existing outfalls, must have an associated maintenance schedule and a robust process to ensure that the schedule is complied with.

> “If millions of pounds are invested in installing new treatment devices across the highway network, it is crucial that they supported by maintenance and operation contracts or commitments and sufficient maintenance funding provision.

d) Automatic closure devices and spill control

Reducing the risk of spillages on road surfaces should also be a key part of pollution control, particularly where the receiving watercourse is sensitive. Spillages on roads can be of fuel oils from road traffic accidents and tanker crashes, but they can also be of milk, treacle, beer and any other liquids and potential pollutants that are carried on our roads in tankers, lorries and vans.

Where the risk is high because of local manufacturing activity, or dangerous corners, the designer should assess the risk of spillage and include spill control devices.

Modern automatic closure devices can be installed within the drainage system that can be closed remotely if an accident is seen. The automatic closure device should ideally be installed downstream of the sediment capture device, but upstream of the vegetative treatment devices. This protects the wildlife in the vegetative treatment device from the spilled chemical.

e) Reducing pollution in the future

The use of the Design Manual for Roads and Bridges[86] to create adequate drainage systems can help to manage the risks of highway runoff contributing to pollution. The gaps in the design guidance discussed above must be addressed to improve confidence that the drainage systems associated with new road-building projects are adequately protecting the environment.

It is essential that new schemes include good drainage design and that they are properly maintained, so that newly built highway outfalls are not adding to the pollution caused by existing highway outfalls.

f) Reducing pollution at source

Ordinarily, when an activity causes pollution, the first step is to try to eliminate the source of the pollutants – source control. For example, lead was removed from petrol in the UK in 2000, because concerns were raised about the toxic effects of lead in air pollution on children.

Removing the water pollutants from cars on the roads in the UK is complex and challenging. Fuel oils are hydrocarbons so it is nearly impossible to remove all of the hydrocarbons from the environment. However, the use of PAH oils in the manufacture of tyres is one source of pollution that could be controlled using new legislation.

Since 2010, extender oils have been prohibited from being placed on the market or used in the production of tyres or parts of tyres that contain more than 0.0001 per cent by weight of benzo(a)pyrene or more than 0.001 per cent by weight of the sum of all listed PAHs. The listed PAHs in this restriction include benzo(a)pyrene, benzo(b)fluoranthene and benzo(k)fluoranthene[87].

More recently, the Euro 7 Emissions Standard has adopted uniform provisions on tyre abrasion limits which will be a significant step in the right direction. New Euro7 standards will come into force in 2025 and even though the UK has left the EU, the government has committed to continuing to use the standard framework.

The European Emission Standards are vehicle emission standards for pollution from the use of new land surface vehicles sold in the European Union and European Economic Area member states and the UK. Once these abrasion limits are in force, tyre manufacturers will need to ensure that all the tyres sold on the market are below the set limits. For those exceeding the limits, manufacturers will need to adjust their material composition or manufacturing process[88].

For fuel oil, legislation that places a maximum limit on the PAH content of diesel has been in existence for several years and in 2009 the upper limit for PAH content in diesel was reduced from 11 to 8 per cent by weight[89] . However, the PAH content of diesel in the UK is considerably lower than 8 per cent[90].

These control mechanisms are slowly reducing pollution from roads and vehicles, but they cannot eradicate it. Even with the advent of electric cars, there will still be pollution from tyre-wear particles and brake dust, so effective pollution control must continue to be pursued.

87. Environment Agency. Polycyclic aromatic hydrocarbons (PAHs): challenges for the environment. October 2021
88. ibid
89. Directive 2009/30/EC
90. Department for Transport. Explanatory Memorandum to the Motor fuel (Composition and Content) and Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2010

8. Key findings and recommendations

Treatment pond serving off the A556 at Manchester

8. Key findings and recommendations

Highway runoff causes pollution of rivers and streams. The extent of this pollution is poorly understood and there is too little monitoring and assessment taking place.

The results of analysis of several highway runoff samples show elevated levels of toxic and bioaccumulative priority pollutants that exceed published standards that have been set to protect aquatic organisms and wildlife from harm.

The effects of these pollutants are varied and far-reaching, affecting organisms and wildlife throughout the aquatic ecosystem and reaching far down river systems as sediments are washed downstream.

Further research

If this problem is to be tackled, there is a need to better understand the harm that pollution from highway runoff is causing in the environment.

A more comprehensive understanding is needed of the effects of EQS failures on river ecosystems, and how far down rivers and estuary systems the effects of pollutants on wildlife persist, including in sediments. This includes establishing how far microplastic tyre-wear particles travel and what factors affect the leaching of pollutants from the particles.

It is also necessary to understand how harm on aquatic organisms manifests itself; the extent to which it causes deformities, failure to reproduce, failure to thrive or death under varying concentrations and conditions.

However, enough is known of the harm that this pollution causes to act now, and important ongoing research must not prevent the delivery of solutions. As described above, these solutions are understood and we know how to install them. So, the delivery of treatment schemes should be accelerated and their effectiveness measured in parallel with ongoing research into levels of harm.

Monitoring and assessing risk

The ongoing impact of highway outfalls on discharges of highway runoff on the water environment – and the harm that they cause to the aquatic ecosystem – is not widely measured.

The Environment Agency does not have a specific monitoring programme assessing the impact of highway runoff on the water environment. Likewise, National Highways and highway authorities do not routinely monitor the discharges of highway runoff entering the water environment from their network. This means that individual highway outfalls are not monitored and controlled.

In the absence of monitoring, the assessment of risk of harm of highway outfalls and subsequent pollution control is directed by National Highways' predictive model, HERWAT, also used by other highway authorities.

However, there are indications that HEWRAT is not wholly effective. As discussed above, the HEWRAT model does not consider total concentrations of PAHs and may be underestimating the risk of harm of certain outfalls. As an example, the M6 outfall at Massey Brook is considered a low pollution risk by the HEWRAT model, yet our analysis shows very high PAH concentrations between 20 and 730 times higher than maximum allowable EQS concentrations.

We are concerned that the understanding of the scale and nature of the highways pollution run off is poor, and there is no robust process to systematically prioritise the deployment of appropriate treatment for harmful runoff.

We consider on the basis of our findings that there is sufficient evidence to show it would be beneficial to test and compare the HEWRAT model and its outputs with the risk assessments completed by the Environment Agency.

> The M6 outfall at Massey Brook is considered a low pollution risk, yet our analysis shows PAH concentrations between 20 and 730 times higher than maximum allowable concentrations.

A catchment approach

Measurement and control of highway pollution must be part of a catchment-based approach, so that the largest contributing outfalls can be identified and prioritised for remedial action.

Pollution control strategies for rivers must take a whole-catchment approach and consider all the different sources of pollution. They should seek to tackle the most acute and harmful sources of pollution (including highway runoff pollution) in any given catchment. This would enable the most targeted use of investment, ensuring best value for money.

Pollutants such as benzo-a-pyrene discharge into a river catchment from lots of different sources, including wastewater treatment works, storm sewer overflows, highway outfalls and industrial discharges. Historically, regulators have focussed on reducing pollutants such as benzo-a-pyrene through tightening permits at Wastewater Treatment Works. However, it is potentially cheaper and easier to remove the same load by installing a treatment device at highway runoff outfalls.

Widespread catchment monitoring is needed to prioritise investment, and catchment modelling of particular pollutants can help identify the most cost-effective strategy to reduce the pollution.

The River Douglas catchment in Lancashire has at least 15 motorway discharges across the catchment and myriad discharges from local authority roads and surface water sewers in Chorley, Leyland, Wigan and Skelmersdale. Together, the pollutant load from these outfalls is likely to be significantly harmful to the river, yet there is no measure of the extent of that harm and it is therefore not possible to identify the best locations to deliver treatment schemes to achieve maximum benefit.

Permitting

National Highways and other highway authorities in England have no permits in place for managing pollutants in any of their outfalls. Water company surface water sewers that convey highway runoff into the water environment do not ordinarily have water discharge permits either.

But this does not allow them to cause pollution with impunity. As described above, the Water Framework Directive requires that the Environment Agency regulate known discharges of priority hazardous substances to ensure that the Environmental Quality Standards (EQS) are not exceeded in water bodies and that harmful levels of pollution are phased-out.

Under the Environmental Permitting Regulations (2016), if a particular discharge is found to be polluting, the Environment Agency should serve a prohibition notice, preventing the discharge from carrying on until a permit is issued.

The data and analysis presented in this report show that highway outfalls at a number of locations fail EQS for several pollutants. Moreover, sampling data from the River Lostock at Cuerden Valley Park demonstrates a motorway outfall causing levels above the EQS for several PAHs in the river downstream.

Modelling and risk assessments carried out using this sampling data[91] and regional water quality data strongly suggests this type of outfall is liable to cause EQS failures downstream in the receiving water body for the pollutants of interest.

Our research illustrates that the levels of pollution are sufficiently high that the discharges should – according to regulations - be controlled using the environmental permitting regime and that the voluntary agreement with National Highways is not effectively protecting rivers from pollution.

Requiring National Highways, other highway authorities and water companies to apply for permits for high-risk outfalls off the road network would enable the Environment Agency to control them more effectively. The setting of permit conditions not only dictates the level of treatment that is required to protect the receiving watercourse but can also require that the treatment devices be maintained and operated properly.

Permitting would also generate an income to allow the Environment Agency to resource this control of the outfalls. It would provide an incentive for highway authorities to reduce pollution at source by working with vehicle manufacturers and to develop more effective treatment devices.

It might be argued that the Environment Agency should serve notice to require that National Highways apply for a permit on the 1054 outfalls identified by the HEWRAT model as posing a high risk of pollution. The Environment Agency would then carry out a risk assessment to assign permit conditions that protect the environment from harm and ensure compliance with the Water Framework Directive.

For the outfalls owned by local authorities and water authorities, desk-top modelling could identify the outfalls at highest risk of causing pollution, and they too could be served with a notice.

“Our research illustrates that the levels of pollution are sufficiently high that the discharges should – according to regulations - be controlled using the environmental permitting regime.

91. Blackwell Water Consultancy Ltd, April 2024. Stormwater Shepherds, Highways outfall impact on the River Lostock R0295

Funding improvements

The pollution described in this report is far-reaching and harmful to aquatic environments. So to address this problem a sustainable and equitable funding mechanism must be found to control highway pollution.

Both manufactured and nature-based treatment approaches are available to address highway pollution and engineers are experienced in the design and delivery of effective treatment schemes.

However, achieving pollution control across many hundreds or thousands of outfalls is going to cost billions of pounds over several decades. The design and construction of a treatment scheme for an existing, polluting motorway outfall can cost millions of pounds. Although local authority roads and water company surface water sewers may be able to utilise cheaper, smaller systems, there may be many more of them that require remediation.

One approach to funding these interventions might be the introduction of a Stormwater Utility Levy, similar to that in Germany, where each household pays a monthly fee into a central or regional fund to pay for better management of surface water. This can include the design, construction and operation of retrofit schemes, as well as the operation and maintenance of new SuDS schemes serving new roads and developments. In Germany and parts of the USA[92] the fee is levied according the impermeable surface area of a property.

The money collected from stormwater utility levies is not used explicitly for pollution control from highway runoff, but it is often used to retrofit SuDS in a catchment to reduce flood risk which can simultaneously reduce pollution.

Alternatively, product levies could be introduced to create a fund specifically to pay for the retrofitting of treatment devices at polluting highway outfalls. The products that could be targeted include tyres, fuel oils and brake pads.

The outfalls that are owned and operated by National Highways should be remediated by National Highways with funds from the Department for Transport.

When National Highways were given the first Roads Investment Fund in 2020, it included money for their Environment and Wellbeing Designated Fund. Although some of this fund was allocated for the installation of treatment schemes at priority outfalls to reduce pollution, it is unclear why this work should be funded via the designated fund.

These funds were said to be for National Highways to deliver improvements that were ‘above and beyond’ their core work. However, the control of pollution from their network is a statutory duty and, we recommend, should be paid for from their core budgets from the Department for Transport, not from a discretionary fund.

Clearly, an ambitious settlement for environmental protection should be included within National Highways’ next road budget. The Department for Transport must look beyond other important issues such as road safety and be ambitious on wider issues that are of increasing importance to the public, such as managing the considerable environmental impact of roads.

These changes and new funding mechanisms will be unwelcome and difficult to negotiate, but it is essential that a funding mechanism is found to deliver pollution control for highway runoff across the UK if the health of our rivers is to be restored.

92. United States Environmental Protection Agency. EPA 833-F-07-012 Funding Stormwater Programs Factsheet. January 2008

Recommendations

We call on the Government to deliver the following actions to improve the management of harmful road runoff:

- The Department for Transport must look beyond other important issues such as road safety and be ambitious on wider issues that are of increasing importance to the public, such as managing the considerable environmental impact of roads.
- There must be far greater emphasis on the control of pollutants at their source, including enforcing legislation to control use of PAHs in the manufacture of tyres, and ensuring new Euro 7 Emissions Standards on tyre abrasion limits are properly adopted by manufacturers when they come into force in 2025.
- All new road schemes should include good drainage design, and crucially provision for effective monitoring, operation and maintenance of drainage and treatment schemes.
- The HEWRAT model should be reviewed and its outputs compared with the risk assessments undertaken by the Environment Agency; we are concerned that there is currently no robust process to systematically prioritise the deployment of appropriate treatment for harmful runoff.
- A catchment-based approach to assessing risk of harm from highway outfalls should be adopted, so that the most polluting outfall sources can be prioritised for remedial action and the most cost-effective solutions developed.
- The control of pollution from National Highways' network is a statutory duty, and should be paid for from their core budget. An ambitious settlement for environmental protection should be included within National Highways' next road budget agreed with the Department for Transport.
- The introduction of extended producer responsibility levies on products such as tyres, fuel oils and brake pads should be introduced. This could provide the Department for Transport with greater budget to allow National Highways to install remediation schemes at high risk outfalls.
- Alternatively, or in addition, the introduction of a Stormwater Utility Levy should be considered (as used in Germany). Under this mechanism each household pays a monthly fee into a central or regional fund to pay for better management of surface water. This could be set up to give local authorities the power to prioritise and address polluting outfalls within their area, as well as delivering against wider government policy objectives, for example, storm overflows and surface water flooding.
- The Environment Agency should seriously consider issuing permits for high-risk outfalls from the road network. This would enable them to control the pollution by dictating the level of treatment that is required to protect the receiving watercourse and requiring that treatment devices be maintained and operated properly. It would also generate an income to allow the Agency to resource the control of the outfalls.

Outfall from the M60

STORMWATER SHEPHERDS

CIWEM

ciwem.org