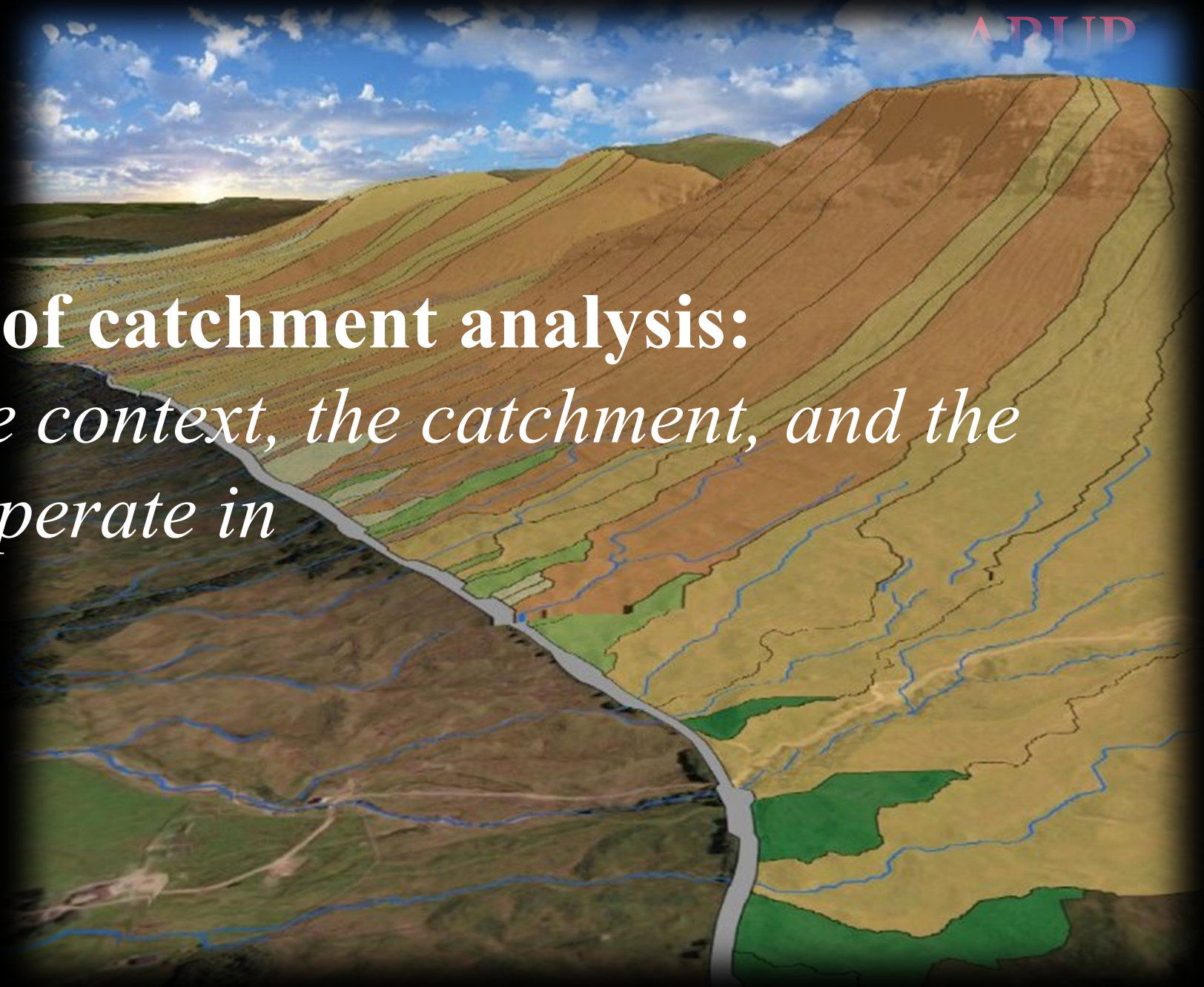


The importance of catchment analysis: *understanding the context, the catchment, and the systems that we operate in*

Dr Faye Beaman



Be **curious**

Understand the **context**

Be willing to **collaborate**

Get **creative**

What are our catchments?

Flood risk and resilience

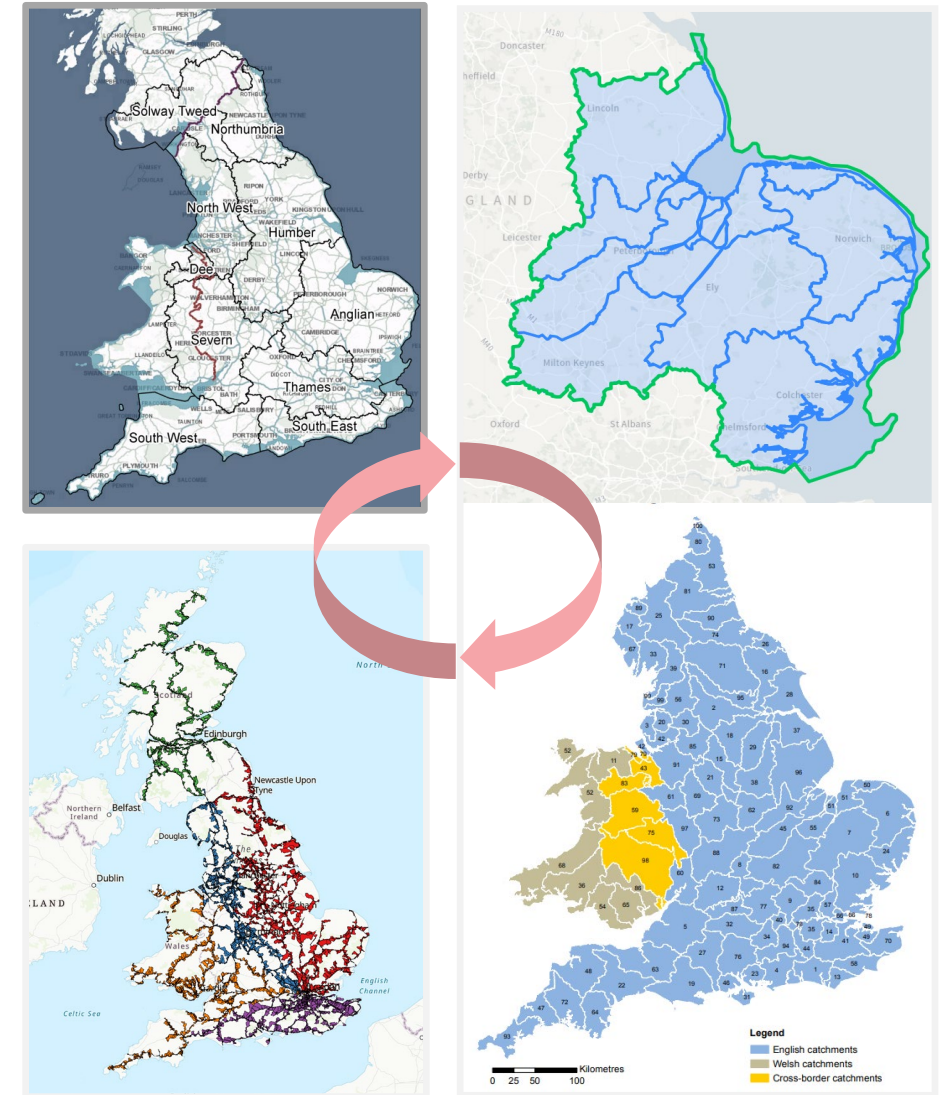
River basin district: The main area for coordinated water management.

River catchment: The river basin districts are then split into river catchments. A river catchment is an area of land where water collects when it rains, often bounded by hills.

Surface water catchment: A surface water catchment is an area of land where all precipitation (like rain or snowmelt) drains into a specific body of water (doesn't necessarily need to be a river). It's essentially the area "drained" by that outfall.

Network Rail sub-catchment: These are surface water runoff catchments that flow towards the railway, see Network Rail's Geo-RINM viewer, Catchment Layer.

Coastal Area and Policy Development Zones: Each Shoreline Management Plan is divided into a number of Coastal Areas, for discussion and policy development. Coastal Areas are further subdivided into Policy Development Zones, lengths of the coastline defined for assessing issues and interactions and developing management options.



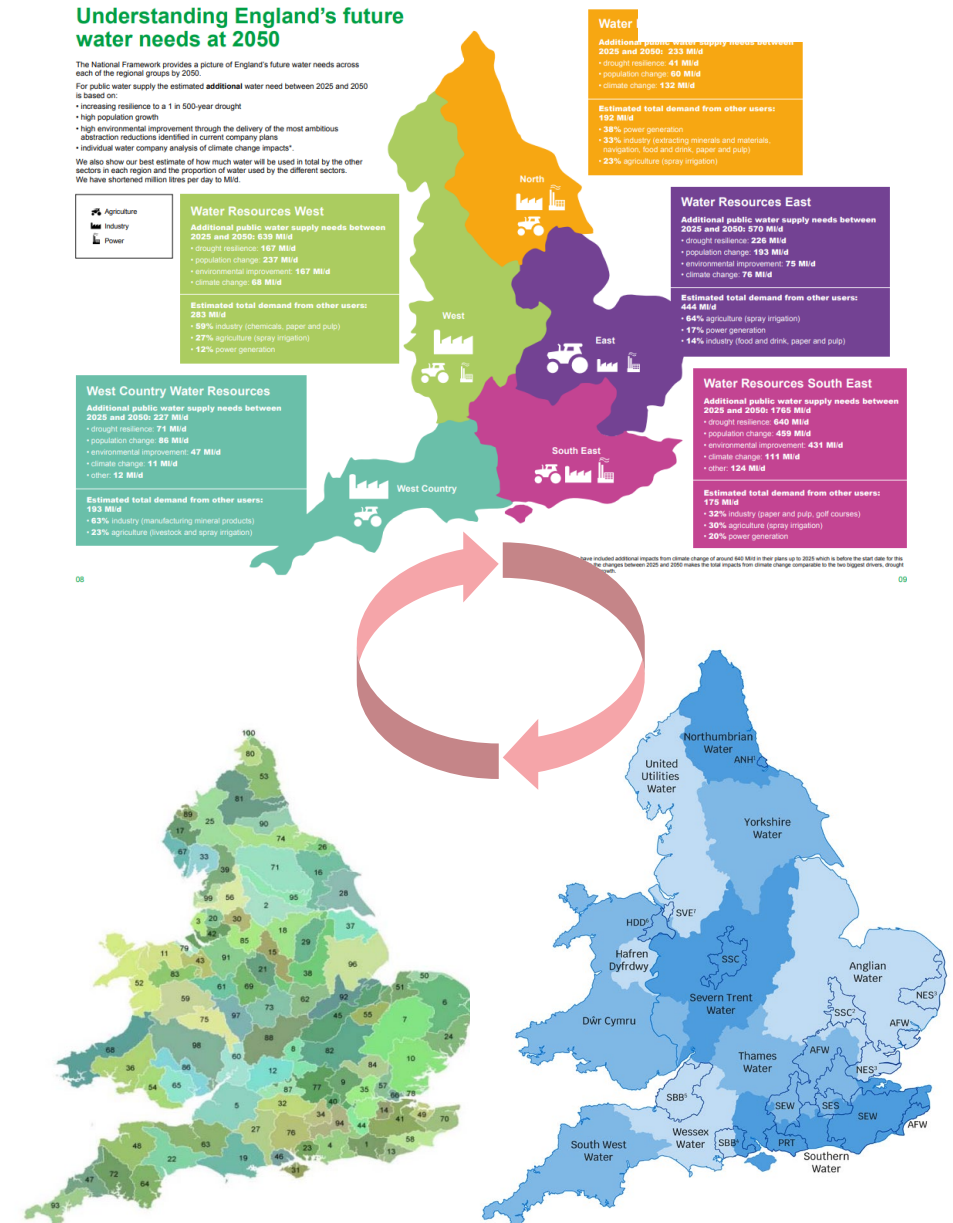
What are our catchments?

Water resources

Water resource groups: Regional groups bring together the water companies that operate in each of England's regions with key water users and other stakeholders.

Water/water and sewerage companies: Organizations responsible for supplying water to homes and businesses for domestic and industrial use. They are also responsible for the maintenance and operation of the public water supply and sewerage systems within their designated area.

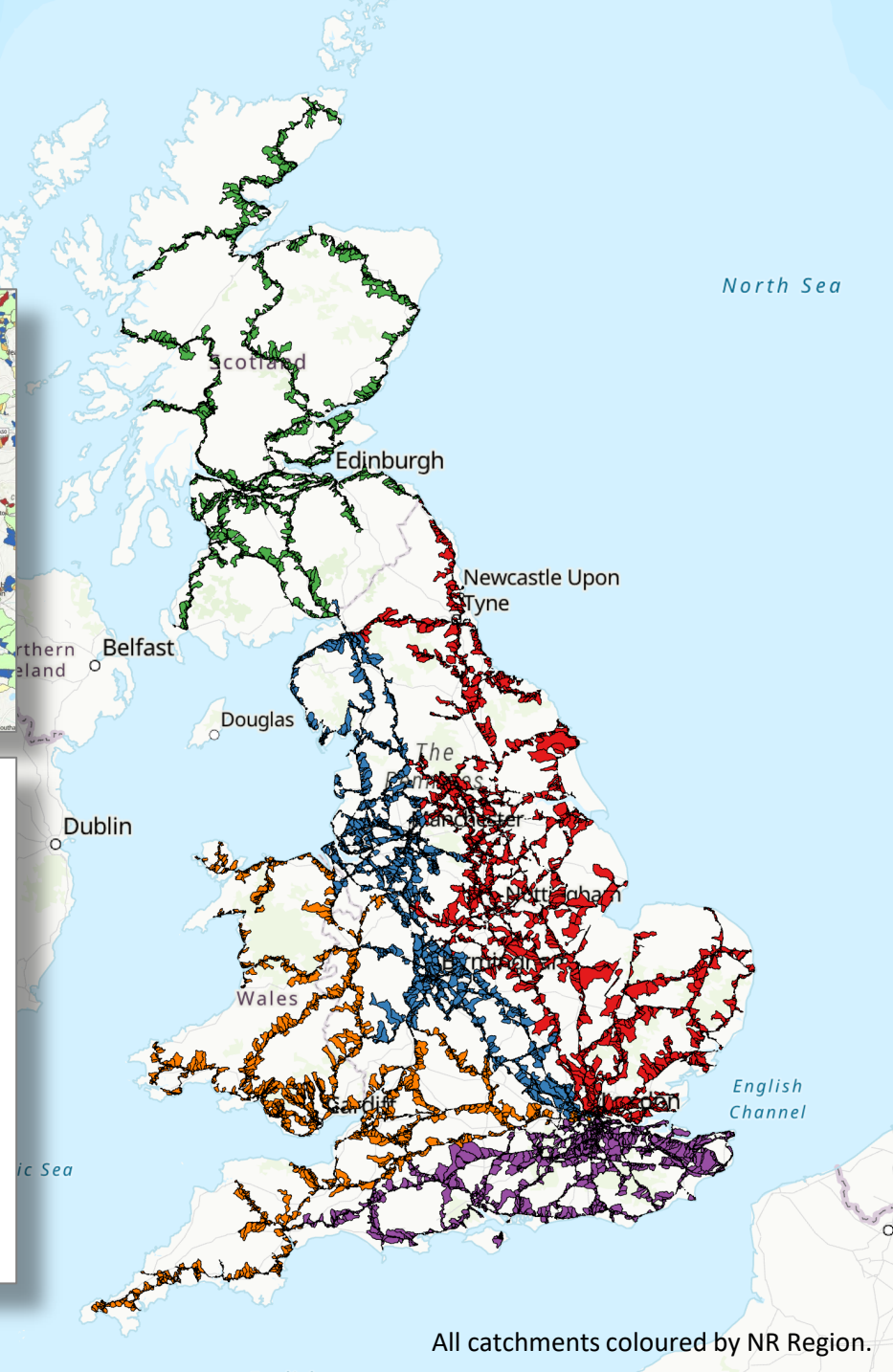
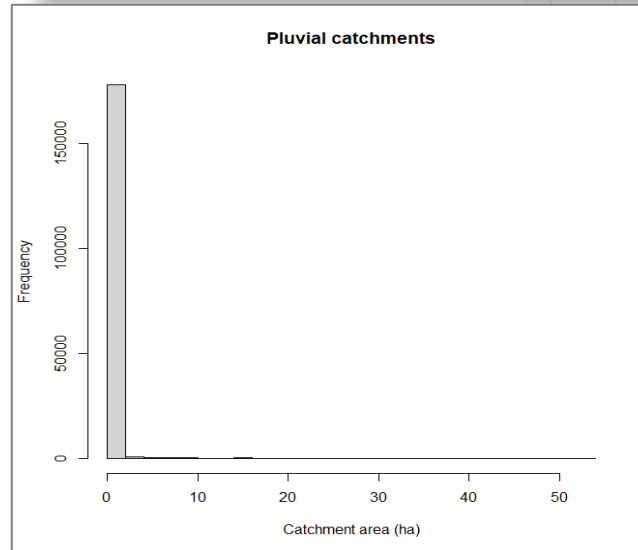
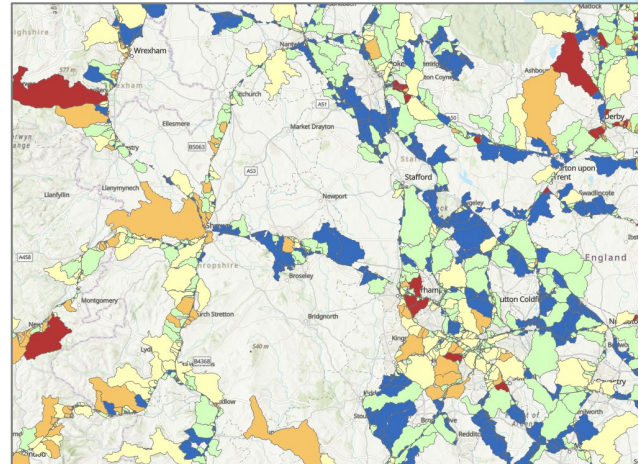
Water Framework Directive (WFD) Catchment: These catchments are used for managing water resources and implementing the WFD's objectives of achieving "good" ecological status for all water bodies.



What are our catchments?

Network Rail

- **>150,000 pluvial catchments** (<5ha)
- > 8000 fluvial catchments
- Nearly **31%** of the railway is located within 1km of (11% within 100m of) a Site of Special Scientific Interest, Special Area of Conservation, Area of Outstanding Natural Beauty or World Heritage Site

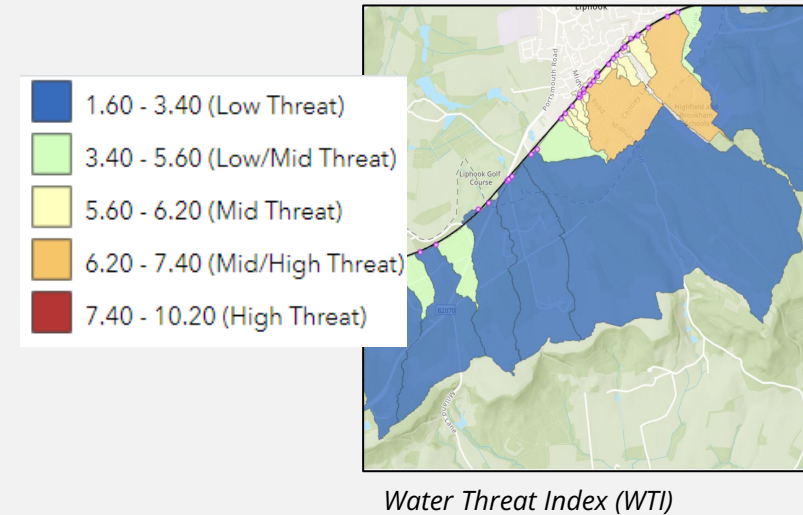


All catchments coloured by NR Region.

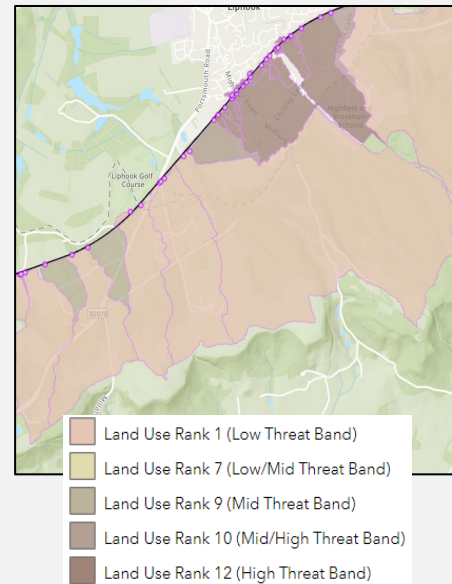
Mapping NR catchments

The national catchment management dataset has been developed to provide a comprehensive, national and regional overview of the surface water catchments discharging towards Network Rail's (NR) asset infrastructure.

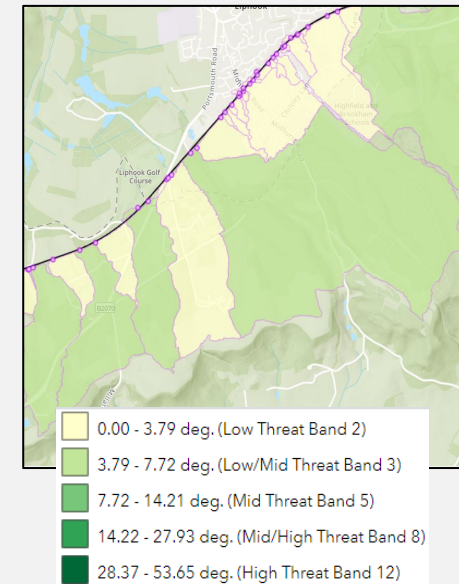
It is intended to provide information to the railways system asset groups on the possible threats that may be posed to the asset infrastructure by surface water runoff.



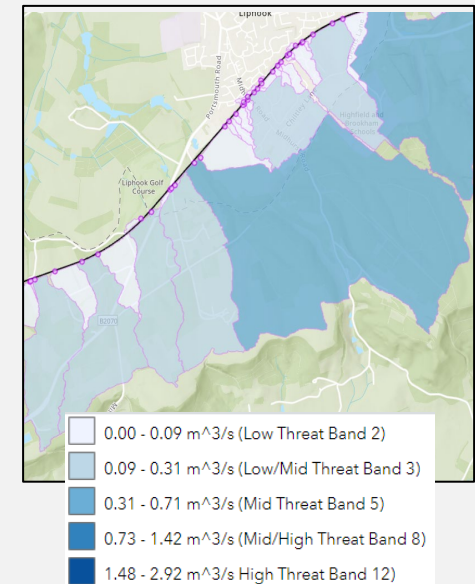
Land Use



Catchment Slope



Peak Flow (QMED Urban)



Mapping NR catchments

Small catchment hydrology

- Several methods that vary in age and complexity, and it is difficult to tell what is right and wrong
- Focus on modified catchments, not ones like that flowing towards NR
- Ongoing area of research
- Lacking data to make decisions

Antecedent conditions

- State of a system before an event or hazard, which can significantly influence the outcome of that event
- E.g. the same rainfall event at three different times of year can lead to very different outcomes



Complex catchment stakeholders

There are a range of organisations who have responsibility for, and interest in, drainage asset management and flood risk.

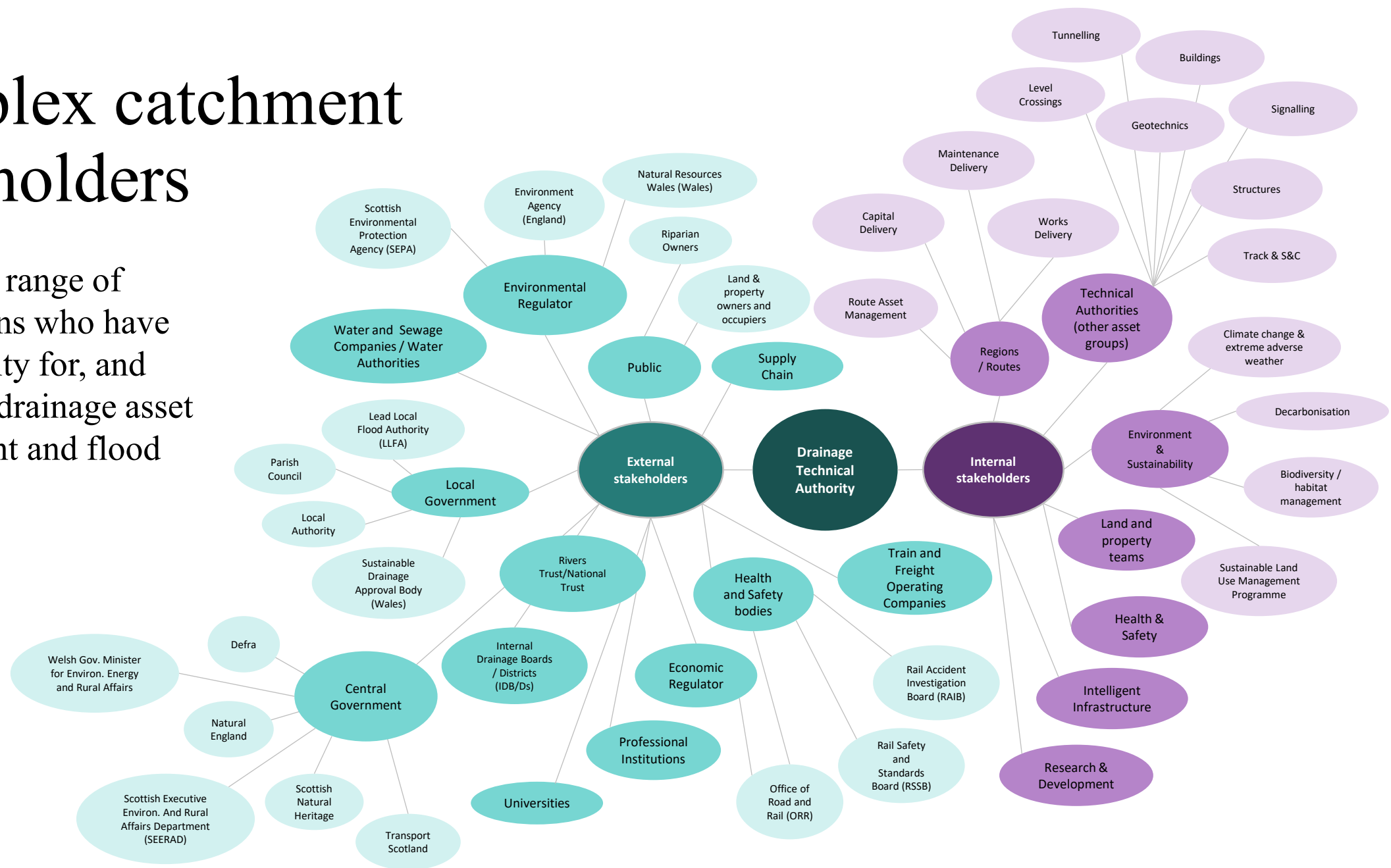


Image showing the drainage stakeholder landscape internally and externally of Network Rail

Complex catchment stakeholders

There are a range of organisations who have responsibility for, and interest in, drainage asset management and flood risk.

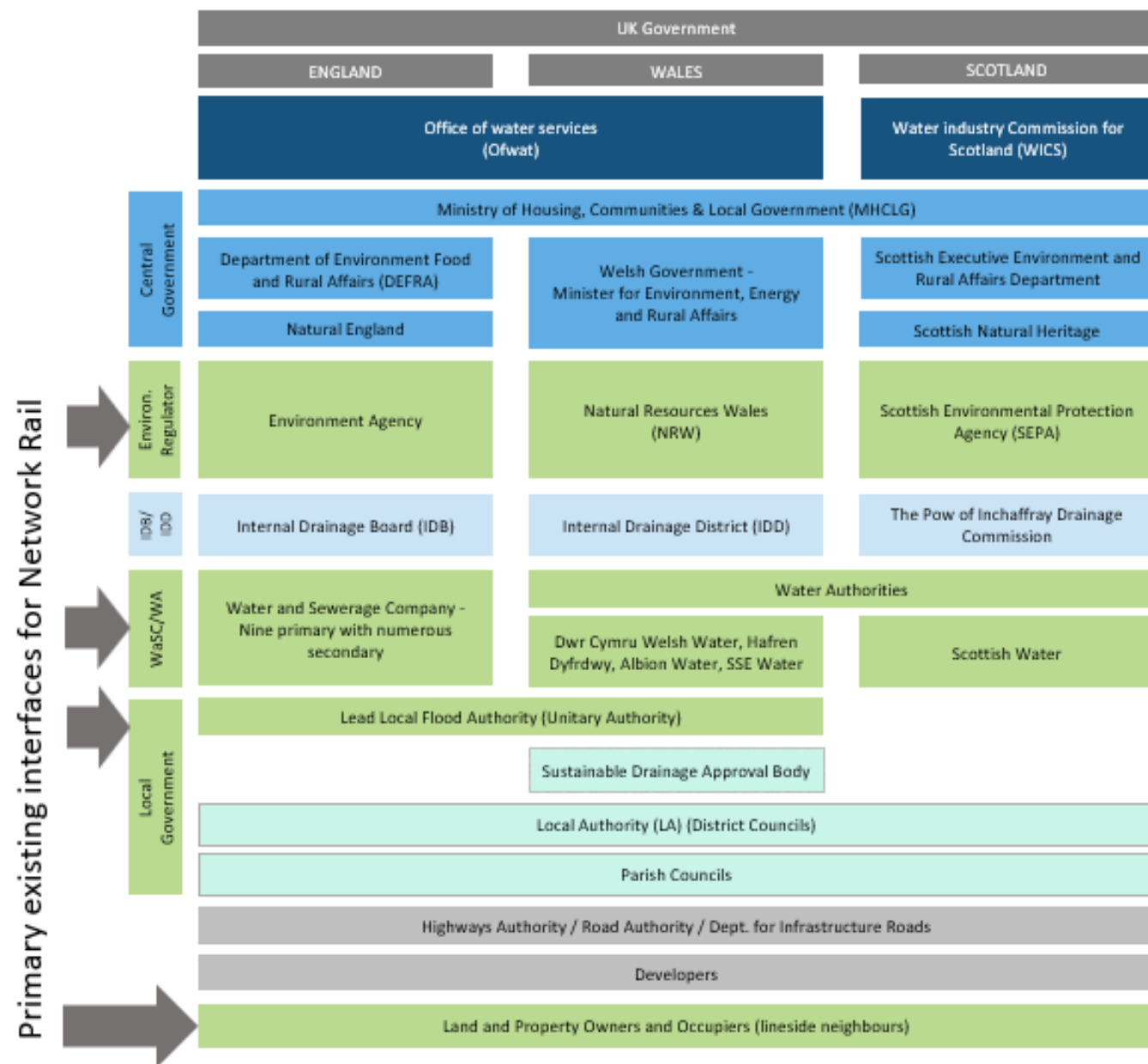
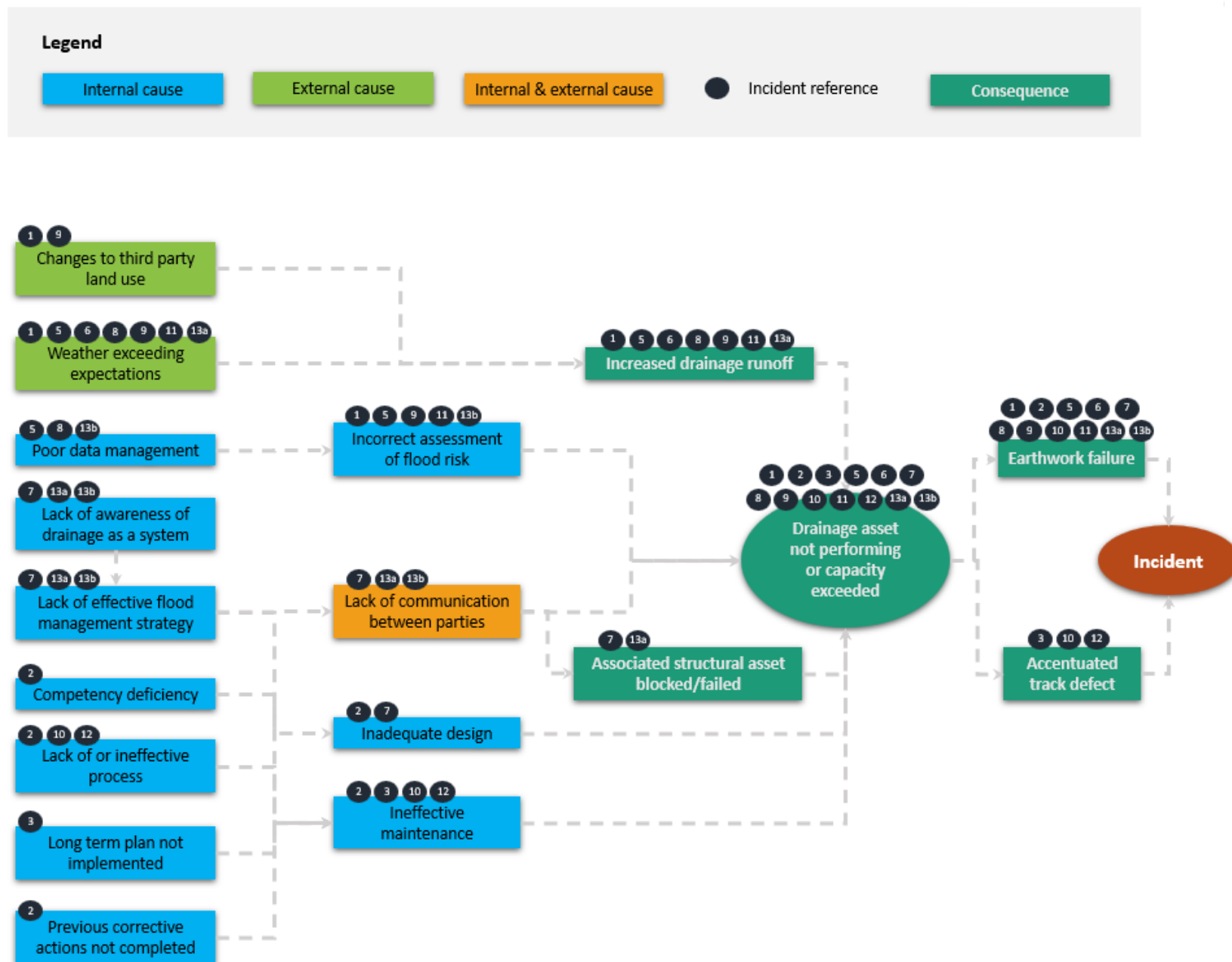


Image showing surface water management stakeholder map within the UK

Understanding the root cause of issues

Incidents included in root cause analysis

1	Derailment near Moy, Inverness-shire (26 Nov 2005)
2	Derailment near Gillingham tunnel (28 Nov 2009)
3	Derailment of freight train near Gloucester (16 Oct 2013)
4	Network Rail ORR improvement notice (18 Feb 2015)
5	Derailment and subsequent collision at Watford (16 Sep 2016)
6	Landslip and derailment at Loch Eilt (22 Jan 2018)
7	Train collision with material washed out from cutting slope at Corby, Northamptonshire (13 Jun 2019)
8	Derailment at Oubeck North (4 Nov 2005)
9	Class investigation into landslips affected Network Rail infrastructure between June 2012 and February 2013
10	Derailment of a freight train at Barrow upon Soar, Leicestershire (27 Dec 2012)
11	Derailment of a passenger train near Kemble (15 Jan 2007)
12	Heworth; Derailment of 10 th wagon on 6S26 (23 Oct 2014)
13a	Linslade (Jan 2016)
13b	Wrecclesham (Apr 2016)



Complex asset interactions

Track: Inadequate drainage leads to poor performance of the track formation. The resulting track geometry defects cause delays and require increased track maintenance and renewals to rectify.

Earthworks: Inadequate drainage or water management leads to earthworks failures which present a significant safety risk to the network.

Signals / Telecoms: A significant proportion of signalling faults are due to waterlogged cable runs or track circuit failures, impacting on train performance. Damage to lineside electrical equipment as a result of flooding or heavy rainfall has increased renewal costs and in some cases risk exposure to electrocution or fire.

Structures: Inadequate drainage also has an impact on structures and can hasten structural deterioration. In some cases, blocked drainage can impact adversely on structural safety (such as tunnel linings).



Image showing impact on track geometry from poor drainage



Image showing impact on earthwork from poor drainage



Image showing impact on earthwork from poor drainage

System complexity and risk

Due to the complex interactions that drainage has with other asset groups, we have seen that the poor management of drainage results in various risks to Network Rail. These include safety and performance but also financial, environmental and reputational risks.

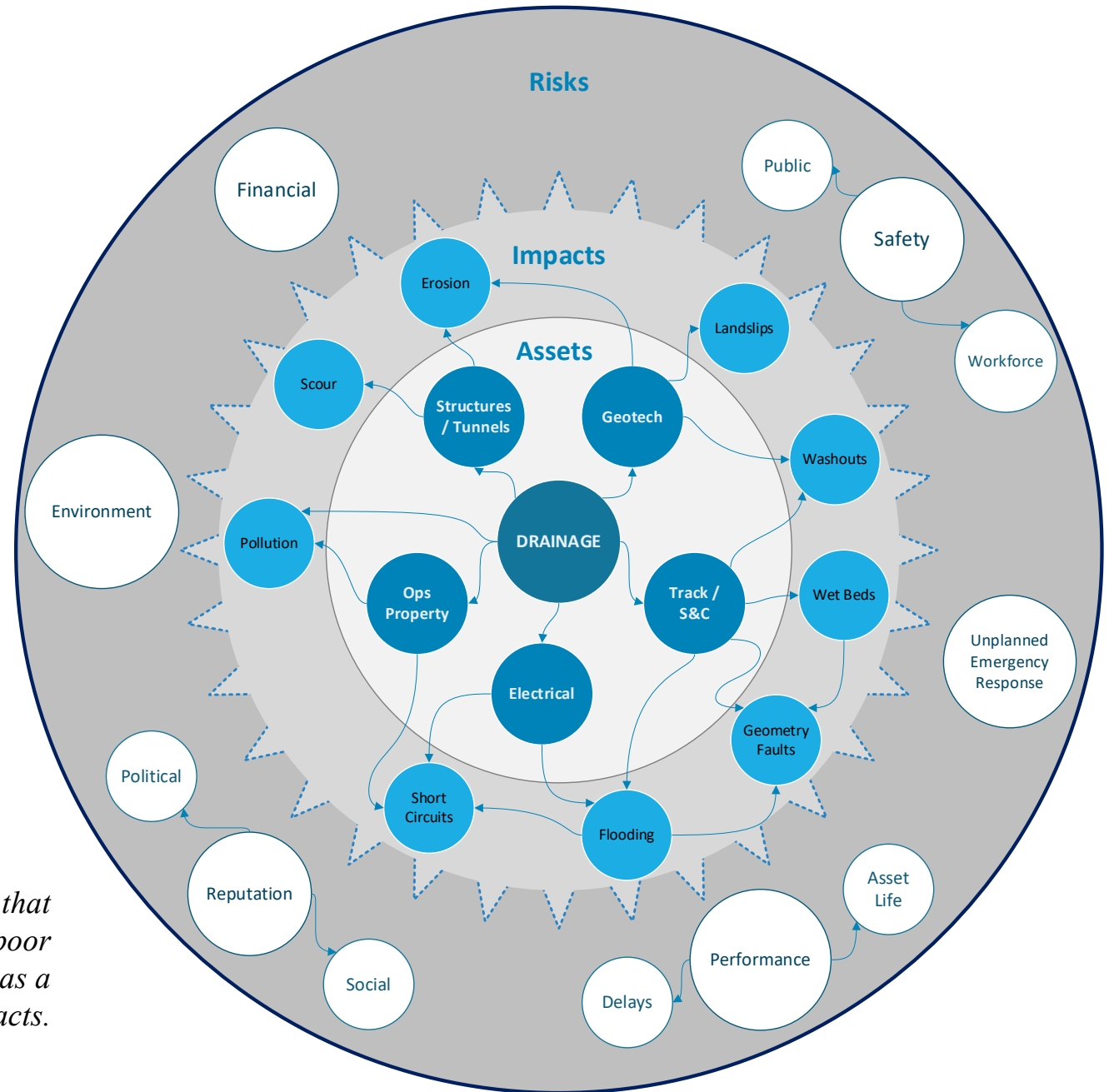


Image summarising the interactions and effects that drainage has on other assets, the negative impact of poor drainage and the resulting risks which can result as a combination of those impacts.

Burning platform

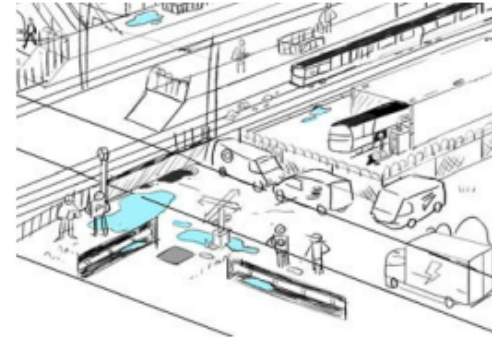
We are facing several significant challenges which are due to the way in which we manage water. This is costing us money, risking lives, and affecting our reputation. These challenges will intensify, driven by the trends and challenges identified. We must respond now before the impacts we face become unmanageable



Poor water management causes failures, impacting the safety and performance of the network.

Water is a common cause of failure at a system level across multiple asset types. From scour, washout, erosion, landslips, and saturation, water-related failures cause significant consequences for the network. More extreme and frequent weather events, combined with poor water management, can accelerate asset deterioration and exceed critical coping thresholds leading to increased intervention¹⁷.

Past derailments have demonstrated the impact on safety and performance. For example, the Glanrhyd Bridge collapse¹⁸ resulted in four fatalities and the Watford Tunnel landslip and its subsequent collision¹⁹. These sadly remind us that good water management sits at the heart of the safety and performance of our network.



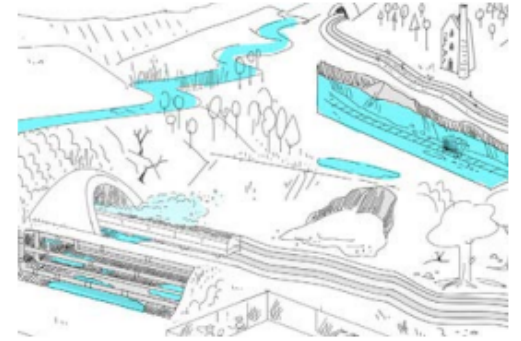
Funding is constrained but partnership money is available for water management.

Funding across the infrastructure sector is constrained, requiring more creativity and consideration around how we fund solutions. We are not accessing all available funds.

Our catchment stakeholders and communities all face similar challenges from too much, too little, or poor quality water. Challenges of misaligned funding cycles and governance can result in siloed working and interventions that do not address root causes of failure.

Without collaboration, we cannot unlock partnership funding opportunities to address these similar challenge that could create cost beneficial solutions.

We are also missing out on unlocking wider, additional benefits that can be harnessed through pooling funding and resources.



Desired outcomes are unrealised unless we work with catchment communities adjacent to railway.

Our 22,000 miles of railway infrastructure²⁰ cuts through administrative boundaries, geographies, and over 100,000 catchments⁷. It is becoming increasingly difficult to manage shock and stress events alone.

We know that activities in one catchment can affect the flood risk or water quality in another. Without a full understanding of our role and interactions with the water cycle, we will fail to understand the full impact of the water we use and return to the environment.

If we fail to fully engage with our catchment stakeholders and communities, we cannot solve challenges across boundaries. We will not be able to efficiently manage water without a system approach.



Flooding incidents cost us £20 million a year on average in Schedule 8 payments²¹.

Poor water management manifests in train delay costs, and inefficient and costly repairs. Flooding comprises 25% of the total cost of all weather-related incident compensation payments²² and is responsible for approximately 414,000 delay minutes network-wide per year²².

We experience flash floods due to intense rainfall and river flooding from heavy rain and snow melt. Increased rainfall also impacts soil health, from erosion and compaction to loss of organic matter and organisms². Intense rainfall events will increase with climate change and 1-in-2 yearly rainfall events are set to get nearly 30% worse²³. This poses a significant risk to our infrastructure, with 40% of the network at high to medium risk of flooding¹. Rising global temperatures and increasing precipitation are resulting in more extreme flood events.

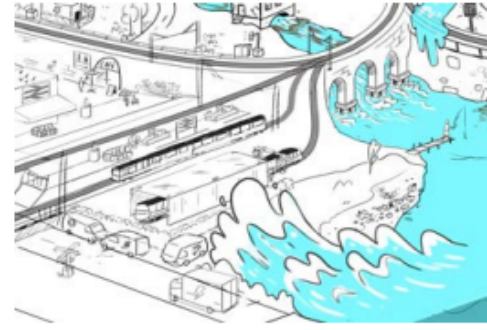


Water shortages could mean we do not have sufficient water available for safe operations.

A significant proportion of the UK is already classified as being under serious water stress²⁴ and demand for water continues to rise. Water shortages are predicted in the next 25 years³.

The Environmental Improvement Plan⁹ highlights the importance of leaving more water in the environment, particularly as the 2018 UK Climate Projections²³ show a trend towards drier summers with stronger drying in the Southern parts of the UK²⁵.

The railway could face challenges with more water intensive activities such as leaf mulch clearance, jet washing carriages, and dust suppression. We are likely to experience restrictions and increasing conditions on the water we use as a result of water shortages and increasing drought risk.



Tidal processes threaten the long-term viability and safety of the railway.

Long sections of our network are located along the coastline. Coastal erosion, flooding, and sea level rise threaten our ability to run a safe, reliable railway. Impacts include scour, destabilised track formation, and overtopping of defences which can result in speed restrictions, closure of lines, and derailments.

By 2050, sea levels around the UK could be between 10-30cm higher than the 1981-2000 period². Rising sea level and subsequent flooding costs the UK Government £540 million every year²⁶ and we expect more coastal incidents like Dawlish²⁷ sea wall collapse. Railway assets must be thoroughly considered in Shoreline Management Plans²⁸. Coastal Change Adaptation Plans²⁹ in Scotland broaden the 'shoreline' planning scope to include coastal hinterland for wider coastal land-use decision making.



Increasing scrutiny of environmental performance and compliance.

The rail industry is responsible for, or linked to, approximately 20 serious pollution incidents every year⁴. The water sector is facing public scrutiny for its environmental performance with UK Government taking action. Southern Water was fined £90 million in 2021 after sewage discharges polluted rivers and coastal waters³⁰. Environmental regulators adopt a Polluter Pays Principle and the scale of fines is increasing.

Alongside financial penalties, environmental protection is of utmost importance for our passengers and communities. 20% of our network runs through surface water catchments with a 'bad' or 'poor' overall status³¹ and we need to take responsibility to identify risks and deliver better pollution prevention.

Some facts

Poor water management causes failures impacting the safety and performance of the network.



We must learn from the past to protect our network and our passengers



7 incidents

In the last 10 years (2013-2023) 7 incidents¹ have occurred that have caused derailment where drainage was cited as one of the underlying causes of failure.

7 fatalities

There have been 7 fatalities² due to water related incidents, 4 occurring in 1986 due to the collapse of Glanrhyd bridge and 3 in 2020 as a result of the derailment at Carmont.

£733,000

We were fined £733,000 for failing to undertake adequate maintenance to prevent a derailment in 2013³.

Flooding is a common cause of poor performance



£225m

Delay costs associated with flooding have totalled over £225m between 2008 and 2022⁴. Regional breakdown is shown below:

Southern	Eastern	NW&C	W&W	Scotland
£41m	£43m	£51m	£57m	£33m

25%

Flooding comprises 25% of the total cost of all weather-related incident compensation payments⁵.

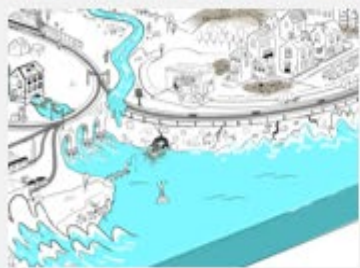
4x

Flood events have quadrupled since 1980 and doubled since 2004 in the UK⁶.

30%

1 in 2 yearly rainfall events are set to get nearly 30% worse⁷.

Tidal processes threaten the long-term viability and safety of the railway



£540m

Rising sea level and subsequent flooding costs the UK Government £540m per year⁸.

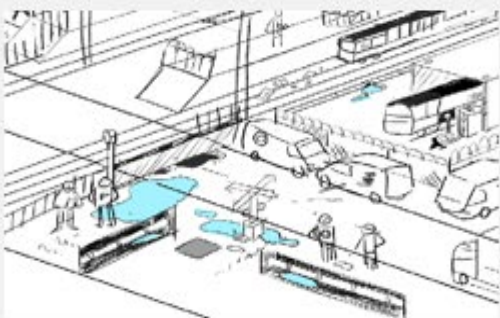
£58m

Reinstatement of the line at Dawlish following the sea defence collapse cost £35 million, and a further £28 million in disruption costs⁵.

10-30cm

By 2050, sea levels around the UK could be between 10-30cm higher than the 1981-2000 period⁹.

We frequently treat the symptoms of failure and defect, not the cause.



Nationally....

£200m+

It is estimated that the cost of wet-bed removal alone is in excess of £200million between 2005/6 and 2019/20⁶.

70+

The most frequently maintained wet bed site has had 70+ work orders in the last 15 years⁶.

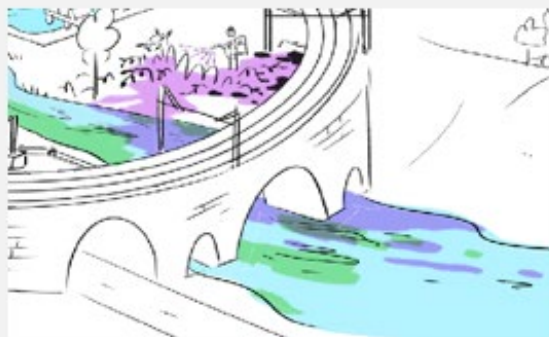
£8.4m

In 2022, the cost of wet bed removal is estimated at £8.4million. Regional breakdown is shown below¹⁰.

Southern	Eastern	NW&C	W&W	Scotland
£2.5m	£1.8m	£1.5m	£1.7m	£0.9m

Some facts

There is increasing scrutiny on environmental performance and compliance.



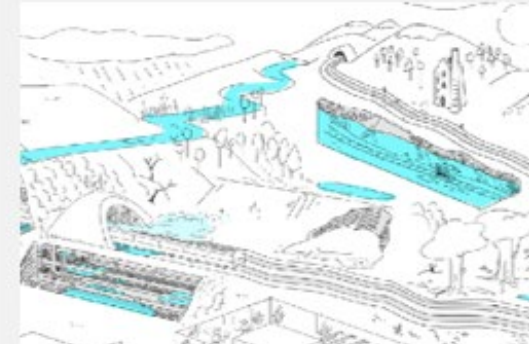
- 30%** Over 30% of the Network Rail network is within 1km of a SSSI/SAC/AONB/WHS¹¹.
- 50%** Approximately 50% of the 63 reported category 1 and category 2 incidents from April 2019-October 2022 were water-related, with almost 90% directly impacting biodiversity¹².
- £90m** The Government are taking action against sewerage discharges from storm overflows, for example Southern Water were fined £90million in 2021 for sewerage discharges into rivers¹³.
- 20%** 20% of the Network Rail network is within 'poor' or 'bad' quality surface water catchments (defined by WFD) and around 8% is within areas designated to protect drinking water sources from contamination¹⁴.

Water scarcity and increasing drought risk threaten the safe operation of the network, but provide opportunities for reuse.



- 40%** The gap between global water supply and demand is projected to reach 40% by 2030 if current practices continue. A significant proportion of the UK is already under serious water stress¹⁵.
- 1.5°C** In 2022, we experienced the driest July since 1935 nationally, resulting in the highest level of Soil Moisture deficit across the network since we started monitoring in 2009¹⁶. By 2050, the UK's average summer could be around 1.5°C warmer than it was on average over 1981-2000 and around 10% drier¹⁷.
- 77,000m³/d** There are opportunities to re-use water. As an example, re-using water pumped out of the Mersey and Severn tunnels (totaling 77,000m³/d) could hypothetically be reused to wash 57 6-carriage trains per day¹⁸.

Working in partnership with our catchment communities will help achieve our desired outcomes.



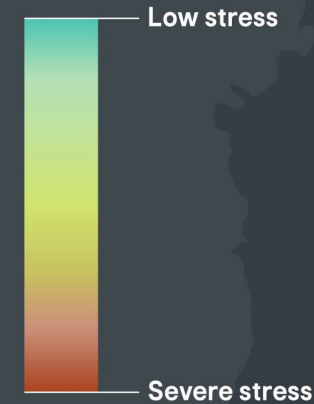
- 100,000** Our 22,000 miles of railway infrastructure cuts through administrative boundaries, geographies and over 100,000 catchments¹⁹.
- £4m** Partnership funding is available. For example, Ofwat has launched a £4m open access competition for innovation delivering customer, society or environmental benefits²⁰.
- £1.5m** We formed a partnership with the lead parties of the Leeds Flood Alleviation Scheme and contributed £1.5million to the scheme. This has resulted in a much higher level of resilience than if we had acted alone to address only the risk to our network²¹.

Common challenges

Too much and too little water

- The UK is facing serious water stress.
- Increasing challenges around population growth and the impact of climate change on water availability have resulted in stretching targets for water companies around consumption and efficiency.
- It is predicted that **demand is expected to exceed available supply by 40% in 2030** without intervention.
- As the fourth largest landowner in the UK, NR have an important role and need to find ways to minimise usage.
- Licensed to abstract a maximum of 43,560 m³ per day, for dust suppression, with other abstraction licences for **rail-related activities totalling nearly 1.3 million m³ per day**.
- Some requirements already for some assets that promote minimising water use such as new buildings requirements for all new construction, refurbishment, renewal, repair and managed schemes.

2030



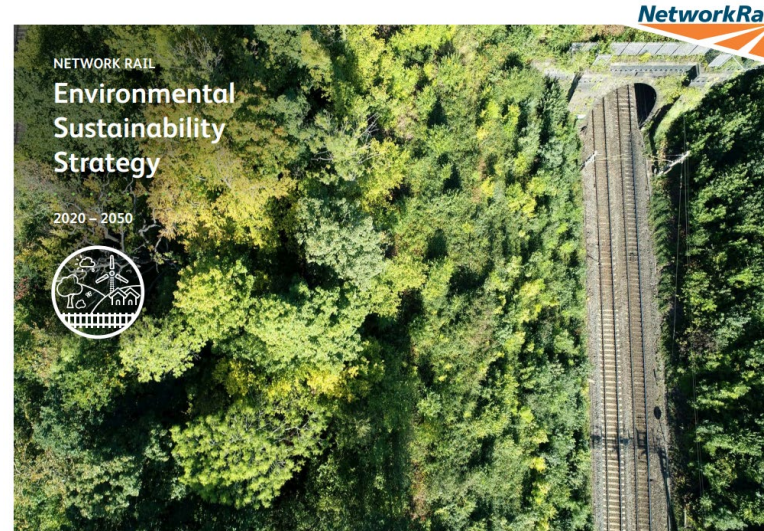
*Regions defined by water resource company areas across England:

- Affinity Water
- Anglian Water
- Bristol Water
- Cambridge Water
- Essex & Suffolk Water
- Northumbrian Water
- Portsmouth Water
- SES Water
- Severn Trent Water
- South East Water
- South Staffordshire Water
- South West Water
- Southern Water
- Thames Water
- United Utilities
- Veolia Water Projects
- Wessex Water
- Yorkshire Water

Common challenges

Unlocking wider benefits

- Water is **intrinsically linked with environmental, economic, community and wellbeing benefits**.
- Wider benefits can be defined as outcomes over and above the primary objective, for example water quality improvement or flood risk reduction.
- The focus on wider benefits has been advanced by the UN SDGs and is fundamental to achieving business targets. These include **achieving Biodiversity Net Gain (BNG)** on each route by 2035, **achieving net zero carbon emissions** by 2045, and furthering the priorities set out in our **Social Value Framework**.



A Green Future: Our 25 Year Plan to Improve the Environment



Celebrating current successes

- **Guidance to engage with existing communities:** CaBA Guidance
- Working with the likes of CaBA groups, Rivers Trusts, County Councils and others, delivering collaborative off railway solutions

Network Rail catchment partnerships guidance note

How to get involved with CaBA (Catchment Based Approach)



Take a holistic view



Resist, absorb, and recover

We contributed to a multi-sector board for the Leeds Flood Alleviation Scheme, Eastern Region, led and delivered by Leeds City Council and the Environment Agency (EA). It is designed to provide a 1 in 200 year (40% climate change uplift) standard of protection to the city. We formed a partnership with the lead parties and contributed £1.5 million to the scheme to support with increasing the resilience to flooding⁸. We also worked in partnership with the EA in Wales & Western to reduce the frequency and impact of flooding between Bristol and Exeter, Great Western Main Line, on the Hele flood alleviation scheme⁵⁶. The scheme involves replacing a bridge with a viaduct, reprofiling the floodplain, and local flood mitigation⁵⁷.



Minimise use of fresh and potable water

We have ongoing desktop studies to identify alternative options for cleaning leaf mulch off tracks including the use of dry ice, plasma and laser technology. Although these techniques are being explored for more effective cleaning and reducing loss of capacity, they have a water management benefit through reduced reliance on the public water supply⁷⁶.

Although at varying levels of development, these techniques have demonstrated that they can effectively clean leaves off the rails.



Join catchment communities

In North West & Central Region, we are working with catchment communities to implement Natural Flood Management. We are identifying suitable land and landowners that could accommodate NFM in locations that will provide benefit to the railway. Stakeholders we are working with include Eden Rivers Trust, West Cumbria Rivers Trust and Ribble Rivers Trust.

Additionally, Eastern Region is working with Lancashire County Council to trial leaky dams in a small section of Council owned land upstream of the railway to resolve flooding issues. We are working with catchment risk management authorities and private landowners to solve flooding issues outside of our land before they impact us.

Endless opportunity

Working across catchments provides endless opportunities to improve resilience to the network, unlock wider benefits and more efficient solutions that are



Seek community and social outcomes

In North, West & Central Region, we have worked with local communities to help implement practical solutions to help maintain community spaces. At Hindley Station, water bowsters were installed from the station roof. The grey water is used in the Friends of Hindley station gardens, providing amenity and health benefits.

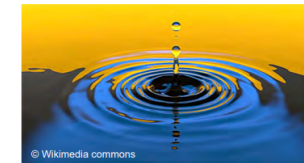
Similarly, we also joined forces with Southern Water and Southeast Communities Rail Partnership to recycle rainwater for use by station volunteer partners at West Worthing to maintain the community gardens. Southern Water donated a water butt and installed free of charge on our land at the station⁹⁶.



Resist, absorb, and recover

We have examples of solutions implemented to resist water threats or absorb the impacts of them. These include:

- Investing £4.4 million to protect the future of the Cambrian Line, Wales & Western Region⁵⁸ which will protect this at-risk section of the railway from future extreme events. This includes installation of rock armour to improve drainage and protect against future washouts.
- Removing selected vegetation to manage the risk posed to track geometry from desiccation in Southern Region⁵². Typically this is re...
- While putting signalling equipment up on stilts⁵⁹ in areas at risk of flooding may solve immediate risks, standard of protection will change with climate change, including carbon footprint reductions.



Smart investment and partnership opportunities

Various stakeholders within the water environment have funding opportunities available to us:

- Ofwat has established The Water Breakthrough Challenge⁴⁴, calling on water companies to join with partners to co-create and deliver transformative innovative solutions in the water sector. We anticipate more cross-sector funding becoming available through these channels.
- Ofwat's Innovation Fund⁴⁵, a pioneering £200 million programme, was set up in 2019 to grow water sector innovation to meet the evolving needs of customers, society and the environment. Initial rounds required water company sponsorship but going forwards it is 'open access' and is an ideal opportunity for us to collaborate and innovate.
- Defra's landscape recovery scheme⁴⁶ is an opportunity to take a radical and large-scale approach to producing environmental and climate goods.
- The 2050 Water Innovation Strategy⁴⁷ seeks to encourage partnerships beyond water companies, through initiatives like catchment partnerships
- Ofwat has launched a £4 million open access competition 'The Water Discovery Challenge⁴⁸' for early-stage innovation with the potential to deliver benefits for water customers, society and the environment.



Adopt a systems-based approach

The Industry Weather Resilience Taskforce⁴³ is in place to develop strategies and frameworks in order to provide a better understanding of the effects of weather on the railway as a system. It exists to enable the rail industry to develop and deliver performance where weather support performance other services for customers

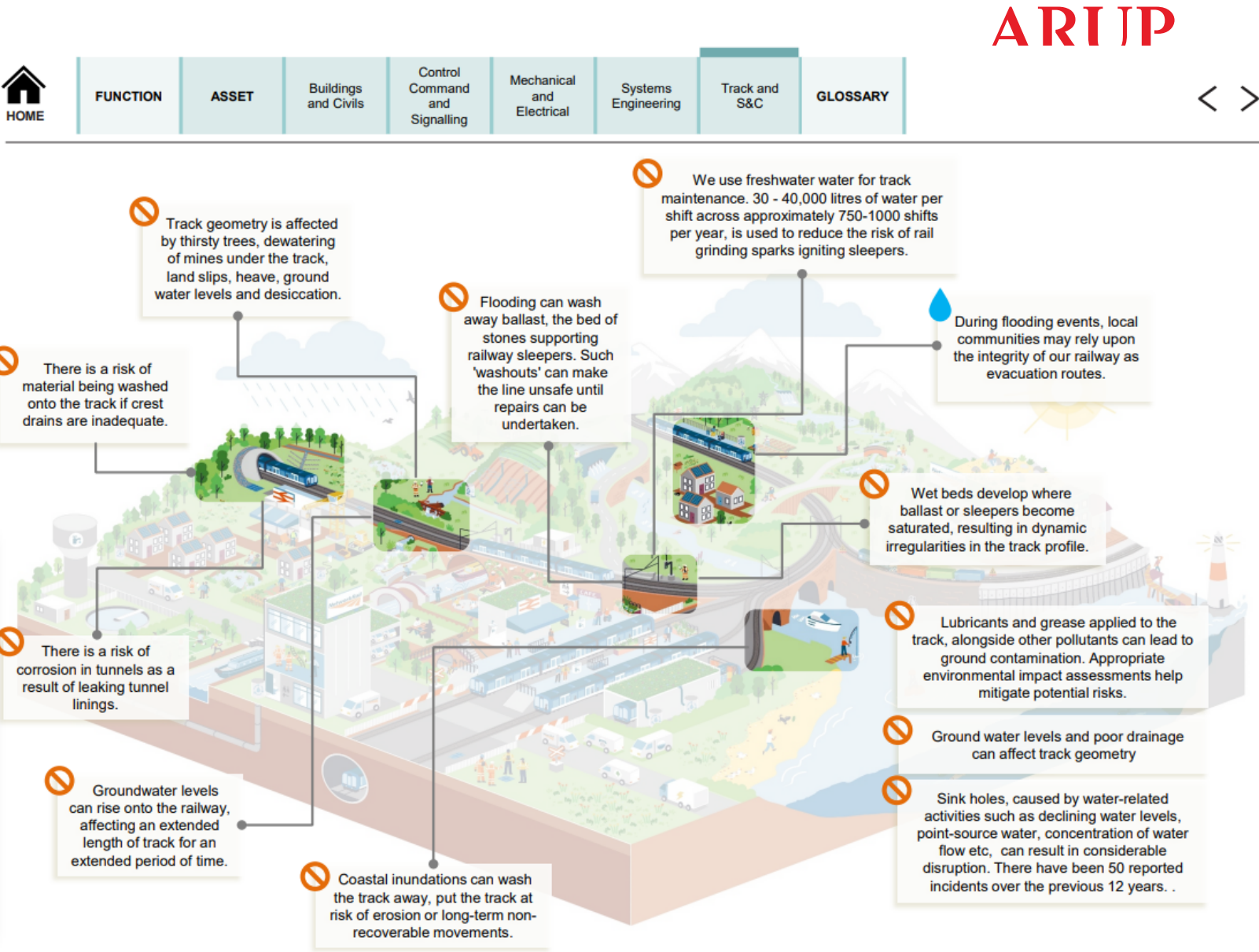


Smart investment and partnership opportunities

We helped fund a project to meander the River Leith in Cumbria at Thrimby Grange, North, West & Central Region, to restore the natural course, in partnership with Eden Rivers Trust, Environment Agency, Natural England and landowners⁵⁰. We now have a strong relationship with the Eden Catchment partnership.

We are providing funding to a Cumbria County Council scheme to provide flood protection through Natural Flood Management at Shap where the village and the West Coast Mainline are highly vulnerable to flooding. This North & Central Region scheme is still in early development.

What does it mean to me?



Be **curious**

Understand the **context**

Be willing to **collaborate**

Get **creative**

ARUP