Creating bathing rivers

Business case 01

Severn Trent
29 January 2021

WONDERFUL ON TAP

SEVERN TRENT

Executive summary

Clean, healthy rivers have the potential to support ecosystems, biodiversity, communities, health and wellbeing, and local as well as national economies. Currently, this potential is largely untapped, the UK has no bathing quality rivers and lags behind other European countries in unlocking the wider benefits of its rivers.

The current approach to improving river quality is not working. The sector has invested £25 bn in wastewater quality since privatization. While we have made significant improvements in water quality from our river discharges, only 14% of rivers meet good ecological status. As one of many contributors to river water quality it is clear it remains a huge challenge to meet the ambition in the Government's 25 Year Environment Plan, of 75% of rivers being close to their natural state. At the current cost and pace the ambition appears both unaffordable and unachievable.

Defra and the Environment Agency are grasping this challenge as we work together to reform the way the environmental programme is defined. We see an opportunity to create a blueprint for how we can initiate a step-change from delivering environmental outputs for our rivers. Where previously we would tackle sector specific legislative drivers through isolated programmes of work, we want to move to delivering tangible and catchment based environmental outcomes.

We are proposing to drive an outcome based step change for two sections of river by considering the current and future risks that could prevent it from returning to its natural state and addressing them in a way that provides tangible benefits and proactively responds to the increasing expectations of our customers and communities. This will demonstrably address their dissatisfaction with poor river quality, facilitate their desire for greater access to nature, and respond to the growth in demand for wild swimming. To stimulate this transition, we propose two large-scale pilots to deliver bathing-quality water in the Rivers Avon and Teme, at a total cost of £153m. This will include:

- [redacted] to upgrade the treatment processes by adding an ozone disinfection stage at six sewage treatment works (five on the Avon and one on the Teme) – this will also tackle emerging issues such as pharmaceutical residues in the water.
- [redacted] to significantly reduce the frequency and impact of 25 storm overflow discharges – by a combination of additional storage, sewer network reinforcement, surface water separation and disinfection of storm water prior to river discharge, contributing to delivering the WFD and responding to customer expectations.
- [redacted] to work with farmers to deliver catchment management interventions such as fencing, relocating livestock feeding troughs and creating wildflower buffer strips to reduce run off from 152,000 hectares of land to reduce faecal pollution.
- [redacted] to set up a water quality monitoring system and public app to provide real time, open and extensive data about the quality of the river water and to facilitate community engagement.
- Partnering with the local community to create riverside guardians including opportunities for citizen science, increasing social cohesion, training and skills development, and fostering behaviour change.
- Working alongside the £1.5m Stratford Riverside regeneration project and other councils to create appealing riverside destinations.

In addition to this, we will ensure our solutions have net-zero carbon impact, through a programme of renewables and offsetting through tree planting. This will cost £8m and offset the increase in electricity costs from the additional treatment and pumping.

We have selected these two catchments for the following reasons:

- The locations are central to our region and more than one million customers living in the catchment will benefit, including those in some of the most deprived areas of England.
- The river stretches are safe, suitable, and accessible for recreation and swimming.
- There are already many popular swimming spots and lots of local enthusiasm, so they are no regrets locations for improvement.
- We will be building on the river quality improvements we have already completed in AMP6, and there is no overlap with our current AMP7 programme. In addition to this we believe some of the investment anticipates likely AMP8 requirements, so it is “no regrets” investment in the short term.
- We expect the water quality challenges to be different for our rural catchment, the Teme, for which agricultural pollution is a stronger contributing factor (71%), compared to our more urban catchment of the Avon (46%).
- There are potential synergies with other projects, including the potential to use our waste product (the final effluent) from the Avon catchment to help address longer term resource challenges in the region.

Clean, healthy rivers that are safe for immersive activities will provide a greater economic, environmental, and societal value than the current situation. Our customers were overwhelmingly supportive of the proposal, with 74% of household customers supporting the proposal and a further 21% stating they did not mind. In addition to their support, we have used co-design research to shape our proposals, and in particular the community aspects which are key to realising the benefits. Our investment will provide the following:

Learning and sharing insight

Our proposals will set a new model for ensuring all parties play their part in improving river water quality by providing a trial space for stakeholders to collaborate, under Severn Trent's leadership as catchment guardians, to ensure all river discharges meet the standard required for safe bathing. Through the investment we will generate insights on the costs, benefits, and technology to meet future challenges such as antimicrobial resistance, pharmaceutical residues, and microplastic pollution. This will keep us ahead of likely future legislation, allowing environmental improvements to be delivered more efficiently and protecting future customers from higher bills.

We will protect customers by recovering 85% of the costs only after the benefits are delivered and working closely with regulators to challenge its scope and delivery throughout.

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1. Need for investment

In July 2020, the Government and water regulators invited water companies to consider how they can support the Green Recovery from the Covid-19 pandemic. We welcome the Green Recovery as a catalyst for enhancing our approach to river quality improvement, allowing us to develop new, future-proof strategies while creating jobs and supporting economic growth in the short and medium term. Unlocking the potential of our rivers represents one way in which we believe we can create a positive legacy from the pandemic, as well as tackling some of the emerging risks we face.

In its 25 Year Environment Plan, the Government has set a bold ambition for at least three-quarters of rivers in England to be restored to their natural state. At present just 14% of rivers meet good ecological status, as defined by the EU Water Framework Directive (WFD)[1]. If we continue with the current approach to improving river water quality, England will never meet its goals. It is therefore time to try something different.

To deliver a material improvement in river water quality we need to change the current approach in three ways:

- Focus on outcomes, particularly as they relate to customers and citizens rather than individual contributions.
- Adopt holistic solutions that address future risks such as pharmaceutical residues and antimicrobial resistance, instead of piecemeal improvements.
- Coordinate improvements at a catchment level, with water companies taking ownership of river outcomes.

We believe that now is the right time to move forward with this investment, for the following reasons:

Near-term, visible customer benefits that meet changing expectations

Our proposed pilots will deliver increased community, economic and wellbeing benefits in line with the UK's cultural shift, that places greater value on access to nature and, in particular, safe places for open-water swimming. These visible benefits are an important consideration, given Severn Trent customers' support for bathing-quality rivers and growing awareness across the UK of the importance of river water quality and enhancing biodiversity.

Delivering a first for the UK

The UK has 644 designated bathing waters, only 16 of which are inland waters – and none are rivers. Although a stretch of the River Wharfe in Ilkley, Yorkshire will be added to the list of designated bathing waters in 2021, it will take time before water quality improvements are implemented and there is a risk the new bathing area might be classed as failing in 2022 if improvements are not made quickly. We believe that by acting proactively we can create the UK's first bathing-quality river, demonstrating the power of the Green Recovery not only in economic terms but also in widely recognised health and wellbeing benefits, including access to low-cost, local recreation and exercise opportunities.

Accelerating the achievement of Government priorities

The delivery of these two pilots will help accelerate the pace of environmental improvements, contributing to the delivery of the 25 Year Environment Plan. Our proposal also supports the

[1] https://deframedia.blog.gov.uk/2020/09/18/latest-water-classifications-results-published/

objectives of the taskforce set up by Defra, the Environment Agency and Ofwat to reform the Water Industry National Environmental Programme (WINEP) in time for PR24. Specifically, it proposes greater flexibility to deliver better environmental outcomes rather than outputs and brings water companies to the centre of the design and development of the programme. This will drive the catchment wide improvements needed to achieve the outcomes.

Sharing learning across the industry

Since there are no rivers in the UK that meet the bathing water standards, we do not know the true complexity of delivering bathing water quality in rivers. Our two pilots will generate insights into the costs, benefits and technologies needed for a wider-scale rollout of bathing rivers, helping inform not only our future strategy, but those of water companies across the UK. Our pilots will also help to drive improvements by providing valuable data on emerging challenges such as antimicrobial resistance and pharmaceutical removal.

Skills and jobs for the UK's Green Recovery

Our proposal offers the opportunity to deliver wider benefits that are common to the Green Recovery objectives, right at the heart of communities. Delivering our proposal will create over 330 much-needed direct jobs (and over 300 indirect jobs) within our region through design, river sampling and modelling, feasibility, and construction. This will develop much-needed engineering skills for the green economy.

Capitalising on the shift in customer expectations, we believe that the creation of safe, healthy bathing waters in targeted rivers could turn an environmental problem into a community-led opportunity. Bathing waters can provide a focal point for our collaboration with stakeholders and communities. This will allow us to move at pace towards our long-term WFD target while delivering the recreation, health and wellbeing benefits that customers – who are, after all, paying for river quality improvements – are demanding.

Working collaboratively with stakeholders will allow Severn Trent to develop long-term, outcome-led environmental improvement plans that also address emerging water quality challenges such as antimicrobial resistance, pharmaceutical residues and microplastic pollution. This will keep us ahead of likely future legislation, allowing environmental improvements to be delivered more efficiently, while protecting future customers from higher bills. By taking ownership of the long-term catchment plan, and the associated quality standards, we will also be better able to deliver the outcomes and benefits that customers both want and pay for. It cannot be right for water companies to continue to invest billions of pounds to deliver a healthier environment on behalf of our customers, only to find that outcomes are not being achieved due to a lack of integration with other parties.

1.1 Customer engagement and support

Over recent years, we have been tracking a step change in customer expectations that we believe provides an opportunity to unlock the wider economic, social, and environmental benefits of clean, healthy rivers. Our proposal is shaped by talking to over 4,000 customers, through both quantitative and in-depth qualitative research. Customers tell us that they value the benefits this proposal would bring, and third-party research supports our belief that it could result in much-needed improvements to health and wellbeing.

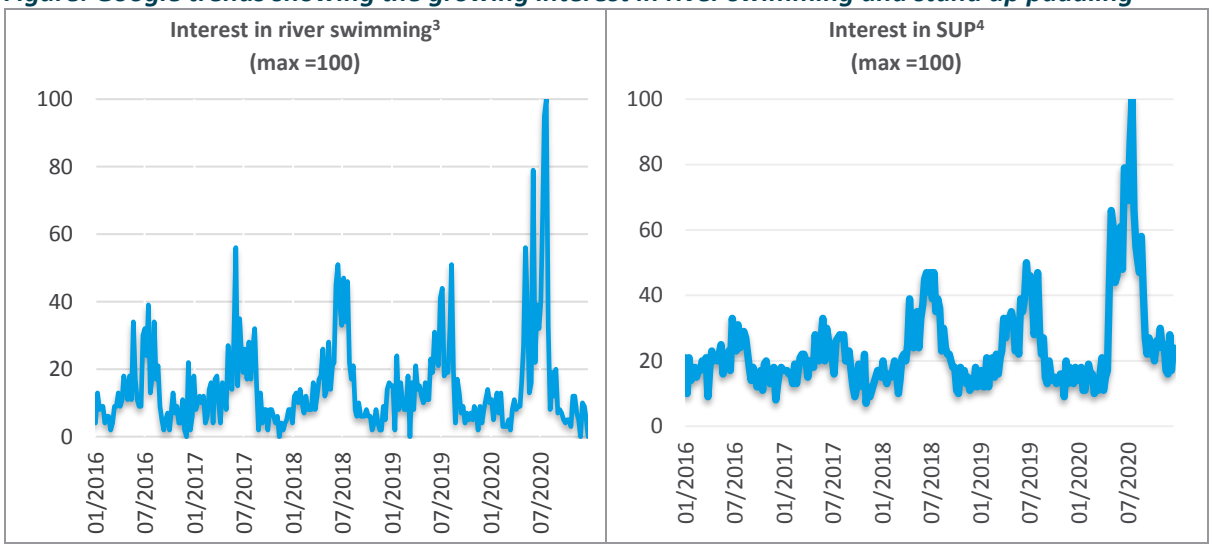
How UK culture is changing

Open water swimming and river recreation are becoming increasingly popular

The popularity of swimming and other recreational activities in rivers has increased, from a somewhat niche activity a decade ago, to a popular pastime, as testified by Google trends (see figure below). Membership of the Outdoor Swimming Society (OSS) has grown from 300 in 2006 to around 100,000 at the end of 2019, and they count 700,000 unique website users per year.

The combination of the Covid-19 pandemic and a hot summer have **normalised outdoor swimming**, both in rivers and at supervised venues such as lakes and quarries. Unable or unwilling to travel, customers are increasingly looking for recreation opportunities in their local area. The increase in outdoor swimming was such that the OSS had to remove their online maps showing swimming spots to ease overcrowding at popular bathing spots during the summer of 2020[2].

Figure: Google trends showing the growing interest in river swimming and stand up paddling



There is growing momentum against overflows and poor-quality rivers

New and established campaign groups such The London Waterkeeper, Ilkley Clean Rivers, Windrush Against Sewage Pollution (WASP), Warleigh Weir Project, Sewage Free Swimmers, #endsewagepollution – Mid Thames and Surfers Against Sewage are **asking for real-time information about sewer overflows and demanding rivers that are safe to swim in**[5].


MP calls for crackdown on raw sewage discharges in English rivers

Exclusive: water firms discharged raw sewage into England's rivers 200,000 times in 2019

Untreated effluent flowed into waterways for more than 1.5m hours, data shows

Over 1,000 people responded to the recent Defra consultation about designating the River Wharfe in Ilkley as a bathing water (the largest response to date for a bathing water consultation), whilst a recent petition

[2] https://www.theguardian.com/travel/2020/jun/02/wild-swimming-site-removes-online-map-to-ease-overcrowding
[3] https://trends.google.com/trends/explore?date=today%205-y&geo=GB&q=river%20swimming
[4] https://trends.google.com/trends/explore?date=today%205-y&geo=GB&q=SUP
[5] For example https://outdoorswimmer.com/news/surfers-against-sewage-petition-launches-for-safer-water-quality-across-uk and https://www.londonwaterkeeper.org.uk/action-real-time-sewer-overflow-alerts-from-thames-water

about bathing water status for the River Thames in Oxford received over 4,000 signatures.

Over 44,000 people signed the #EndSewagePollution petition, which calls for better water quality legislation and was presented to George Eustice, Secretary of State for the Environment, Food and Rural Affairs. A **new Private Members' Bill** – the Sewage (Inland Waters) Bill – is seeking a duty on water companies to take all reasonable steps to ensure that untreated sewage is not discharged into inland waters, and would require the Secretary of State, the Environment Agency and Ofwat to use their powers to ensure compliance with that duty[6].


Yorkshire swimming spot to get bathing water status in UK first

Campaigners in Ilkley hope River Wharfe designation will 'trigger a clean-up' of local sewage system

Momentum for this shift in customer expectations is clearly growing, and the designation in December 2020 of a stretch of the River Wharfe as a bathing site has been widely celebrated as a significant environmental landmark. Applications for designation for more river stretches across the UK will no doubt follow on the back of this movement. For instance, we understand that Warleigh Weir Project intend to apply for bathing water status on the Bristol Avon imminently.

Designation for the River Wharfe means that from the 2021 bathing season the EA will be required to monitor the water quality, and the bathing water will be formally classified the following year based on the previous year's data. If the first year's data shows the bathing water quality as poor, then the local authority will be required to put up warning notices to highlight this. On the back of the designation Yorkshire Water have announced a new partnership to help manage the bathing water and look more widely at the overall health of the river, but there is a risk that if improvements are not implemented quickly the stretch will be classed as failing in 2022. The implications of this for the water sector are not positive – we want to take a more proactive approach.

There is a growing need to tackle mental and physical health

There is a well-recognised global crisis of **physical inactivity**, with consequent implications for health. A significant proportion of children, adolescents and adults in the UK fail to meet the national recommendations for physical activity, including 80% of 5-to-15-year-olds and 39% of adults[7]. Physical inactivity costs the NHS around £1 bn per year. Including costs to wider society (such as the cost to industry of sickness absence), this figure rises to around £7.4 bn a year[8]. Physical inactivity now rivals smoking as one of the nation's biggest health problems and is responsible for 17% of early deaths in the UK[9]. There is therefore a huge value in encouraging people to be active, and in particular exercising outdoors in natural and green spaces is more beneficial to health and wellbeing than indoor exercise[10].

[6] https://services.parliament.uk/bills/2019-21/sewageinlandwaters.html
[7] Health and wellbeing benefits of swimming. Commissioned by Swim England, 2017
[8] Ossa D and Hutton J (2002) The economic burden of physical inactivity in England and https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/374914/Framework_13.pdf
[9] Prescribing green space https://nhsforest.org/sites/default/files/Prescribing%20Green%20Space-3.pdf
[10] Thompson Coon J, Boddy K, Stein K, Whear R, Barton J, Depledge MH. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. Environ Sci Technol. 2011 Mar 1;45(5):1761-72. doi: 10.1021/es102947t. Epub 2011 Feb 3. PMID: 21291246

Mental health too is a growing concern – approximately 1 in 4 people will experience a mental health problem in any given year[11] and prevalence has increased over the past 30 years. The NHS planned to spend £13 bn on mental health services in 2019/20, 14% of local funding allocations[12]. The total economic and social cost of mental health problems in England was estimated to be £105 bn in 2009/1013.

It is well documented that spending time in the natural environment improves our mental health and feelings of wellbeing. It can improve immune functioning, social cohesion, enhance physical activity and improve relaxation and restoration and it can combat loneliness and bind communities together[14]. Despite these benefits, the number of people who spend little or no time in natural spaces remains high: some 12% of children do not visit the natural environment in any given year[15].

Physical activity can have a positive impact on mental health by improving mood, increasing self-esteem, lowering the risk of depression, slowing dementia and cognitive decline and improving sleep and reducing stress[16]. Swimming has been shown to significantly reduce symptoms of anxiety or depression for 1.4 m adults[17]. Cold-water swimming can be used as a treatment for depression, and also provides benefits in terms of boosting the immune system, activated endorphins, improving circulation, increasing libido and reducing stress[18].

What our customers tell us about the environment and bathing rivers

As well as tracking a macro-level shift in customer expectations, we have conducted extensive research with customers on our proposals. 95% of household customers told us they support our proposal (or don't mind) and their support is not purely driven by personal gain – the majority cited potential economic, environmental and societal benefits to the region rather than a personal desire to enjoy the cleaner water.

We spoke to customers across our region, and particularly with customers in the vicinity of our proposed bathing rivers to understand local issues and how our proposals can deliver beneficial outcomes. Our research is described in more detail in the Customer Engagement Annex (A03), here we summarise the key views. In Section 2.4 we explain how we have learnt from our codesign research with customers and adapted our proposals as a result.

[11] https://www.england.nhs.uk/wp-content/uploads/2016/02/Mental-Health-Taskforce-FYFV-final.pdf
[12] Mental health statistics for England: prevalence, services and funding. House of Commons Library briefing paper 6988 23 January 2020
[13] The economic and social costs of mental health problems in 2009/10 Centre for Mental Health https://www.centreformentalhealth.org.uk/publications/economic-and-social-costs-mental-health-problems-200910
[14] Healthy environment, healthy lives: how we environment influences health and wellbeing in Europe. EEA report. No 21/2019.
[15] HUNT, A., STEWART, D., BURT, J. & DILLON, J. 2016. Monitor of Engagement with the Natural Environment: a pilot to develop an indicator of visits to the natural environment by children - Results from years 1 and 2 (March 2013 to February 2015). Natural England Commissioned Reports, Number208.
[16] https://www.mentalhealth.org.uk/sites/default/files/lets-get-physical-report.pdf
[17] Mental Health and Swimming Mind and Swim England Fact sheet - https://www.swimming.org/swimengland/health-and-wellbeing/
[18] https://www.iprshealth.com/news/8-benefits-of-cold-water-swimming/

Customers value the enjoyment they gain from time spent in natural spaces

In the past decade, our customers have consistently told us that the natural environment is very important to them. Customers recognise that our rivers sustain the natural environment, are a perfect habitat for wildlife and a resource for recreation. Many look back with nostalgia to the days of their youth and times spent splashing around in the local river.

"*I love being close to the water for my mental health and wellbeing. I moved to the area so I could be close to it*." Customer living near the River Avon, Britain Thinks research

Figure: Photos from our customers showing how they enjoy swimming in their local rivers

Third-party research[19] also tells us that connection to nature is also a significant factor in relation to wellbeing and pro-environmental behaviours.

[19] Monitor of Engagement with the Natural Environment (MENE) survey – Natural England/Defra

Covid-19 has increased customers' focus on local recreation and health and wellbeing

Our PR19 research told us how important the natural environment is to people, and **how local green spaces provide opportunities for escapism, relaxation, improving health and wellbeing, spending time with friends and family and building connections with the local community**. This has been enhanced by the Covid-19 pandemic which has shown us how the public have embraced the environment, both in terms of concern for the global environment but also appreciation of local natural spaces.

Independent research on the impact of Covid-19 on people's lives, found that one of the three key takeaways from the pandemic has been **the value of feeling connected to where you live**[20]. Research from the Royal Society for the Protection of Birds found that, during lockdown, 71% of people felt that nature became more important to them[21]. This is echoed by our own research which demonstrates that **customers have become more aware of the natural world during lockdown**, and that this has brought them a lot of pleasure. Customers have valued a slower pace of life, spending more time with family, and noticing more kindness and sense of community. More people reported using the river for recreation and identified a positive mental health impact from this activity.

Customers think (some) rivers should be fit to swim in

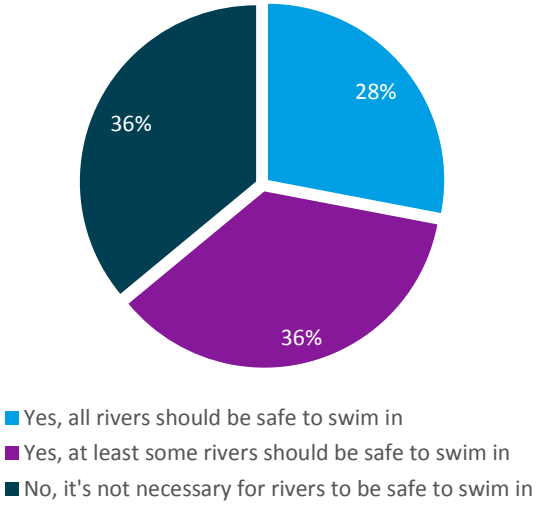
Our research tells us that 40% of customers think the rivers and streams in their area are unsuitable for recreation activities (and 26% simply don't know). Typically customers feel this way because "it's dirty or murky", "there is pollution / rubbish / litter", or because they perceive it to be dangerous. Customers tend to be aware that no single authority is accountable for maintaining water quality, but do expect Severn Trent to be playing its part. When we talked to customers about our proposals, they were surprised that there are no designated bathing rivers in the UK.

"*It would be fab to have designated bathing rivers. I didn't realise that we didn't have any and that there wasn't anything to control river quality*." Customer living near the River Avon, Britain Thinks research

Improving river water quality is important to customers in general, whether or not they use the river. Third-party research from the WWF tells us that **82% of people across the UK think our rivers should be fit to swim in**[22]. Our own research on Tap Chat revealed that almost two-thirds of customers believe at least some of the rivers in our region should be of bathing water quality. Customers thought cleaner rivers would enable people to enjoy the health and recreation benefits of swimming outdoors, as well as helping wildlife flourish. Many customers have happy memories of swimming and playing in rivers when they were younger, and want their children and grandchildren today to be able to experience this too. It is possible that recreational use of water in the home (e.g. paddling pools and sprinkler play) could reduce if suitable places for bathing and enjoying rivers were available[23].

[20] https://britainthinks.com/pdfs/Coronavirus-Diaries_Summary-report_weeks-1-to-12.pdf
[21] https://www.rspb.org.uk/globalassets/downloads/recovering-together-report/recovering-together-report_nature-and-green-recovery_rspbyougov_june-2020.pdf
[22] Flushed Away. WWF-UK. 2017
[23] In our 2020 research following the hot weather, we found that cleaner rivers could encourage around a quarter of customers to use less water at home (e.g. for paddling pools and sprinkler play). Agreement was highest amongst young people and those who use water for recreation.

Figure: Tap Chat poll with 321 customers on whether some or all rivers should be safe to swim in



"I like to see people enjoying themselves and swimming/playing in rivers. Definitely some rivers should be bathing friendly! The health benefits can be amazing!" Customer, Tap Chat

"I used to paddle and swim in streams and rivers when I was younger and enjoyed it. We need to stop nannying so much and learn to enjoy life again. Living always has risks!" Customer, Tap Chat

Storm overflows are unacceptable to many customers

Our research has confirmed that some customers are appalled that raw sewage is ever discharged into rivers, and **they expect us to invest in infrastructure that avoids this**.

"No wastewater should go into rivers under any circumstance, it's time to stop this everywhere. Anybody contaminating any watercourse should be made to pay in full for the clear up and be fined." Customer, Tap Chat

A WWF report (2017) found that the public wants rivers to be safe to swim in and thinks regulators and companies should do more to tackle pollution[24]. However, awareness of the problem was low – half of respondents were not aware that raw sewage could be released into rivers, and 35% have flushed or put down the drain something they shouldn't have in the past month. 80% think that it is never acceptable to release raw sewage into rivers and 87% think the public must be told when this happens.

Customers expect us to be ahead of environmental legislation

Our deliberative research at PR19 showed that as customers become more aware of the environment, and how central it is to our activities, they showed an even stronger support for prioritising the environment and ensuring it is protected. **Customers told us we should be seeking to do as much as possible to protect and improve the environment**, and weren't concerned about the distinction between legal requirements and additional action.

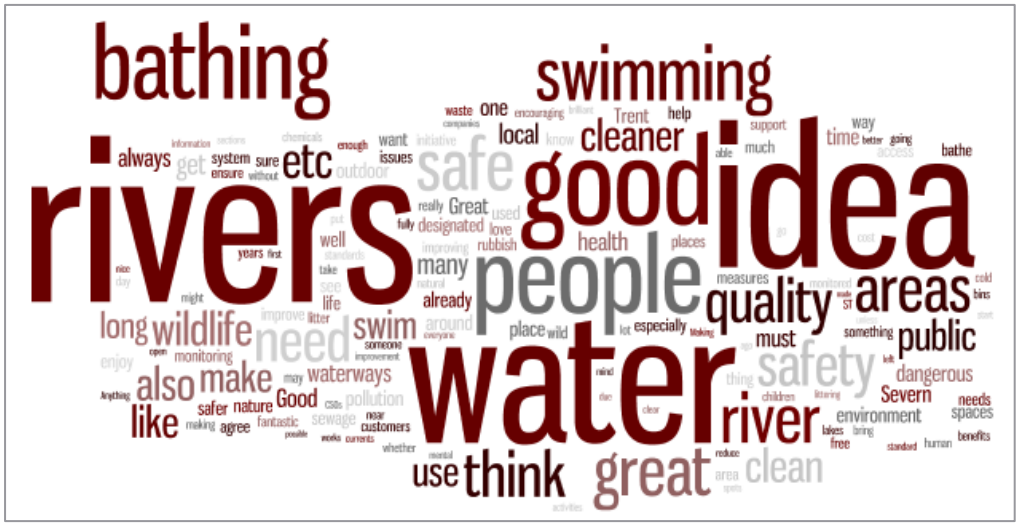
This is not an unexpected finding, as public opinion is often one of the driving factors behind the introduction of new environmental legislation – for example, the Water Framework Directive was conceived in the 1990s, passed by the EU in 2000, formally adopted into UK law in 2003, and began implementation in 2009. Storm overflows are a good example of public opinion moving ahead of legislation: although permitted by the Environment Agency and in compliance with current legal requirements, the recent adverse publicity shows that at least a proportion of the general public does not find them acceptable.

[24] Flushed Away. WWF-UK. 2017

Customer feedback on our proposal

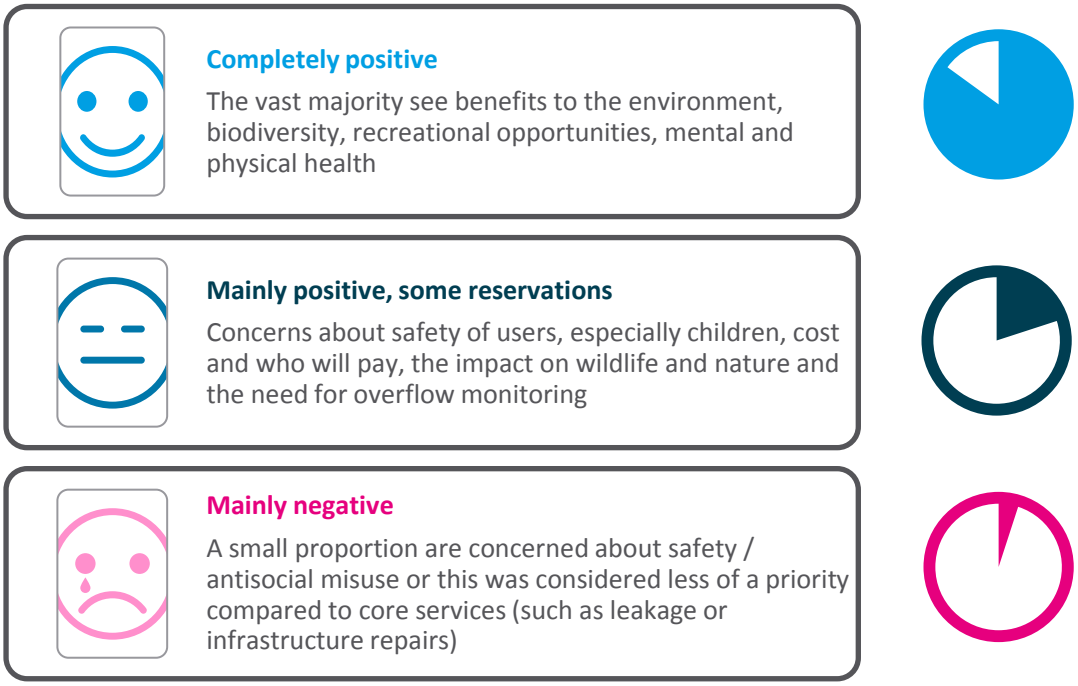
We have tested our proposals with # customers. In our quantitative acceptability research with over household 2,000 customers we found that **95% of customers either support our proposal (74%) or don't mind** either way (21%). The support is echoed in our qualitative research (on Tap Chat and in the deliberative online research and the co-design research undertaken by Britain Thinks). The figure below represents the initial views of customers when presented with our proposal to pilot bathing rivers on the Avon and Teme, on Tap Chat.

Figure: Initial views from customers on our bathing rivers proposals



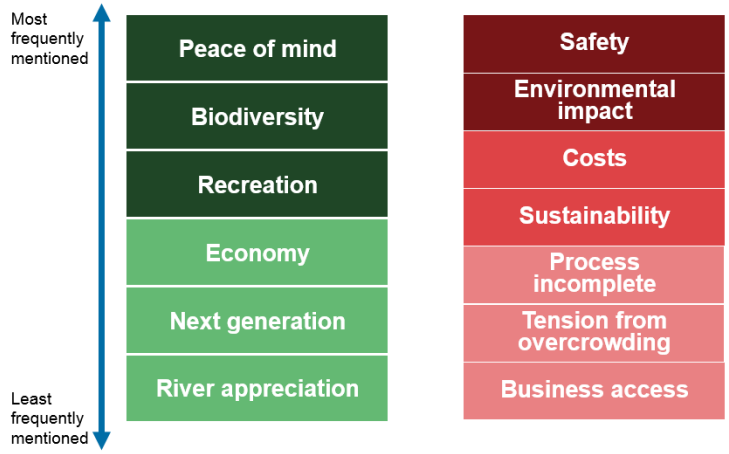
Overall, the vast majority of Severn Trent customers are happy about the proposal, although support is not universal and some also expressed some reservations. There are also a few who are mostly negative about the idea. We have summarised views from this qualitative research in the figure below.

Figure: Summary of customer feedback from our qualitative research on our bathing river proposal



This was echoed in the co-design research conducted by Britain Thinks on our proposal. Overall enthusiasm for the proposal was tempered with some concerns about how the scheme could work in practice. We have used this feedback to design some of the relevant aspects of our proposal, as discussed in Section 2.4.

Figure: Customer views on the benefits and concerns surrounding bathing rivers, from our co-design research



Many of the responses mention **the ability to enjoy and exercise in improved rivers** as a key benefit, recognising that river use (e.g. through swimming, kayaking, canoeing or simply just being outside, in and around nature) will lead to better physical and mental health. They felt that younger generations in particular would enjoy the time outdoors. There was mention that the initiative will lead to a cultural change, where people are fitter and more aware of nature, and that it will provide an affordable and sustainable form of recreation, which is easier to access than the coast from our region.

"What a fantastic idea. Not just for people to enjoy but great for wildlife and a brilliant way to teach future generations to preserve and enjoy nature and wildlife. Long overdue." Customer, Tap Chat

"My initial thought is this is a great idea, it's so important for people's mental health to be able to get out…some families also can't afford to go to the beach but may be able to drive to their local river." Customer, deliberative research

Some of the reservations concerned facilities (such as toilets, wheelchair access, parking, equipment, benches and bins) and potential misuse, including antisocial behaviour and littering. Others commented on the 'danger' element of wild swimming, including Weil's disease, strong currents, cold water, algae and the need to notify people when the river is unsafe for swimming, or the potential detriment to nature from increased footfall and littering. At the same time customers recognised the dichotomy between fear of overcrowding and the potential stimulus to the local economy, in towns where tourism is a major source of income and employment.

"If proper facilities were not provided i.e. bins in area it would create more pollution " Customer near the River Avon, Britain Thinks research

"I am totally against swimming in rivers – it is unsafe and they should be left for the wildlife. There are indoor and outdoor facilities that are safe for everyone to use." Customer, Tap Chat

"[We may get] too many people coming to the countryside - parking issues, spoiling all the quiet spots that only locals know about (very selfish I know)! Increase in litter. Increase in safety issues, leads to bad publicity" Customer near the River Teme, Britain Thinks research

1.2 Our long-term strategy for rivers

Our local environment plays a vital role in supporting communities, ecosystems, biodiversity, the economy and health and wellbeing. Severn Trent's long-term vision for bathing rivers in our region is part of our wider commitment to delivering a thriving environment, recognising the link between water, the natural environment and health and wellbeing[25].

Our environmental strategy

In relation to the environment, our vision for 2045 is to be operating a set of assets that make a positive difference to the environment and to have contributed to the delivery of the Government's 25 Year Environment Plan. In the case of river quality, we expect to have addressed all our WFD reasons for failure where it is cost-beneficial to do so, and enhanced biodiversity within the areas that we operate.

Our environmental strategy for rivers is as follows:

- All rivers that are designated as a Special Area of Conservation (SAC) or Site of Special Scientific Interest (SSSI) will achieve favourable conservation where it is our responsibility to deliver it.
- We play our part in ensuring that at least three-quarters of rivers in our region achieve WFD good ecological status, in line with the Government's 25 Year Environment Plan. We will also work with other sectors as needed to ensure that this ambition is delivered.
- No river shall fail to meet its environmental objectives on account of our activities, and we will ensure that no river in our region suffers from a deterioration in WFD class on account of our activities.
- We will ensure that all our water abstraction activities are environmentally sustainable, even under drought conditions. This will include investigating options for beneficial indirect reuse of sewage effluent to reduce abstraction pressures on rivers.
- We will take steps to proactively address emerging issues of concern such as microplastic pollution, pharmaceutical residues in sewage effluent and anti-microbial resistance.
- We will implement measures to create safe bathing waters on selected rivers within our region through enhanced sewage treatment and improvements to the sewerage system to reduce sewer overflow events.

Storm overflows are used to relieve the pressure on the sewerage system, and have become an increasingly contentious practice, subject to recent media scrutiny[26]. Following the introduction of the Storm Overflow Assessment Framework (SOAF) and the installation of Event Duration Monitors, the industry is now taking steps to identify and improve problem overflows – but more needs to be done to address public concerns.

Our strategy for storm overflows and the wider sewer network is as follows:

- We will fully implement the SOAF, to ensure that all our overflows are compliant with the requirements of the UWWTD, and we will take steps to substantially reduce spill frequencies and the duration of sewer overflow events.

[25] https://www.stwater.co.uk/content/dam/stw/about_us/pr19-documents/sve_full_plan_document.pdf
[26] https://www.theguardian.com/environment/2020/jul/02/mp-crackdown-raw-sewage-discharges-rivers-philip-dunne-private-members-bill-polluter

- We will improve any storm overflow that is responsible for a failure to meet WFD good ecological status.
- There will be no category 1-3 pollution incidents arising from any of our assets or operations.
- There will be no uncontrolled escapes of sewage from our systems that cause significant detriment to local communities, and zero domestic properties will be at risk of flooding up to a 1-in-50-year storm event.

Delivery of these objectives will be challenging. The traditional approach of piecemeal, overflow-specific interventions is not going to be able to deliver the desired outcomes; increasingly, we will need to look to catchment measures such as surface water separation and infiltration reduction, as discussed in our Flooding Resilience business case.

Our vision for bathing rivers

River swimming is an important part of the heritage of our landlocked region. Although popular in the early 1900s, public concern over water quality and the safety of river bathing meant that the practice fell away, and swimming in pools became the norm. Today, we are seeing a resurgence of this traditional pastime[27].

At the same time, the expectations of both the general public and NGOs are changing. Increasing national media coverage around storm overflows, disappearing chalk streams, and claims that the UK has "no river safe to swim in" are suggestive of a mood for even further and more meaningful environmental improvement. **To date, virtually all our investment in rivers has been focused on delivery of environmental targets, with very little reference to how customers want to interact with their local watercourses**. Our vision for the rivers in our region goes beyond simply meeting environmental targets – we want our rivers to be safe for 'contact' activities such as swimming, canoeing and stand-up paddling. That means ensuring that customers can engage in immersive activities without fear of being made ill due to the presence of harmful bacteria.

Our vision is to create safe bathing waters on selected rivers in our region, so that customers can benefit from the recreation and amenity our rivers provide. Being mindful of affordability for our customers, we will phase delivery of our vision over a number of AMPs. Our ultimate ambition is to **bring 30% of the rivers in our region up a standard that is appropriate for bathing and other 'contact' recreation activities.** The proposal in this business case represents the first phase in delivering this step change in river quality.

It is important to note that our ambition is not to bring all rivers up to bathing water standards; instead, investment will be targeted at specific sites identified using the following selection criteria:

- **Location.** River reaches to be improved to bathing water standards must be reasonably accessible to the general public (see images below).
- **Suitability and river access.** We will consider whether the river is suitable for meaningful immersive activity, taking into account depth, safety and other river users. This is important because customers have told us that being able to access the river safely is an important consideration in choosing where to swim.

[27] See Appendix A for more details of the history of river swimming.

- **Deliverability and affordability.** Bathing rivers need to be technically achievable and affordable, bearing in mind both the interventions required on our assets and also those in the wider catchment. These criteria are essential to defining both ambition and pace of progress.
- **Safety**. Some river sections are likely to be fundamentally unsafe due to the speed of river flow, dangerous manmade structures, and other dangers. There is no public benefit to achieving bathing water quality in rivers that are unsafe to swim in.
- **Popularity and community support**. We will consider where people currently swim and use the river for recreation in order to prioritise interventions where we can deliver the most benefit. For example, the River Blythe could be a good candidate for improvement in terms of relative proximity to Birmingham and Solihull (large customer centres). However, we have not managed to identify any current usage for wild swimming amongst the community at all, nor is there much other usage for recreation, such as boating and stand up paddling. In comparison this is all well-established on the River Avon, whilst still being close to a large number of customers.
- **Contribution to the levelling-up agenda**. We will look where possible to prioritise areas where the health and wellbeing and economic benefits are most needed.

Figure: Photos showing a river less likely to be used for recreation (left) and one more suited to recreation (right)

We have used these criteria to identify two pilot areas – the upper River Avon and the Teme - which have differing catchment characteristics (the Teme is a very rural catchment whereas the Avon has many larger urban centres) and will therefore provide different opportunities for learning. Assuming successful delivery of our pilot projects we have identified several further candidates in both the Severn and Trent catchments. The intention is to target specific sections for promoting river usage, whilst noting that the wider environmental benefits will extend well beyond the target areas. Our future strategy for our catchments is outlined in Appendix D. We have used a simple red-amber-green (RAG) status to identify the potential each river has for bathing water standards, classifying a further five rivers as having good potential, and two others are having moderate potential[28].

Urban pilot: The River Avon

The River Avon rises in Naseby, Northamptonshire, and flows in a predominantly south-westerly direction through Warwickshire and Worcestershire before joining the River Severn at Tewkesbury. The river is around 85 miles long and the overall river catchment area is just over 1,000 square miles. In total, **around 1 million people live within the catchment area, over 10% of our customer base**. The principal towns and cities along the river include Rugby, Coventry, Warwick & Leamington, Stratford-upon-Avon, Evesham, and Tewkesbury.

[28] See Appendix D for details

The historic provision of weirs and locks means that the river is navigable up as far as Stratford, with a number of significant weirs on the Avon and Leam further upstream. As a consequence, the river is generally wide, deep and slow moving most of the way from Coventry down to the River Severn, creating good conditions for swimming, rowing and other activities. Under normal conditions, the river flows at around 0.5mph.

Figure: Map showing the River Avon

The upper Avon and one of its principal tributaries, the River Leam, is the main source of potable water for most of Warwickshire, via Draycote and Campion Hills WTWs (c.45Ml/d combined output).

The Avon has benefited from the substantial quality improvement investments we have made over the last 20 years to deliver the WFD/UWWTD/Freshwater fisheries directive objectives, including state-of-the-art tertiary treatment at Finham STW. As a result, **the river now achieves WFD high or good status for both ammonia and dissolved oxygen along its entire length**. Investments made in AMP6 will deliver our share of phosphate removal targets down as far as Warwick, with further work planned in AMP7 and AMP8 to tackle the rest of the catchment. Further work by other sectors will be required to address non-wastewater sources of phosphate.

River swimming in the Avon

Across **Warwickshire**, swimming clubs trace a history of swimming in the River Avon in the late 19th Century. In Stratford-upon-Avon, the river has always been an important place for leisure and recreation. In the 1920s and 1930s, the Old Bathing Place was a popular swimming area, and had diving boards, a water chute, changing huts and a swimmer's safety boom. Photos show how people flocked there to enjoy the river, as well as other major events such as the Stratford regatta.

Figure: Old photos showing swimming in the River Avon in Stratford in the 1920s and 1930s

Today, the River Avon is popular with wild swimmers and other river users, including canoeing, rowing, kayaking and stand-up paddling (SUP) clubs. Popular swimming locations include:

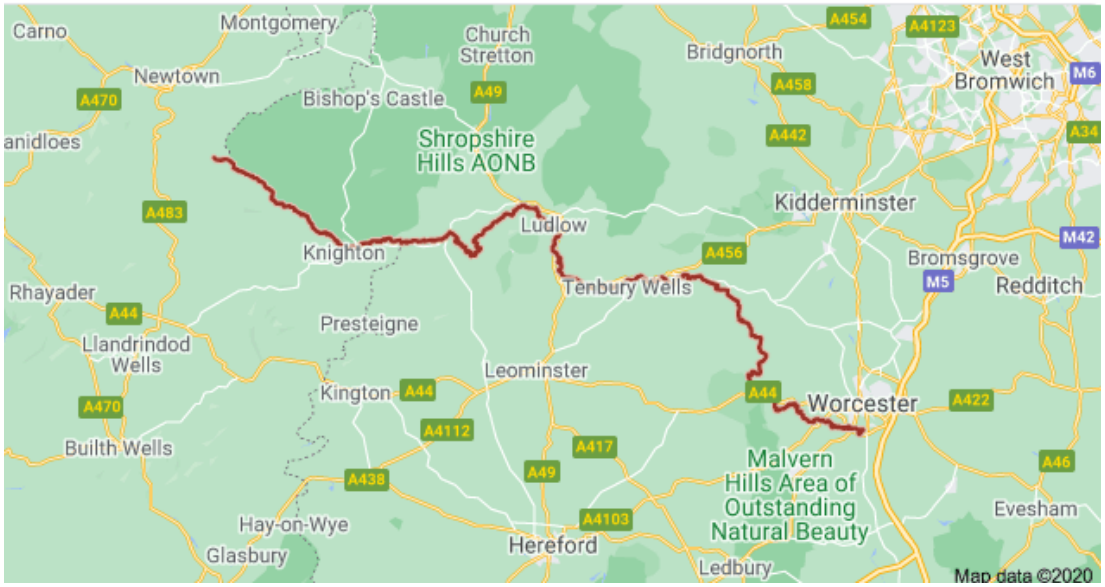
- The Saxon Mill and Guys Cliffe (north of Warwick)
- St Nicholas Park (Warwick)
- Jephson Gardens and Victoria Park (Leamington Spa)
- The Old Bathing Place (north Stratford-upon-Avon) and central Stratford

In previous years – before the Covid-19 pandemic – open-water swimming events such as the 2.5km Stratford Swim have been held in the Avon, attracting a growing number of swimmers, benefitting the local economy and raising money for charitable organisations.

Rural pilot: The River Teme

The River Teme rises in Mid Wales, south of Newtown, and flows southeast along the border between England and Wales. It becomes fully English near Bucknell and continues to flow east to Ludlow in Shropshire, before joining the River Severn south of Worcester. The river was designated as an SSSI in 1996 and is 130km long.

Figure: Map showing the River Teme



The Teme is a rural river, passing through just three towns (Knighton, Ludlow and Tenbury Wells). It is remote, beautiful and rich in wildlife, history and heritage. Despite being one of the fastest flowing rivers in Europe, there are tranquil spots which are popular with swimmers and other water users.

Through Ludlow the river is picturesque, tumbling over a series of weirs under the watchful eye of the castle. It has historically been the centre of leisure activity for the people of the town, serving both as playground and a venue for swimming and boating clubs. During the Edwardian years, Ludlow hosted annual regattas, with people travelling from Birmingham to enjoy the entertainment of boat races and water polo.

Figure: People enjoying the River Teme in the past (Ludlow Civic Society, Heritage News)

Today, leisure boats can be hired at The Linney Park, a popular spot with families enjoying the water, and the area is also popular with wild swimmers, both in Ludlow and further up and downstream, for example at Ashford Carbonel and Leintwardine.

Learning from bathing rivers in Europe

The UK is lagging behind other European countries, which are providing significant benefits through bathing rivers, including in Munich and Copenhagen, and across France, Spain and Germany[29]. Our customers look to Europe as an example of how rivers could be used if water quality were improved and cultural mindsets shifted. Below, we outline how the restoration of the River Isar in Munich has led to significant and wide-ranging benefits.

Case study: The River Isar, Munich

In 1995 the "Isar-Plan" was launched as an interdisciplinary initiative, integrating objectives of flood protection, ecological restoration, landscape design and recreational use of the River Isar which flows through Munich. The project was led by a working group including the State Office of Water Management Munich, the City of Munich and an alliance of NGOs. The City and District councils were also involved in the process. The design was put through public consultation including an internet platform, info-brochures, excursions, workshops, media, roundtables, and information points.

An 8km stretch of the river (formerly with a fixed, canal-like riverbed) that cuts across the city has been re-natured, with measures including restoration of the riverbanks, improved access routes and setting flood defences back from the riverbank. The remediation works took 11 years to deliver, including removal of WW2 debris, increasing flood protection, creating a public beach, weir removal, planting and installing water disinfection systems.

The total project cost has been reported at €35m, funded by the Bavarian State Government and the City of Munich, with high levels of public consultation. It was led by the Munich Water Management Office, which owns the riverine area. Involving stakeholders in the process and inviting citizens to feed into the idea development and design has led to a greater sense of ownership and pride in the project, and genuine support and investment. The Isar is now perhaps the most iconic place in Munich.

The benefits of the project include improved protection from flooding, an almost natural river flow, enhanced aesthetics, better access for visitors, improved water quality and a restored habitat that supports local fauna and flora[30]. The flood protection in particular has been a turning point in people's attitude to the river, but it also now provides a precious habitat and an attractive place for recreation. Thanks to the benefits delivered by the scheme, around 30% more people visit the Isar every weekend now, compared to the end of the 1980s, and several prominent events take place every year on the riverbanks, including river surfing.

Water quality in the River Isar has improved to the point where it now meets bathing water standards, thanks to upgrades at the wastewater treatment plants to include UV disinfection systems and source control at combined sewer overflows. In 2005 the disinfection plant at Gut Marienhof sewage works went into operation, along with plants at a further five works. The facilities are operated in the bathing season (15 April to 30 September). In August 2015, the agreements for operating the disinfection systems were extended to 2030.

[29] See Appendix B for details

[30] Case study Isar River, Munich https://www.therrc.co.uk/Bulletin/Apr2013/Isar_Munich.pdf

The degree of effort that has gone in to achieving bathing water quality for the Isar was unmatched in Europe, and as a result Munich is now a city with an 8km bathing site, where **large numbers of people flock in the summer months to unwind and enjoy the environment**. The restoration of the Isar has also benefited **the economy and biodiversity** through the creation of new habitats and allowing fish to move along the river. **The success of the scheme has been such that Munich City Council are considering an extension to the North**.

"The urban river concept combines the nature-oriented design of an urban river with an urban lifestyle, it goes beyond simple cost benefit analysis and is of immeasurable value to the population."[31]

"For me, the renaturation of the Isar has been a very successful policy from the city authorities. By taking the decision and going on to implement it, the city has done something that benefits the entire population, not just individual interests. Where concrete industrial aesthetics once ruled, visitors are now indulged with a sensory experience as clear water rushes over pebbles, and dippers dive into the river. Clearly the new wilderness is also attracting people." – ***Citizen in Munich***

We have included further details on other inspiring European case studies in Appendix B. The report from our consultants on the river transformation in Munich is available on request.

1.3 Accelerating the achievement of Government priorities

There is much to be done, both by the water industry and other sectors, to deliver the Government's ambitions for improved river water quality. We believe that a focus on bathing waters will allow us to move at pace towards the achievement of good ecological status under the Water Framework Directive, for as many rivers as possible. This will deliver the recreation, health and wellbeing benefits that customers are asking for.

The **Government's 25 Year Environment Plan** includes the following commitments:

- Improve at least three-quarters of our waters to be close to their natural state as soon as is practicable.
- Make sure that all those with a role to play take action to improve water quality by, for example, removing misconnected plumbing, improving surface water drainage and land management, and maintaining private sewage systems to a high standard.
- Continue to develop the Environment Agency's forecasting and warning system so that bathers are warned of a possible short-term pollution problem, perhaps owing to spills from overloaded sewers during heavy rain.

There is clearly a lot to be done, both by the water industry and other sectors, to deliver these objectives. **We believe that the creation of safe, healthy bathing waters in targeted rivers could turn an environmental problem into a community-led opportunity**. Bathing rivers can provide a focal point for collaboration with stakeholders and communities, allowing us to move at pace towards our long-term WFD target while delivering recreation, health and wellbeing benefits.

We need a multi-stakeholder approach to achieve WFD targets

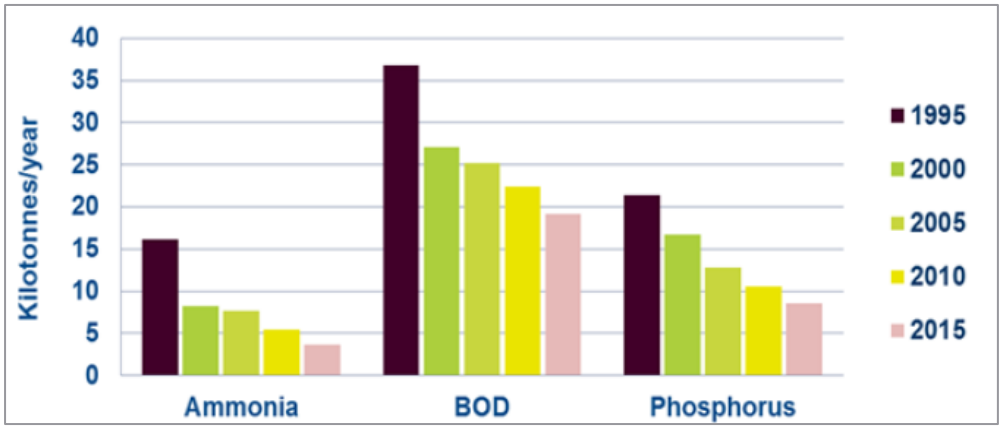
The EU Water Framework Directive (WFD) came into effect in 2009 and requires all European surface waters to reach good status by 2015, subject to being technically achievable and cost beneficial.

[31] Arzet and Joven (2013) Case Study: Isar River, Munich. Available online at: https://www.therrc.co.uk/Bulletin/Apr2013/Isar_Munich.pdf

Application of 'disproportionate cost' criteria allows for the deferral of cost-beneficial improvement to 2027.

Significant water industry investment has already been made over the last 30 years to deliver the WFD and other environmental legislation, with a lot more to come in AMP7. Our rivers and coasts are in better condition than at any time since before the industrial revolution and the water industry is investing significantly more than other sectors to drive this improvement. For example, the figure below shows the reduction in ammonia, biochemical oxygen demand (BOD) and phosphorus load discharged to rivers by sewage treatment works in England and Wales between 1995 and 2015.

Figure: Reduction in Ammonia, BOD and Phosphorus pollutant loads in rivers from the water industry between 1995 and 2015 [32]



In our PR19 business plan we showed how we are on track to deliver our WFD requirements for continuous discharges by 2027, with our interventions to date focused on ammonia and phosphorus reductions. 90% of the WFD waterbodies in our region achieved good or high status for **ammonia** in 2016, and of the 58 waterbodies not already achieving this, we have measures in our investment programmes to deliver the required improvements.

Phosphate remains a significant challenge, both for Severn Trent and for other sectors. In 2016, monitoring showed that phosphorus was the most common reason for rivers not achieving good status, and of all the assessed river water bodies in England, 55% were at less than good status for phosphorus[33]. Investment to deliver Urban Wastewater Treatment Directive (UWWTD) standards has delivered considerable improvement, but more needs to be done to deliver the exacting standards set by the WFD to protect the environment. To this end, we are investing over £0.5bn over the period 2015-2025 to reduce phosphate levels in over 3500km (out 6800 km) of rivers, with further work planned in AMP8.

However, despite the investment by the water industry, the latest WFD classification status data, published by the Environment Agency, shows that in **2019 only 14% of rivers in England met good ecological status, and no river met good chemical status under the WFD**[34]**.** This is in part because a key challenge of improving river water quality is the large range of contributing factors, including water companies' effluent quality and storm overflows, pollutants from agriculture, runoff from roads, and industrial pollution. The Environment Agency's database of "reasons for not achieving good

[32] The state of the environment: water quality. Environment Agency report. February 2018
[33]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/709493/State_of_the_environment_water_quality_report.pdf
[34] https://deframedia.blog.gov.uk/2020/09/18/latest-water-classifications-results-published/

status" (RNAGS) against the WFD shows that the water industry and agriculture have the most significant adverse impact of all stakeholders[35]. **Accelerating improvements in river water quality will require a collaborative, multi-stakeholder approach. In this business case we take such an approach and tackle both reasons for failure at our assets but also sources of agricultural pollution, thus accelerating progress towards the WFD target.**

Frequent operation of **storm overflows** is potentially the biggest impediment to the successful delivery of bathing water standard water quality in rivers. This means that the successful delivery of our vision to create safe bathing areas in our region is inextricably linked to the delivery of our storm overflow strategy. **We are anticipating a significant statutory programme of CSO improvements in AMP8 and 9**, as the data from the Event Duration Monitors (EDM) we installed in AMP6 helps identify those which are causing an adverse environmental impact. **In this business case we propose to tackle 1.25 storm overflows which have an adverse environmental impact and prevent the achievement of bathing water standards. These interventions will accelerate the progress towards the overall WFD target.**

The contribution of bathing waters to WFD progress

Whilst the standards that define safe bathing water and good ecological status are very different (the former being a **bacteriological standard** and the latter being a combination of **chemical and ecological standards**), there is a considerable degree of overlap between the interventions needed to deliver them.

As we have discussed, the predominant reason for failure to meet WFD good status is **phosphate pollution**. The sources of phosphate are largely the same as the sources of bacteria that define safe bathing water quality. For the water industry, this is sewage effluent and storm overflows. For agriculture, the main sources are livestock farming and nutrient management (particularly slurry spreading). It therefore follows that interventions to prevent bacterial contamination of rivers will also address phosphate pollution.

Our proposed pilots on the Rivers Avon and Teme include the installation of advanced disinfection treatment. Whilst there is not an obvious link between the disinfection of sewage effluent for bathing water and the removal of phosphate, it is the case that both require the installation of good tertiary solids removal to work effectively. There is therefore some synergy between meeting bathing water and WFD objectives when it comes to implementing process upgrades at sewage works.

At our proposed bathing river area on the River Avon, there are five waterbodies that will benefit directly from the interventions in this business case. All five currently fail to meet good ecological status, and in all cases, phosphate is a cause of failure.

[35] The state of the water environment: water quality EA report. February 2018

Table: Waterbodies on the River Avon that will benefit from the investment and their current water quality status

Water body name	Overall water body class	Ecological class	Ecological certainty less than good	Phosphate class
Avon - confluence River Sowe to confluence River Leam	Moderate	Moderate	Very Certain	Poor
Avon – Clay Coton Yelvertoft Brook to confluence River Sowe	Moderate	Moderate	Very Certain	Moderate
Leam - confluence River Itchen to confluence R Avon	Poor	Poor	Very Certain	Moderate
Avon confluence River Leam to Tramway Bridge, Stratford	Moderate	Moderate	Very Certain	Poor
Sowe - confluence Withy Brook to confluence R Avon	Moderate	Moderate	Very Certain	Poor

For these five waterbodies, the Environment Agency has identified 29 separate RNAGs, 24 of which are phosphate-related and 18 are either water industry or agriculture. Reference to SAGIS source apportionment data[36] shows that the remaining six phosphate RNAGs make relatively minor contributions to the phosphate problem.

Table: Sectors and activities which contribute to the reasons for failure

Sector	Activity	Number of RNAGs
Water Industry	Sewage works	8
Water Industry	Storm overflows	4
Agriculture	Livestock farming	4
Agriculture	Poor nutrient management	2
Urban and Transport	Urbanisation	4
Domestic general public	Private sewage treatment	2

Most of the eight sewage works-related RNAGs were addressed in AMP6, but completed too late to be 'ticked off' in the latest dataset. Of the two that remain, one is covered by our AMP7 programme and the other forms part of this bathing waters project. The key remaining inputs of phosphate into the River Avon are therefore primarily from storm overflows and agriculture. The measures that we need to take in these areas to reduce phosphate are the same as those required to deliver sate bathing waters.

Of the other five RNAGs, four are tagged against a chemical fail for Tributyltin. There is some uncertainty as to the source of this pollutant, but we do know that the process upgrades installed at sewage works to deliver WFD phosphate objectives are compatible with removing this pollutant.

We acknowledge that the measures required to deliver safe bathing rivers will not by themselves deliver WFD good ecological status (for example we cannot guarantee the impacts from urban areas and the general public). However, **they will address the majority of reasons for failure and deliver substantial additional benefits, taking us as close as possible to the overall target.**

[36] The Source Apportionment-GIS (SAGIS) Tool is a GIS-based tool to apportion loads and concentration of chemicals to WFD water bodies has been developed to support river basin planning by the UK Water Industry and the Environment Agency to identify effective programmes of measures, whilst maintaining the 'polluter pays principle', thus ensuring a fair proportioning of responsibility for improving water quality across all responsible sectors.

1.4 Securing best value for the long term through WINEP reform

As well as achieving environmental improvements in line with the Government's 25 Year Environment Plan, our proposed focus on bathing rivers will deliver long term value for our customers. Taking a proactive approach to community-led demand for bathing waters will allow us to respond to emerging trends efficiently and effectively, and to support the evolution of the WINEP to meet the challenges of the future.

Responding to emerging trends

We have recently undertaken a comprehensive process considering the **emerging external trends that influence our operating environment,** and how we should respond to them. Several of these trends relate directly to the bathing rivers approach outlined in this business case:

Table: Emerging trends and challenges we have considered

Challenge / trend	Details
Reducing phosphate in watercourses	• Legal requirement through the Water Framework Directive (WFD) and driver of £0.5bn of investment in 2015-2025. • High certainty of further work in AMP8 (or through the Green Recovery). • Likely to be one of the target measures included in the Environment Bill.
Hazardous chemicals	• Standards are laid down in the Environmental Quality Standards Directive (EQSD), 'daughter directive' of the WFD. • Environment Agency/Defra policies on hazardous substances are being finalised. • Significant water industry investigation undertaken in AMPs 5, 6 and 7 through the Chemical Investigations Programme at a cost of c£150m. • Indicative permit limits for a number of sites provided by the Environment Agency that may form part of AMP8.
Pharmaceutical residues	• Some are already on the EQSD 'watchlist'. • Research by the water industry suggests that adopting the Swiss micropollutant removal strategy in the UK could incur costs of between £6.8 and £7.9 bn (as net present value, over 20 years) – including around £1bn for Severn Trent[37]. • In addition to removal already implemented in Switzerland, the EU is considering amending the Urban Wastewater Treatment Directive (UWWTD) to follow suit. Feedback suggests member states support this. • Full-scale treatment plants for removal of pharmaceutical compounds are operating in Sweden and in Germany, and at pilot scale in the Netherlands. • Investigations have already shown some residues are present in effluent at levels sufficient to cause concern in low-dilution rivers.
Anti-microbial resistance (AMR)	• AMR is a global health and development threat, which the World Health Organisation has declared as one of the top 10 global public health threats. • AMR is also on the UK Government Register of Civil Emergencies. • 700,000 people a year die from antimicrobial resistant infection, predicted to rise to 10 m across the world by 2050[38]. • Wastewater has a role as a significant conduit by which AMR bacteria can enter the environment. £2m research project included in AMP7, to build upon some recently completed UKWIR research. • There has been media coverage on sewage effluent, following academic research in this space[39].

[37] UKWIR Pharmaceutical reduction at WWTW – Cost and Effectiveness. Report ref 20/WW/17/18
[38] https://www.who.int/antimicrobial-resistance/interagency-coordination-group/IACG_final_report_EN.pdf?ua=1
[39] https://www.theguardian.com/society/2019/may/27/worlds-rivers-awash-with-dangerous-levels-of-antibiotics

Challenge / trend	Details
Microplastics	• Plastic pollution is a high-profile issue of concern for customers and society and currently under investigation by in the water industry[40]. • Water UK has recently published its 'source to tap' research into microplastics in sewage and drinking water. Further work is included in AMP7 as part of the Chemical Investigations Programme. • Whilst the removal rate of microplastics through sewage treatment is high (80-95%), several studies point at storm overflows as one of the most common pathways for microplastics to enter the environment[41].
Customer expectations – Inland bathing waters	• High-profile media coverage and pressure from some NGOs (such as the Rivers Trust) and campaign groups. • Successful application made for bathing water designation for the River Wharfe in Ilkley in Yorkshire. Other campaign groups are planning to follow suite and make applications.
Storm overflow improvements	• Improvements driven by both WFD and UWWTD legislation. • High-frequency spilling overflows being investigated in AMP7. • High-profile media coverage and pressure from campaign groups. • Private Members' Bill launched by Philip Dunne MP (chairman of the Environmental Audit Committee), seeking a duty on water companies to take all reasonable steps to ensure that untreated sewage is not discharged into inland waters, to be considered in March 2021.

These challenges / trends represent a mixture of potential future legislative changes and changes in customer expectations, both of which could drive significant investment requirements. For example, **the demands for both storm overflow improvements and inland bathing waters represent a shift in customer expectations**. Despite the Environment Agency's statutory duty to "promote the use of inland waters for recreational purposes" (to such extent as it considers desirable), no inland river water in England is designated as a bathing water.

In the face of these changes, we can choose to take a reactive approach, meeting new legislation as and when it becomes a requirement in a piecemeal fashion, or a proactive customer-led approach, allowing us to deliver additional benefits that customers and society value, and learn more about the costs and benefits of a more ambitious rollout in the future. As we discuss below, the biggest issue with the reactive approach is that the interventions required to deliver the current obligations are sub-optimal for meeting foreseeable future needs. This means that customers could potentially pay more in the long run.

We are ideally placed to take a leadership approach to setting environmental goals that draw together stakeholders and communities, rather than waiting to respond to future legislation. We believe that this proposal is an opportunity to move to a genuinely customer-led environmental programme, that delivers improvements that customers and society value.

Supporting WINEP reform

Environmental enhancement has been driven primarily through the Water Industry National Environmental Programme (WINEP), and its predecessor, the National Environment Programme (NEP), issued by the Environment Agency. Investment through the WINEP has been substantial – between 2020 and 2025 approximately £5bn will be spent on asset improvements, investigations, monitoring and catchment interventions.

[40] https://trends.google.com/trends/explore?date=today%205-y&geo=GB&q=microplastics
[41] Briefing Note: Microplastics and the water sector. Current knowledge, challenges and possible solutions 2019. Eur Eau

Defra, the Environment Agency and Ofwat recognise that the WINEP needs to evolve to deal with the growing pressures from pollution, population growth, climate change, and customer expectations, and have set up a taskforce to review WINEP in time for PR24, focusing on three areas:

- **New environmental outcomes**. What outcomes should an updated WINEP deliver in the water environment?
- **Ways to deliver outcomes**. How can WINEP be less prescriptive and allow more flexibility to deliver better environmental outcomes?
- **Involvement of water companies and other stakeholders.** How can water companies and other stakeholders be more central to the design and development of the WINEP, whilst increasing accountability of water companies?

We are actively supporting the taskforce, and our bathing river pilots will support the objectives of the review, including more flexibility to deliver better environmental outcomes and water companies being more central to the design and development of the programme. **We strongly believe this will deliver the long-term lowest-cost solution compared to the current approach.**

In the past, whilst we have been able to influence the timing and location of enhancement work, we have been working within the Environment Agency's framework and are significantly constrained by the national guidance and methodology. WINEP is by nature reactive, in that it details interventions required to meet existing legislation; a very small part of the programme (1-2%) is research into emerging issues. In addition, delivery timelines in the WINEP largely reflect water industry AMP periods, although by exception a few obligations do have dates that spill over into the next AMP. Both of these issues present a significant challenge when it comes to designing long term investment strategies. The biggest risk is that the interventions required to deliver the current obligations are sub-optimal for meeting foreseeable future needs, such as those emerging trends and challenges identified.

For example, we are mindful of the **emerging risk of hazardous substance control**. The Environment Agency is using the Chemicals Investigations Programme (CIP) data to calculate new permit limits that might be applied from AMP8 onwards. Up to 70 of the sites that could be affected are in our AMP7 WFD programme, which creates a risk that our AMP7 investment is not futureproof. Whilst we have identified some options to mitigate this risk, we must be mindful of the future uncertainty and the need for customer bills to remain affordable.

In Appendix C we give some examples of how a fragmented approach to delivering legislative requirements, without reference to a long-term, overarching strategy can lead to inefficiencies.

We agree with Defra's preferred approach of setting **longer-term objectives at river catchment level that cover both existing and foreseeable future requirements**. This would give us the flexibility to design efficient investment programmes that work towards the delivery of the long-term vision, and avoid what has happened all too often in the past, when we have had to revisit sites AMP after AMP to deliver the next improvement.

It is true that we cannot always predict the exact treatment standards that will be required 15-20 years in the future. However, we can predict the direction of travel and ensure we implement strategies that are compatible with future needs.

1.5 Overlap with AMP7 programme

We have carefully considered how the activities required to deliver bathing quality water in our region's rivers are distinct from, and go above and beyond, our AMP7 programme.

There are no overlaps between the work proposed in this business case and either our wastewater AMP7 WINEP obligations. The River Avon project does include work at two sewage works that are also included in our AMP7 quality enhancement programme but in neither case does the improvement required for delivering bathing river quality overlap with the WFD enhancement obligation. None of the other assets identified for improvement are included in WINEP or contribute towards the WFD performance commitment.

Table: Sites which have AMP7 WINEP obligations and the distinct bathing river activities proposed

Site	AMP7 Enhancement	Bathing rivers
Itchen Bank STW	Chemical dosing + tertiary treatment for phosphate removal	Effluent disinfection with Ozone
Wellesbourne	Chemical dosing + tertiary treatment for phosphate removal	Provision of additional stormwater storage

As with the River Avon pilot, the proposed River Teme trial does not materially interact with the AMP7 programme. There are a couple of small sewage treatment works further upstream that will be upgraded with phosphate removal in AMP7. Whilst this could be of marginal benefit to the proposed bathing area, the upgrades planned in Ludlow in no way alter these upstream improvement obligations.

It is worth noting that we have an AMP7 obligation to investigate the River Teme as a whole to identify what measures could be required in AMP8 to help the river achieve SSSI conservation objectives. **The measures proposed to meet bathing water standards will also help the river to meet its SSSI targets** and we will use the report's findings to refine our interventions and maximise the benefits.

1.6 Overlap with other Green Recovery business cases

We have identified one area of overlap between this business case and the 'Accelerating AMP8 WINEP' Green Recovery business case. The latter includes WFD quality improvements on the River Avon downstream of Warwick sewage works (Longbridge STW) which are, in part, reliant upon the works upgrade included in this business case. In the event that this bathing rivers proposal does not receive approval, but the WINEP case does, it would be necessary to restate the costs of the latter to include £5.8m for phosphate removal at Warwick STW to enable delivery of these outcomes.

1.7 Why intervention is required

Our proposed pilot areas – the Avon and the Teme – are important parts of the local landscape, interwoven with the daily lives of local communities. In order to deliver improvements for these communities, we'll need to build on the significant investment we've made in these rivers in recent years, and target specific interventions that reduce bacteria in the water.

There are three main sources of pollution in rivers and other inland waters: agricultural, wastewater and surface water runoff from roads and urban areas. Typically, the first two account for approximately 80% of river pollution, although this will naturally be catchment specific. Bacteria and viruses can come from wild animals, human sources (including badly connected pipes, poorly

maintained septic tanks, and storm overflows) and agricultural sources, and can cause illness in river users. For example, in 2012 Public Health England investigated an outbreak of gastrointestinal illness amongst participants of the Hampton Court Swim in the river Thames, following over 30% of the 1,000 participants experiencing symptoms of illness [42].

The new Bathing Water Directive entered into force in 2006[43] and recognises that **faecal matter, for example from inadequate sewage treatment and pollution from animal waste, is the primary health threat to bathers**. The Directive sets of the standards required for two microbiological indicators of faecal contamination: Esherichia coli (E.coli) and intestinal enterococci. The assessment is based on a percentile evaluation and defines three different standards separately for inland and coastal bathing waters. The standards for 'excellent' and 'good' quality are based on a 95-percentile evaluation, and the standards for 'sufficient' are based on a 90-percentile evaluation. Bathing waters not meeting the standards for 'sufficient' quality are classified as 'poor'.

We are absolutely confident that intervention on our assets will be required to deliver bathing standards in rivers. The table below gives the bacterial levels that correspond to the Bathing Water Directive classifications for inland bathing waters[44]. This shows that levels of E.coli will need to be below 1,000 Colony-Forming Units (CFU) per 100ml.

Table: Bacterial levels corresponding to the Bathing Water Directive for inland bathing waters

Classification	E.coli threshold (Colony-forming units per 100ml)	Intestinal enterococci threshold (Colony-forming units per 100ml)	Confidence interval
Excellent	500	200	95%ile
Good	1,000	400	95%ile
Sufficient	900	330	90%ile
Poor	Worse than sufficient		

Data published by Defra in the table below shows that **typical sewage effluent, even with tertiary solids removal, has levels of E. coli above the bathing water standards**[45]**.** In rivers with high dilution and with very low contamination from other sources, it is possible that bathing standards could be met through dilution alone; however, this is not the case in our pilot areas.

Table: Data from DEFRA on typical levels of E.coli in sewage effluent

Works type	E.coli (log10 CFU/dl)	CFU/dl
Filter works effluent	5.22	160,000
Filter works + TT[46]	3.70	5,000
ASP effluent	4.59	40,000
ASP + tertiary treatment	3.07	1,200

[42] Epidemiological investigation of an outbreak of gastrointestinal illness following a mass-participation swim in the River Thames. London. October 2013. Public Health England report
[43] https://ec.europa.eu/environment/water/water-bathing/index_en.html
[44] https://environment.data.gov.uk/bwq/profiles/help-understanding-data.html
[45] Impact of Waste Water Treatments on Removal of Noroviruses from Sewage. R&D Technical Report WT0924/TR. November 2011.Table 3.7. Note that this report did not include a figure for biofilter works with tertiary treatment, so we have assumed that tertiary solids removal delivers a similar reduction to that delivered at activated sludge plants.
[46] The Defra data did not include a figure for filter works with tertiary solids removal – this figure is based on the log reduction that tertiary treatment gives on ASP works.

The impact of **storm overflows** on bathing water quality can be substantial due to the high bacterial loads in untreated sewage. E.coli levels are typically 10^6 CFU so several orders of magnitude higher than the bathing waters standards. For this type of asset, **spill frequency and volume** are the best indicator of the need for change, as any significant spill containing this level of E.coli (and high levels of other faecal bacteria) will be a major problem in respect of bathing water standards.

We have assessed the data for the storm overflows in our pilot areas, particularly to check that the overflows will be an issue during the times of year when customers are most likely to want to swim and use the river. The data for 2019 and 2020 shows that in the period May – September (the bathing "season") there were a total of 232 spills with a total duration of 853 hours, across all the storm overflows in the Avon and Teme catchment locations we are considering. This is split as follows:

Table: Number of storm overflow spill events and duration in the Avon and Teme catchments during summer months

Catchment	Number of spill events	Duration of spill events
Avon	155	577
Teme	77	276

Storm overflows that discharge to coastal bathing waters are limited to three spills per bathing season. The impact of any given storm overflow on a river is a function of three basic parameters, all of which are highly variable (both within a specific storm overflow events and between different events):

- The bacterial load in the storm overflow discharge.
- The storm overflow spill volume.
- Dilution in the receiving watercourse.

Bacterial load will vary according to the intensity and duration of the storm event that causes a storm overflow to operate. In a large, long duration storm event, the concentration of E.coli will diminish in proportion to the diluting effect of rainwater entering the system. However, there is a likelihood of higher concentrations entering the river at the onset of a storm due to a 'first flush' of the network. To assess which of our storm overflows may require investment to reduce spill frequency and volumes, we carried out mass-balance calculations using a range of E.coli concentrations:

Table: Range of E.coli concentrations (cfu/dl) used in our mass balance calculations

High[47]	Medium[48]	Low	Bathing water standard
5×10^6	7.85×10^5	1.56×10^5	1×10^3

It is clear that, even at the low end of the range**, E.coli concentrations in storm sewage are likely to be two orders of magnitude higher than the bathing water standard**.

Based on this analysis intervention at both our treatment works and storm overflow assets is required in order to deliver bathing water quality. In Appendix F we set out the modelling we have done to identify, for our pilot areas, which specific assets require intervention.

[47] The high range figure is a standard number for untreated sewage.
[48] The medium and low range figures are taken from a 2019 Spanish research paper entitled 'Evaluating health hazard of bathing waters affected by combined sewer overflows'. Medium represents a smaller, short-term event and the low figure is for a large, 12-hour duration spill.

1.8 Why interventions is “no regrets”

As discussed in the previous section, our proposals to deliver improved river water quality to bathing standards will require intervention on the storm overflows and the final effluent from our sewage works as well as a programme of catchment management . In this section we discuss how / which of these are no regrets interventions. In the following table we highlight the investment driver for both asset classes.

Table: Investment drivers for the improvements proposed at our storm overflows and sewage works

Intervention	Investment drivers				
	WFD (AMP8)	UWWTD / SOAF	Base maintenance and growth	Customer expectations	Future legislation
Storm overflows	✓	✓		✓	✓
Sewage works (final effluent disinfection)				✓	✓

There are two drivers for **storm overflow improvement** (other than delivering bathing water quality) – these are to achieve WFD good status and / or to tackle high frequency spilling overflows under the UWWTD / SOAF process. Both will drive spill frequency reductions, but not necessarily to the same extent as the bathing rivers objective. In addition to this, we expect that requirements to address storm overflows might become more stringent over time due to customer expectations finding these increasingly unacceptable, and future changes in legislation that might result from the Private Members Bill for Inland Waters, being considered by Parliament in March 2021.

The driver for improving the **sewage works effluent** by introducing disinfection is very much a longer term “no regrets” investment. If / when legislation on pharmaceutical removal or antimicrobial resistance is introduced then this is a no regrets investment. It is unlikely this would be introduced before AMP9. However, from the perspective of delivering environmental improvements , even if it does go beyond current legislative requirements, we consider this is beneficial investment. In Section 3 we highlight in more detail for each of our pilots where the specific asset interventions sit.

2. Options for driving holistic catchment outcomes

In this section, we analyse the technical solutions required to deliver bathing quality water in rivers. We have assessed each intervention through our robust optioneering process and believe that the options we have selected represent the best value for customers in terms of the scale of benefits unlocked by considering how we can achieve multiple environmental outcomes.

We have considered a wide range of options for each stage needed to deliver bathing quality rivers. We have not however considered this objective in isolation, but by considering how we can achieve multiple environmental outcomes we can maximise the benefits to customers. As part of our solution we have included both aspects within our direct control and aspects that will require us to work in close partnership with others in the catchment.

Whilst it is not possible to eliminate all sources of bacteria in rivers, we can reduce the risks and deliver a higher quality river environment through five key interventions, summarised below.

Figure: Five key interventions to deliver bathing quality rivers

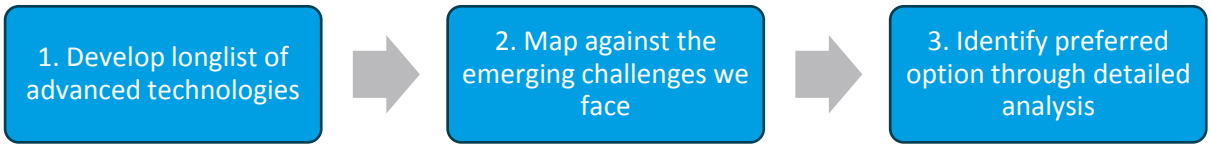
2.1 Installing advanced treatment at our sewage works

We have considered a range of treatment options. We need to select the right process that will:

- Deliver the strategic ambition of unlocking the potential of our rivers for recreation, health and wellbeing.
- Futureproof against the emerging challenges we face.
- Take advantage of any additional opportunities – for example, producing a product that is suitable for indirect effluent reuse.

The diagram below outlines our optioneering process.

Figure: Optioneering process



Step 1: Develop longlist of advanced technologies

The table below details the technology options we considered, and the advantages and disadvantages of each.

Table: Assessment of the pros and cons of the technologies we have considered

Technology	Pros	Cons
Ozone	Versatile Can remove residual BOD and NH3 Known technology for clean water	Potentially expensive, especially if new tertiary solids removal is required Not currently used for bathing waters in the UK
Ultraviolet (UV)	Already used for coastal bathing waters and to deliver bathing water quality for the River Isar, Munich	Very high OPEX (manpower and power) Limited benefits
Powdered Activated Carbon (PAC) / Granulated Activated Carbon (GAC)	Known technology for clean water	Expensive regeneration – shorter media life in wastewater (GAC) Very high OPEX and big increase in sludge (PAC) Will not provide disinfection
Enhanced tertiary solids removal	Known technology (extensively rolled out in AMP6/7) Natural fit with / complementary to ozone and UV (good solids removal is a pre-requisite) Versatile Can reduce bacterial loads (which may be sufficient for some small sewage treatment works)	Can be high cost
Enhanced biological treatment	Known wastewater technology Can reduce chemical costs	Higher OPEX and carbon Not always deployable

As part of our assessment, we analysed case studies from across Europe. We were mindful of the approach adopted in Switzerland for the micropollutant strategy, where, based on pilot studies, ozonation and activated carbon processes were found to be the most efficient at removing a wide range of pollutants[49]. In particular, **ozonation has been found to be the technology of preference for larger wastewater treatment works while smaller works have an equal share between Powdered Activated Carbon (PAC) and ozonation**. However, PAC is not considered feasible in the UK because it greatly increases sludge production. It is acceptable in Switzerland, where most sludge is incinerated, but not in the UK, where it is recycled to land. There is also limited environmental gain from removing micropollutants from effluent using PAC and then transferring them onto farmland through biosolids recycling.

[49] Pharmaceutical reduction at WWTW – cost and effectiveness. UKWIR report 20/WW/17/8

Ozone treatment for pharmaceutical removal has been used in two full-scale case studies in Sweden (at Knivsta STW, treating 12,000 population equivalent (PE), and Nykvarnsverket STW, treating 235,000 PE). It is likely that in Finland advancements will be made in the near future, as the government has started looking at the costs of treatment options. The Netherlands is currently assessing different methods for removing pharmaceutical compounds from wastewater at pilot scale, including ozone, whilst in Germany there were 17 full scale ozone applications for pharmaceutical removal at sewage treatment works by 2017. We have included further details in the report from our technology scouting, available on request.

A further option identified by our technology scouting exercise is **Chlorine or sodium hypochlorite** for disinfection, as used in some locations in America. We have not considered this further because there are several clear disadvantages of using chlorine as a wastewater disinfectant:

- The need to store large volumes of chlorine gas close to residential areas – a health and safety risk – or, to avoid this, expensive on-site chorine generation.
- Sodium hypochlorite would be impractical at scale due to the volumes of tankered chemical required.
- A further dichlorination stage is required (e.g. using sodium bisulphite) to avoid ecological impact on the river.
- There is the potential for formation of chlorinated disinfection by-products such as trihalomethanes. We do not have sufficient data to rule out the possibility that such compounds could be of environmental significance in the river.

Step 2: Map against the emerging challenges we face

We mapped the treatment options against the future challenges we are facing (discussed in Section 1.4). This has helped us identify that **ozone treatment will deliver bathing quality standards, as well as tackling the issues of AMR and pharmaceutical residues and partially tackling the issue of hazardous chemicals**. The other option that would deliver bathing quality standards, and which is typically used at coastal sewage works, is disinfection using ultraviolet (UV). In Step 3 we discuss these two options further.

Table: Mapping the treatment options identified in Step 1 to the emerging challenges

Treatment options	Hazardous chemicals	Pharmaceuticals	Bathing waters	AMR	Microplastics[50]	Phosphate
Ozone	Partial	Yes	Yes	Yes	No	No
UV	No	No	Yes	Yes	No	No
PAC / GAC	Partial	Yes	No	No	No	No
Enhanced tertiary solids removal	Partial	Partial	Partial*	No	Yes	Yes
Enhanced biological treatment	Partial	Partial	No	No	No	Partial

**when addressing relatively small discharges*

[50] We have included microplastics here as one of the emerging challenges we face, although the removal rate of microplastics through sewage treatment is high (80-95%). There are however several studies that point at storm overflows as one of the most common pathways for microplastics to enter the environment and therefore our storm overflows interventions will deliver a benefit here.

Step 3: Identify preferred option through detailed analysis

Our analysis in Step 1 and 2 leads to two options having the potential to deliver bathing-quality water. Whilst traditionally UV disinfection is used for coastal bathing waters, we propose to use **ozone treatment** for our pilots, for the following reasons:

- Ozone will remove a number of pharmaceutical residues – an emerging issue of concern.
- Some hazardous substances monitored under the Chemical Investigations Programme can also be degraded by ozone.
- Ozone disinfection greatly reduces or eliminates the transmission of antimicrobial resistant (AMR) organisms into the environment – another emerging issue of concern.
- OPEX costs (and operational carbon emissions) should be lower, especially manpower and energy.

Pharmaceutical residues in sewage effluent

As described, one of the reasons why we have proposed ozone disinfection rather than UV is its ability to remove pharmaceutical residues from sewage effluent. In the box below, we set out the reasons why we consider it likely that there will be forthcoming regulatory requirements to address the emerging issue of pharmaceuticals in the environment.

Pharmaceuticals in wastewater: an emerging risk

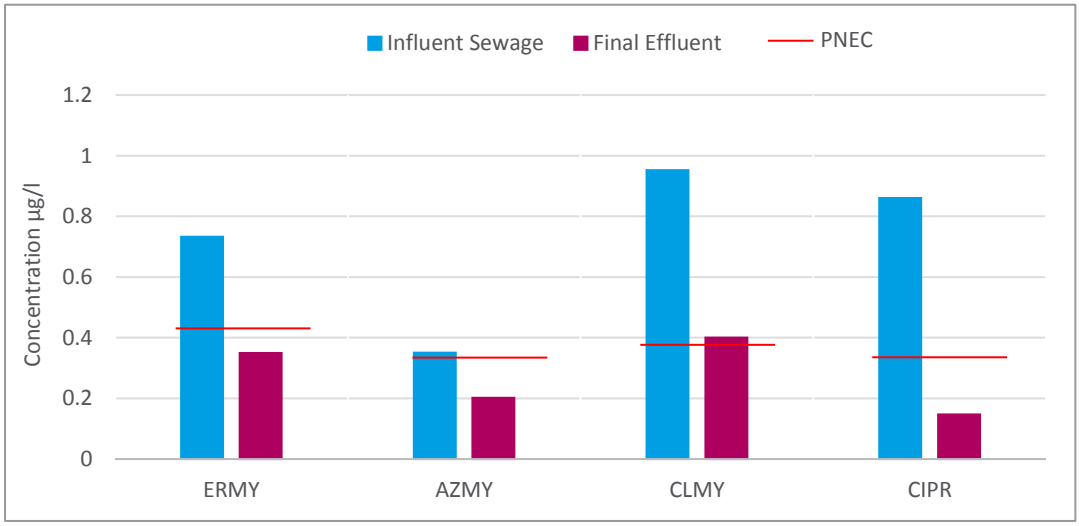
- Article 8c of the EU Environmental Quality Standards Directive (EQSD) requires the EU Commission to develop a strategic approach to address pollution of water by pharmaceutical substances.
- The EU is consulting on changes to the Urban Wastewater Treatment Directive to include a provision on pharmaceutical removal (along similar lines to measures adopted in Switzerland in 2015).
- A number of pharmaceuticals (including several antibiotics) have recently been added to the EQSD 'watchlist'. This means that formal evaluation is underway to determine whether to set EU-wide river quality standards under the Water Framework Directive.
- In the UK, there is an All-Party Parliamentary Group looking into the issue, along with a multi-stakeholder Pharmaceuticals in the Environment group looking into future policy options.
- We strongly believe that, should the EU change their standards in this area, the UK would follow. The UK government has committed to at least maintaining environmental standards post-Brexit. This principle is enshrined in the Environment Bill and will be overseen by a new Office for Environmental Protection. We expect higher standards for rivers in the longer-term, not lower.
- We consider early intervention in this area is a longer term "no regrets" investment, although it is unlikely we would be compelled to do it before AMP9, due to the environmental benefit delivered.

There is particular concern about antibiotic residues in the UK's rivers, as this may contribute to antibiotic resistance. Consequently, we believe **that it is essential that any 'end-of-pipe' control measures implemented to address pharmaceuticals must also be compatible with strategies to control the spread of antibiotic bacteria** (which are also present in sewage effluent).

Research carried out as part of the AMP6 Chemical Investigations Programme 2 (CIP2) showed that whilst conventional sewage works with tertiary treatment can remove some pharmaceuticals, the percentage removals achieved fall short of what is likely to be needed to meet PNEC (probable no effect concentrations) in receiving rivers. The chart below shows the removal rates for four antibiotics

(Erythromycin (ERMY), Azithromycin (AZMY), Clarithromycin (CLMY) and Ciprofloxacin (CIPR)), all of which are now on the EQSD 'watchlist'. The implication of this work is that sewage works with dilution in the receiving river of < 3:1 are at risk of adversely affecting the environment. For reference, dilution at Coventry sewage works under average river flows is < 1:1 and many of our largest works fall below the 3:1 mark.

Figure: Median influent and effluent concentrations and the Perceived No Effects Concentration (PNEC)



Technical outcomes of our pilot proposals

There are several thousand pharmaceutical compounds in current use, and it would clearly be impractical to monitor sewage works removal rates for all of them. Instead, we propose to follow the approach adopted in Switzerland of selecting a much smaller number to serve as indicators of overall removal. A final decision on which substances to monitor is still to be made but it will be based upon a combination of environmental risk (e.g. the EQSD 'watchlist') and common usage (e.g. Diclofenac and Ibuprofen). **Our objective will be to increase the average sewage works removal rate for these substances to over 80%**, in line with the target in Switzerland. The information gleaned will then be used to further inform UK policy with regards to the potential cost and effectiveness of 'end-of-pipe' measures for pharmaceutical control.

Comparing costs for ozone vs. UV disinfection

For disinfection at large sewage treatment works, there are essentially three disinfectants that could be deployed. The technology that is conventionally deployed in the UK is UV, which achieves a 1.5- to 2-log reduction in harmful bacteria at the intensity generally deployed. Whilst this is the norm for sewage disinfection in the UK (mainly for coastal regions), **we have costed our project using ozone, primarily for the co-benefit of pharmaceutical removal**. We also believe that ozone is likely to be more effective at reducing levels of harmful viruses such as Norovirus.

Whilst we do have a cost curve for UV disinfection, this is for clean water applications in locations where the initial coliform loads are likely to be an order of magnitude or two lower. The cost curve range is also for units an order of magnitude lower than those needed at our larger sewage works. Taking into consideration the need for a more units to treat for a higher load, a top-level estimate for Coventry sewage treatment works indicates that UV could be around 10% cheaper than ozone (noting that both estimates have a high degree of uncertainty).

As part of our detailed feasibility work, we will consider UV as an alternative and consider what the cost for alternative treatments for the pharmaceuticals issue would be, if UV were adopted for disinfection.

2.2 Improving storm overflow performance

There are four basic options for improving storm overflow performance:

- Increase storage provision.
- Increase capacity of the downstream sewer network.
- Install surface water separation.
- Disinfect storm water prior to river discharge.

To estimate costs for this business case, we used sewer hydraulic modelling to generate maximum spill volumes from the storm overflows identified. We then used these volumes to generate cost estimates in the STUCA project estimator. Whilst current bathing water standards, as applied by the Environment Agency to coastal bathing waters, allow for three spills per bathing season on average[51], we have assumed we should aim for zero (on a 1-in-1-year basis) as a worst-case cost estimate. This is because the modelled spill volumes used for the initial costing exercise do not fully cover the projected impacts from climate change and urban creep. We acknowledge that additional sewer and river quality modelling work will be required to refine and optimise our package of interventions.

We have priced the business case using cost estimates for either **increasing sewer network capacity or providing additional storm water storage.** This is partly because pricing of these interventions can be done using our STUCA cost models, and partly due to the fact that there is limited application of alternative interventions upon which to base robust costs. However, we are aware of alternatives that may be viable for at least some of the sites identified and these will be fully considered as part of detailed feasibility work:

1) UV disinfection

We are aware of around a dozen installations (mainly sewage works storm tanks) in the UK where UV has been installed. Whether or not this is suitable for our sites will be dependent upon the quality of the effluent coming off the storm tanks – the higher the turbidity, the more UV lamps will be needed to deliver an effective dose. Also, we understand that the typical log reduction achieved through UV is between 1.5 and 2. This is at the lower end of the range that we have calculated would be needed given the lower dilution available in rivers.

Based on four data points (for existing installations sized to disinfect > 1000l/s), the approximate cost to treat our largest spill volumes (at Coventry STW) would be approximately [redacted], with a range of [redacted]. Subject to the caveats above, this would compare favourably with the option to increase storage provision.

[51] Storm overflows that discharge directly into or impact on bathing waters with a target of good or sufficient status, must have no more than 3 significant spills per bathing season on average. The bathing season is from May to September (https://www.gov.uk/government/publications/water-companies-environmental-permits-for-storm-overflows-and-emergency-overflows/water-companies-environmental-permits-for-storm-overflows-and-emergency-overflows)

2) Filtration followed by UV disinfection

We are aware of a small number of installations in America where filtration followed by UV disinfection has been used to treat storm overflow spills. Our Innovation team is in the early stages of assessing a compressible filter media process, marketed by Westech, which may well be suitable for this type of application. Solids removal coupled with UV is likely to offer a log reduction of around 3, which is likely to be sufficient to deliver the required outcome in the River Avon.

We have a very provisional estimate for what it would cost to install this type of technology at Coventry STW. When added to the central estimate for UV disinfection above, the overall cost would be very similar to the storage option. OPEX is likely to be somewhat higher, but the carbon impact may well be lower, as the storage option involves building large concrete tanks with high embodied carbon.

3) Surface water separation within the network

As an alternative to storage or treatment, removal of surface water at source is likely to have the lowest carbon footprint, and is also the most sustainable in terms of resilience to climate change, improved biodiversity, and health and wellbeing benefits. However, it is very unlikely that sufficient separation (using the measures proposed in our Flooding Resilience business case) could be delivered to eliminate the need for some additional storage or treatment. Costing surface water separation will require very detailed feasibility work to identify the volumes of surface water that it would be possible to remove. Unless there are areas where surface water systems have been connected into combined sewers, this option could be difficult and disruptive to implement as it would entail surface water separation at the individual property level.

For the larger storm overflow discharge issues at sewage works and terminal pumping stations, **it is likely that the optimal solution that comes out of the detailed feasibility work will be a blend of storage, treatment and source control**. It is less likely that treatment will form part of the mix for storm overflows within the network. This is because most of the overflows of concern are within densely populated urban areas without the space to build, operate and maintain such assets.

2.3 Enhancing catchment management

Agricultural pollution can have a significant impact on the watercourse, and its essential that we tackle this issue to deliver the desired bathing standards in our rivers. We have an industry-leading approach to catchment management and will be working in 44 catchments in our region by 2025. Our programme to date has been targeted at managing pesticides and other chemicals including metaldehyde, helping to protect our raw water supplies by changing agricultural practices.

Fresh manure and slurry can contain harmful bacteria, so these need to be kept away from the watercourse, through appropriate slurry storage and good manure management. Interventions that could be required to deliver bathing water quality are:

- **Grass and/or wildflower buffer strips next to the river,** to provide a grassy buffer so that soil, runoff, pesticides and fertiliser cannot pollute the water.
- **Watercourse fencing** to keep livestock out of watercourses and off banks adjacent to watercourses, thus avoiding bank erosion and contamination of water with soil and faeces.
- **Managing manure heaps** to keep field muck heaps well away from slopes, watercourses and field drains.

We have included some photos of catchment management initiatives below.

Figure: Examples of our catchment interventions (from left to right, top to bottom a constructed wetland, a concreted livestock handling area, post and wire fencing and a permanent electric fence)




2.4 Working in partnership to maximise the societal benefits

Our research with customers has given some valuable insight into how they expect us to ensure the riverside is taken care of. This highlights that **community engagement will be vital to the successful delivery of the project**. We have seen how, in Ilkley in Yorkshire, plans to designate the river as a bathing water were publicly opposed by some councillors due to fear of overcrowding in summer, littering, lack of toilet facilities and concerns over safety, despite recognising the need to end the discharge of raw sewage into the river. Likewise we understand there are council concerns about the proposed application for Warleigh Weir on the Bristol Avon. Despite these concerns, the stretch of the River Wharfe will be added to the list of designated bathing sites from 2021, highlighting the need to work in partnership with communities to deliver a solution which mitigates local concerns.

In the following table, we show the feedback customers have given us in our co-design research, and how we plan to address this as we deliver our pilots. In Section 3 we discuss more on the local engagement we have carried out for each pilot.

Table: Feedback from customers and how we will respond

What customers told us in our research	How we will respond through our scheme design
The majority of customers told us that they have concerns about the river water quality, both specifically across the region, and in the pilot areas. They do not currently regard it as safe to swim in. Storm overflows in particular make them uncomfortable about using the river.	Our scheme will improve the river water to bathing quality standards, with resolves customers' main concern about using the water for recreational purposes.
River users want to be able to access reliable data about the river water quality that is easy and intuitive.	We will design an app (or similar) to provide appropriate real-time information on sewer overflows and river water quality, so people can make informed decisions about using the river. We will learn from information services provided for coastal areas and in other European countries, discussed in Section 2.5.
Experienced swimmers are aware of river levels and currents, but non-swimmers might be less aware.	We will consider how to link our real-time information to the Environment Agency's river flow data so that flow and quality data are provided in one place.
They are concerned about people littering and antisocial behaviour.	We will work with local councils to ensure adequate bins are provided and consider how we can continue to use our community volunteering to support riverside care.
There is a need for education about the river being a shared resource.	We are considering how we can work with the Rivers Trust and use a citizen science approach to get customers involved – further details are provided in this section.
Wildlife based signage could help build up knowledge on the natural world.	We will work with the local authorities and other partners on relevant signage for each area, including highlighting any particular local features such as the salmon in the River Teme.
Some customers are concerned about the need for access infrastructure and lifesaving equipment and would like to know who will provide this.	We will work with the local authorities to ensure appropriate access and life rings are in place, including ensuring access does not damage the natural environment.
Customers questioned why we would not apply for bathing water designation and wanted to see local authorities on board with the proposals.	We are engaging with local authorities on our proposals. Feedback so far from the local councils has been positive and in the case of Stratford there are promising synergies with their current regeneration plans. We will support any applications for designation, and also ensure that information on river quality is available from our monitoring so we can show public accountability.
They find it hard to estimate timescales for the project but in general support the benefits as soon as possible.	In order to deliver the benefits as soon as possible, and to deliver jobs in the short and medium term, we are proposing this as a Green Recovery project rather than waiting for PR24.
They are keen to get involved, for example through volunteering and pro-environmental behaviours.	We will work with local partners such as the Rivers Trust to use a citizen science approach for example for the river sampling, and we will look at volunteering opportunities for riverside care (e.g. litter picking). We will also continue to disseminate our messaging on how customer behaviour influences the environment.

Partnership with The Rivers Trust

We have been engaging with The Rivers Trust to understand how we can leverage partnerships to deliver our objectives. The Rivers Trust has welcomed the opportunity to support our proposal, and we have identified the following ways in which we can work together.

Empowering local communities

We have the opportunity to work with local Catchment Based Approach (CaBA) partners to mobilise communities local to our proposals through citizen science projects (such as the Outfall Safari), training local volunteers to collect water quality sample, identify misconnections, report on pollutions and be our 'eyes on the ground' to increase the chances of spotting pollution and other issues. Our

customers have told us they are keen to be further involved, and we have seen success in citizen science involvement in the campaigns for improved river quality for the River Wharfe, the Bristol Avon and Oxford Thames.

Beyond the benefits of data gathering, the citizen science approach will deliver valuable social impact[52] through:

- **Health and wellbeing benefits by connecting people to nature**, providing opportunities for green/blue prescribing and reaching out to deprived and BAME (Black, Asian and Minority Ethnic) communities, especially those most affected by the pandemic.
- **Social opportunities to overcome isolation**, an important part for post-pandemic physical and mental health recovery.
- **STEM training, education, skills development and job prospects** through exposure to science and technology, data analytics and social engagement, which can promote the economic recovery – particularly for younger people and those who are unemployed.
- **Fostering customer behaviour change** at a local and regional scale by increasing awareness and engagement with environmental issues.

Information sharing

We will work together to create a two-way data- and evidence-sharing approach which allows all stakeholders to understand what essential information is needed to build the bigger picture around water quality and the state of local rivers. This in turn will enable better and more informed decision-making, driving long-term change, supporting regulatory data, increasing awareness, building public appreciation, changing behaviours and transforming healthy rivers and catchments for communities.

Joint communications

We will run a join public awareness and communications campaign, providing a consistent, positive and credible narrative. This addresses the relevant issues that require greater social awareness and collaboration. This will include a strong element of citizen science and local shared ownership of solutions with local communities, schools and customers. As seen in the research by Natural England, higher levels of engagement and awareness are generally accompanied by more pro-environment behaviours (e.g. flushing habits)[53].

2.5 Providing real-time information on water quality

One of the things customers are asking for is real-time information on when storm overflows are operating, so they can make informed decisions about using the rivers. This would represent a step change in the information we provide – moving from infrequent and largely superficial monitoring to real time, open and extensive public data reporting. In designing how we provide this data we will build on the expertise developed in building our award winning metaldehyde prediction tool for abstraction management[54].

[52] Understanding Citizen Science and Environmental Monitoring. Final report on behalf of the UK Environmental Observation Framework by Roy, H.E., Pocock, M.J.O, Preston, C.D., Roy, D.B. and Savage, J.. NERC Centre for Ecology and Hydrology. November 2012

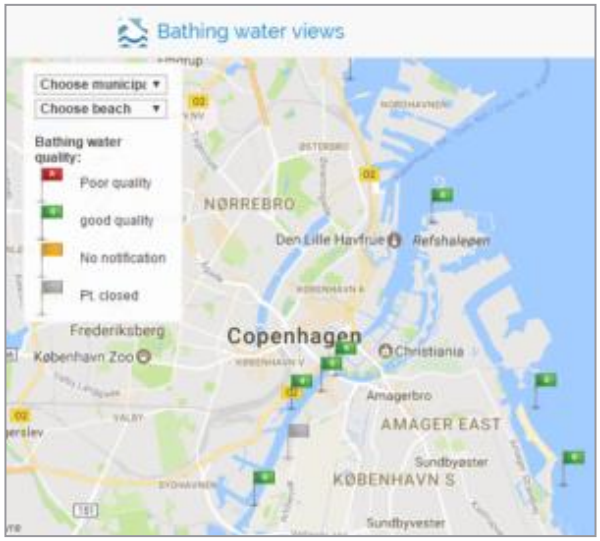
[53] Monitor of Engagement with the Natural Environment. A summary report on nature connectedness among adults and children in England. March 2020.

[54] Smart Systems and Digital Water Economy Gold award at the IWA World Water Congress in Tokyo in 2018.

Some water companies with bathing sites are providing alert notices on storm overflows in real time, raising customer expectations that this information should be available to them. In fact, we have a duty to make this information available on request, and we **expect increasing pressure for this information in the future**.

Moving from infrequent, largely superficial monitoring of water quality to real-time, open and extensive data reporting will not only deliver what customers want, but **will also help us [and other agencies] to target improvements where they are needed most**.

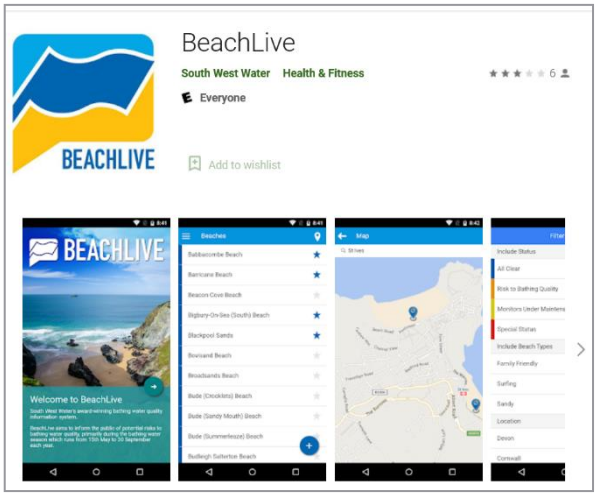
Case studies: Real-time water quality monitoring



Real-time information on water quality is being provided effectively in other European countries. For example, Copenhagen has a **state-of-the-art app** making real time information on the bathing water quality easily available to the public. The daily bathing water forecast tracks every spill from the sewers and simulates the spread and decay of polluting bacteria, based on an extensive computer model that uses information on overflows, currents and water flows.

In the UK, the award-winning **Safer Seas Service** is a national real-time water quality service that protects all water users from pollution. Running at over 370 beaches across England, Scotland and Wales, the service alerts water users when sewer overflows discharge untreated human sewage into the sea based on real-time sewage alerts provided by the water companies. The app includes daily pollution risk forecasts by the environmental regulators. It is also possible to submit a health report if you have fallen ill after entering the sea, to help water quality campaigning.

South West Water was the first water company to develop a real-time stormwater overflow alert service. They operate a system called **BeachLive** as part of the BeachWise partnership which promotes the safe enjoyment of the South West's beaches and clean bathing waters. BeachWise is supported by Cornwall Council, the Environment Agency, Keep Britain Tidy, Marine Conservation Society, RNLI, South West Coast Path Association, South West Water, Surf Life Saving Great Britain and Visit Cornwall. It brings together beach safety advice and useful information from all the organisations involved.



Since 2011, BeachLive has offered live information on the potential risks to bathing water quality caused by overflows in the sewage network. There are now 61 live feeds, growing from 16 in 2011. The information and warnings come from South West Water's monitors, and therefore do not measure other sources of pollution such as dog fouling, agricultural pollution, runoff from roads and

discharges from private sewers. The alerts are sent to beach managers, the Environment Agency and Surfers Against Sewage. An alert is triggered when an overflow event occurs which could significantly affect bathing water quality, based on the Environment Agency's assessments of significant flow (this can differ at each bathing water). The alert is withdrawn when there have been no further significant overflows at the bathing water for 12 hours.

BeachLive runs beyond the official 'bathing season', and in 2020 it was extended until 4 November to support the tourism economy. Over the winter months the service does not operate, partly due to the resource requirements relative to the number of users. The Environment Agency's Pollution Risk Forecast system also does not operate outside of the bathing season.

3. Our pilot proposals

We have selected two pilot areas, the River Avon and the River Teme, which will present different challenges and learning opportunities due to the catchment characteristics. In this section we have outlined our vision for each catchment and the interventions required, then in Section 4 we outline the detailed programme costs.

We propose two large-scale pilots to deliver bathing-quality water in the rivers Avon and Teme, at a total cost of £153m. This will include:

- [redacted] to upgrade the treatment processes by adding an ozone disinfection stage at six sewage treatment works (five on the Avon and one on the Teme). This will also tackle emerging issues such as pharmaceutical residues in water, as discussed in Section 2.
- [redacted] to significantly reduce the frequency and impact of 25 storm overflow discharges – through a combination of additional storage, sewer network reinforcement, surface water separation and disinfection of storm water prior to river discharge. This will contribute to delivering the WFD and responding to customer expectations.
- [redacted] to work with farmers to deliver catchment management interventions such as fencing, relocating livestock feeding troughs and creating wild flower buffer strips to reduce run off from 152,000 hectares of land, to reduce faecal pollution.
- [redacted] to set up a water quality monitoring system and public app to provide real time, open and extensive data about the quality of the river water and to facilitate community engagement.
- Partnering with the local community to create riverside guardians including opportunities for citizen science, increasing social cohesion, training and skills development and fostering behaviour change.
- Working alongside the £1.5m Stratford Riverside regeneration project and other local town councils to create appealing riverside destinations.

In addition to this, we will ensure our solutions have Net-zero carbon impact, through a programme of renewables and offsetting through tree planting. This will cost £8m and offset the increase in electricity costs from the additional treatment and pumping.

Our two pilots were selected based on the criteria we outlined in Section 1, and **summarised** in the table below.

Table: Reasons for selecting the pilot catchments

Criteria	Avon	Teme
Location	~ 1 million customers live in the Avon catchment, as well as the region attracting over 6 million tourists per year	The river is a SSSI and a centre of leisure activity for the town of Ludlow and surrounding area, a popular tourist destination
Suitability, safety and river access	The river has suitable access points and is safe for recreational use	
Deliverability and affordability	The interventions required build of those environmental improvements already delivered in AMP5 and AMP6, and are synergistic with future growth and capital maintenance requirements and we / our partners have good connections with the local agricultural community.	
Popularity and community support	Both these rivers have already got many popular spots for swimming and other forms of river recreation, and there is local community support for water quality improvements.	
Contribution to the levelling up agenda	Some of the most deprived areas in England are within easy distance of the river, with the opportunity to contribute to the levelling up agenda	

In additional to this:

- The River Avon presents us with synergistic opportunities with our long-term water resource needs in the region (as discussed in the water resilience Green Recovery business case).
- There are synergies with other 3rd party funded developments in the area (e.g. the £1.5m Stratford Riverside redevelopment project).

Clean healthy rivers that are safe for immersive activities will provide a greater economic, environmental and societal value than the current situation. Our investment will provide the following benefits (discussed further in Section 5):

Learning and sharing insight

Delivering bathing water quality for rivers will be a first for the UK water industry. The emerging challenges, which are outlined in Section 1.4, have not been tackled previously through a holistic catchment-based approach. There is a big opportunity to advance our knowledge for the benefit of the entire industry. Our proposals will set a new model for ensuring all parties play their part in improving river water quality. This will be done by providing a trial space for stakeholders to collaborate, under Severn Trent's leadership as catchment guardians, to ensure all river discharges meet the standard required for safe bathing.

Our proposed pilots will help us to understand, and share with the industry:

- The extent to which advanced treatment meets the emerging challenges such as antimicrobial resistance, pharmaceutical removal and microplastic pollution, and help establish success factors such as the proportion of particular pharmaceuticals that are removed through advanced treatment).
- The cost of delivering bathing rivers.
- How we best work with other partners and communities to unlock the societal benefits.
- How we can feed in to the WINEP reform process.
- How we can baseline and monitor changes in customer behaviour, environmental engagement and river use.

3.1 Urban pilot: the River Avon

Our vision is a catchment where we have tackled all the causes of adverse impact on water quality. Through a holistic programme of interventions on our assets and catchment management, we will be delivering visible improvements to water quality, led by the evolution in customer expectations.

For a total cost of £138m we will:

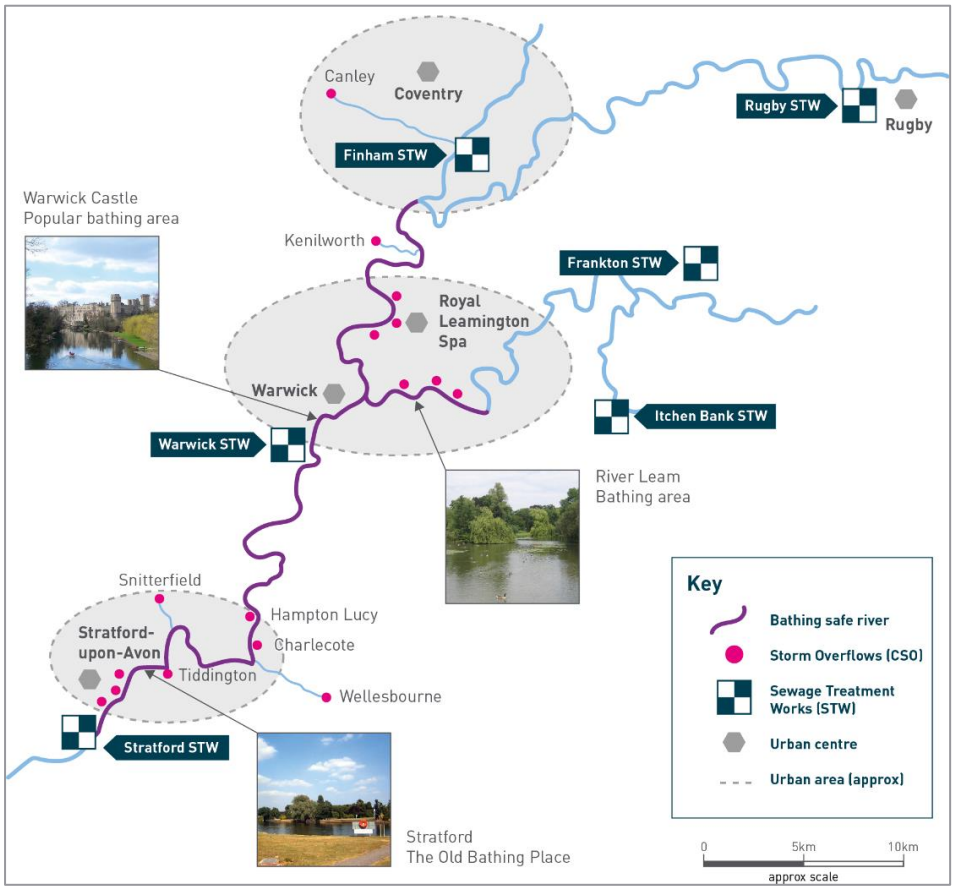
- Achieve bathing water standard water quality between Coventry and Stratford-upon-Avon.
- Deliver the WFD objective of good ecological status in this stretch of the river.
- A longer-term benefit of increased supply resilience through an additional 30 Ml/d of water resource (enhanced final effluent of a quality suitable for indirect reuse) to support Draycote reservoir[55].
- Provide new sewage treatment capacity to cater for population growth in the catchment[56].
- Remove pharmaceutical residues and some other chemicals of concern at selected STWs.
- Tackle the emerging issue of antimicrobial resistant (AMR) bacteria in sewage effluent.
- Offset the increased carbon and electricity impact by a programme of renewables and tree planting.
- Develop systems for working in partnership with other sectors to help deliver the above objectives.

The stretch of the river improved is determined primarily by geography, the catchment characteristics and the location of our sewage treatment discharges and overflows. For example, in the Avon catchment, in order to deliver bathing water quality at Stratford upon Avon, we need to tackle the assets upstream as far away as Rugby.

[55] The transfer of high quality final effluent from Finham to an expanded Draycote reservoir was not selected through our cost benefit analysis for the Green Recovery. It will however be re-considered for the Water Resources West Regional Plan 2024. Section 4 of Green Recovery Decarbonising water resources business case.

[56] See Appendix E for the allocation of costs between the growth and maintenance requirements and the proposal in this business case.

Figure: Schematic showing the river stretches improved, the location of our assets and some of the popular bathing locations



Determining the interventions required

As described in Section 2, there are five key interventions that will enable us to deliver our vision. In this section, we discuss each part of the solution for the River Avon.

Gathering data to determine which assets require improvement

In order to meet the water quality standards necessary to deliver bathing quality water, a number of sewage treatment works and storm overflows will need to be upgraded to reduce the load of harmful bacteria. We are confident that intervention on our assets will be required to meet this objective as the Avon is a low-dilution river. Measured sewage works and river flow data show that in dry weather over 50% of the flow in the River Avon just upstream of Warwick is made up of effluent from Coventry and Rugby STWs. Even assuming that there are zero E.coli inputs from any other sources, these two works alone would give a level of E.coli that is around two-thirds of the bathing water standard.

Determining exactly which assets will require improvement requires a combination of **detailed sewer hydraulic and river quality modelling**. It also requires detailed modelling work to quantify the agricultural runoff from livestock farming. The interactions between the numerous sewage works, storm overflows and diffuse pollution with the river are both complex and variable.

Our ability to undertake this detailed modelling has been severely hampered by the ongoing Covid-19 pandemic. In order to accurately model the river, we need some base data on E.coli and intestinal enterococci levels against which to calibrate any model. This information is only routinely collected by the Environment Agency at existing designated bathing water sites. This means that there is no

bacteriological quality data available for the Rivers Avon or Teme and, as there are no bathing rivers in the UK, no data from other rivers to use as a proxy. We also need to collect data from our sewage works. We have attempted to arrange some sampling work but have been unable to do so due to a lack of analysis capacity – the labs that could do this work for us are occupied with processing Covid-19 tests.

However, it has been possible to use some default values for E.coli loads to undertake mass-balance calculations and to progress some high-level modelling through our specialist modelling contractor Intertek. This work primarily focuses on **identifying which of our assets have the potential to cause an exceedance of the bathing water standards when operating in isolation**. The results of this screening exercise then underpin our cost estimating process and are described in Appendix F.

Intervention 1: Installing advanced treatment at our sewage works

In order to assess the potential impact of final effluent discharges on the River Avon, we have used typical E.coli values contained in a report published by Defra[57]. We have looked at the impact of the sewage works in both dry and wet weather. We then considered the potential impact of each works in isolation (rather than the cumulative impact). The results of this assessment are set out below.

Table: Results of our assessment showing the works which require improvement

Site Name	Flow to Full Treatment (m3/s)	Dry Weather Flow (m3/s)	Bacterial Conc. (EC/100ml)	River flow dry weather (m3/s)	River flow wet weather (m3/s)	E.coli concentration dry weather (CFU/dl)	E.coli concentration wet weather (CFU/dl)
Coventry - Finham	2.59	1.33	1174	1.05	5.32	655.59	384.35
Frankton	0.02	0.01	5000	0.29	2.58	171.14	37.32
Itchen Bank	0.08	0.03	1174	0.29	2.58	121.07	36.46
Lutterworth	0.08	0.03	1174	1.05	5.32	30.19	16.33
Rugby Newbold	0.69	0.25	1174	1.05	5.32	225.33	135.54
Warwick - Longbridge	0.73	0.42	5000	1.05	5.32	1,418.02	606.50
Weston-Under-Wetherley	0.01	0.00	5000	0.29	2.58	54.87	13.34
Wellesbourne	0.04	0.02	1174	1.05	5.32	19.79	9.16
Snitterfield	0.02	0.00	5000	1.05	5.32	18.79	17.62
Leek Wootton	0.01	0.00	5000	1.05	5.32	11.52	11.40
Bubbenhall	0.01	0.00	5000	1.05	5.32	20.04	7.61
W0lston	0.08	0.02	1174	1.05	5.32	16.80	16.78

Whilst only one sewage works (Warwick Longbridge) is currently predicted to cause an outright failure of the bathing water standard, it is important to note that the calculations above assume that dilution is into river water that is free of any E.coli contamination. We know that this will never be the case in reality; in addition to inputs from upstream sewage works, there will also be contributions of E.coli from agricultural and urban diffuse pollution. For initial costing purposes, we have assumed that any

[57] Impact of Waste Water Treatments on Removal of Noroviruses from Sewage R&D Technical Report WT0924/TR table 3.7. Note that this report did not include a figure for biofilter works with tertiary treatment, so we have assumed that tertiary solids removal delivers a similar reduction to that delivered at activated sludge plants.

sewage works that is making an E.coli contribution of >10% of the standard (1,000 CFU/dl) will require enhancement.

In total, **we have identified five sewage works where sewage effluent disinfection will be required as part of the overall package of measures**:

- **Finham STW – Effluent disinfection with ozone.** As discussed, we propose to deliver this through ozone disinfection tertiary treatment. The site is well suited for this technology, as the recently installed Co-Mag plant delivers the very high-quality effluent required for efficient ozone disinfection.
- **Warwick Longbridge – Large-scale rebuild and ozone disinfection.** We anticipated that this site would require capital investment in AMP8, as we expect a tighter P limit to deliver WFD objectives as well as significant extensions to cater for growth in the catchment. In addition, there are a number of significant impending capital maintenance requirements. To deliver the growth, maintenance and WFD requirements we were anticipating a substantial rebuild, to which ozone disinfection will be added to deliver the bathing water objective.
- **Rugby – Effluent disinfection with ozone.** We have completed a high-level assessment of travel time, dilution and natural E.coli die-off rates in rivers, and it seems probable that disinfection would be needed at Rugby STW. We have assumed a 1-2 day travel time from Rugby to the first bathing water in Warwick which is insufficient for any significant E.coli die-off to occur. We propose to deliver the disinfection through ozone.
- **Itchen Bank and Frankton STWs – Effluent disinfection with ozone.** Both of these sites are smaller than the works listed above, and discharge into the smaller River Leam. Initial calculations indicate that disinfection will be required.

Intervention 2: Improving storm overflow performance

To assess which **storm overflows** require intervention we produced storm overflow spill volumes using our calibrated sewer hydraulic models. For this initial assessment, we used the 1-in-1-year events. Whilst it is likely that a small number of spill events per year will not prevent us from achieving our desired outcome, we have used the worst-case 1-in-1-year event as an allowance for the future impact of climate change, growth and urban creep.

To calculate available dilution, we used measured river flow data collected by the Environment Agency at their flow gauging stations. Flows in both the River Avon and the River Leam vary significantly, with peak flows being 10 to 20 times higher than in times of prolonged dry weather. We have therefore looked at the potential impact of each storm overflow under average and 80%ile flow conditions to identify those that are likely to cause a problem.

The results of this mass-balance assessment are included in the table below, with further details in the Appendix F. We identified that the storm overflows in the table below have a high potential, when operating in isolation, to cause a failure of the bathing water standard. There are a few more where the potential to cause a failure looks marginal and the volumes of sewage involved are very small. We have excluded these from the list below on the grounds that any intervention will have minimal costs associated (and there is every possibility that no work will be needed).

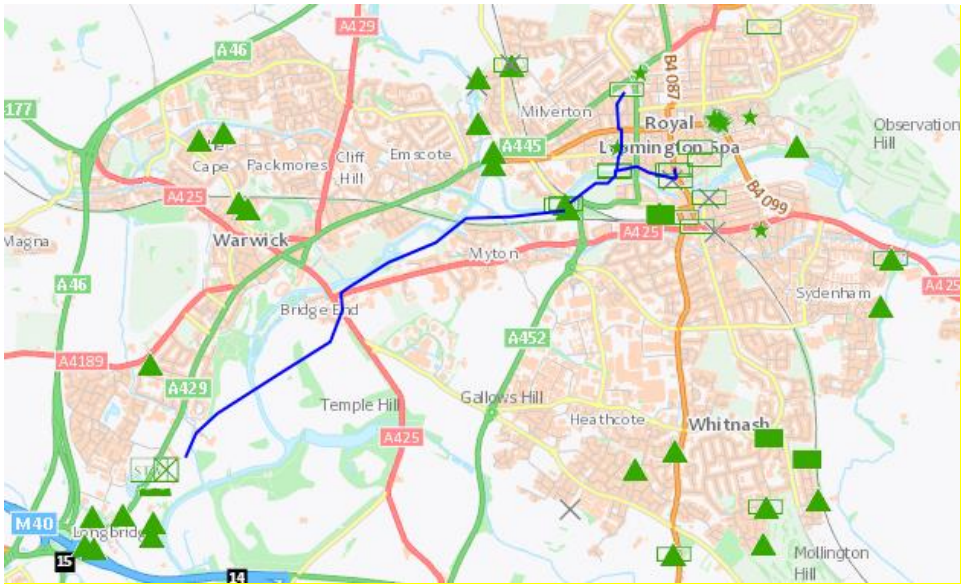
Table: Results of the mass-balance assessment showing the overflows which require improvement

River Leam	River Avon	Sewage works storm tanks
Leamington - Adelaide Rd (CSO)	Canley storm tanks	Coventry STW (Sowe)
Leamington - Parade/Regent GROVE (CSO)	Kenilworth TPS storm tanks	Coventry STW (Sherbourne)
Leamington - Princes Dr (Ref 19A) (CSO)	Stratford – Shipston Road (CSO)	Warwick STW
Leamington - Princes Dr (Ref 19B) (CSO)	Stratford – Banbury Rd/Swans Nest (CSO)	Wellesbourne STW
Leamington - Stamford Gardens (CSO)	Tiddington – Main Street (CSO)	
Leamington - Lower Avenue (CSO)	Snitterfield – Lodge Farm Drive (CSO)	
	Stratford – Paddock Lane SPS	
	Warwick – Charlecote (CSO)	
	Hampton Lucy (CSO)	

River Leam storm overflows

There are six storm overflows spread across five separate locations that have been identified as having significant spill volumes. Desktop assessment suggests that there is very limited space to build the storage volumes required. Therefore, the solution proposed is a linked programme of sewer network reinforcement to convey storm water through to Warwick Longbridge STW. It is also the case that there is already significant storage within the Leamington catchment, built in AMP5 as part of a flood alleviation programme. The existing sewer from Leamington to Warwick was built in the early 1970s to replace the Victorian vintage works that used to serve Leamington. This sewer was only designed to convey 'flow to full treatment' volumes to Warwick STW, with storm tank storage retained at Princes Drive pumping station. This imposes a significant constraint on how quickly additional storage tanks can be drained after a storm event and could result in insufficient storage volumes being available to cater for back-to-back storm events.

Figure: Intervention required for the River Leam overflows



River Avon (Coventry and Kenilworth) storm overflows

Two overflows within the Coventry catchment area have been identified as having significant spill volumes (Canley storm station and Kenilworth terminal pumping station). Both of these are ex-sewage works locations with existing sewage works-type radial flow storm tanks. The notional solution has been priced based on providing additional storage. An alternative option for Kenilworth may be to increase the flow to Finham STW.

River Avon (Stratford-upon-Avon) storm overflows

There are several small overflows where extra storage would eliminate spill events, and one large overflow at Paddock Lane terminal pumping station where storage or an increased pass forward flow will be required. Space at the site is very limited, so the option priced is for an increase in flow to Stratford Milcote STW, downstream of the proposed bathing area.

Sewage works storm tanks

Very large spill volumes are predicted at Finham because there are very few storm overflows in the upstream system. We also need to cater for a lot of storm water at Warwick Longbridge as the priced option for Leamington overflows is to convey flows to the sewage works. The assumption for Warwick is that part of the required storage will be provided by recycling the 10 existing humus tanks that will become redundant as part of the proposed works upgrade element of the project.

We are confident that the storm overflows will be an issue during the times of year when customers are most likely to want to swim and use the river. The data for 2019 and 2020 shows that in the period May – September (the bathing "season") there were a total of 155 spills with a total duration of 577 hours, across all the storm overflows in the Avon catchment locations we are considering.

Intervention 3: Enhancing catchment management

We already have catchment protection schemes in place for the Rivers Leam and Avon, upstream of Rugby, to protect the raw water feeds into Draycote and Campion Hills. This element of the scheme envisages extending the area to include parts of the Avon, from Coventry down to Stratford.

The figure below shows the agricultural part of the River Avon catchment upstream of Warwick and the catchment characteristics identified using the Rural Payment Agency Customer and Land database (CLAD) data. This is wider than our current catchment schemes, which targets the River Avon around Stanford reservoir (highlighted in purple).

Figure: Agricultural part of the River Avon catchment

- 732 farms in the Avon catchment.
- A total of 29,483ha of agricultural land.
- An average farm size of 40ha, and average field size of 3.7ha.
- Lots of arable and mixed farms, with livestock farms in the north of the catchment.

We estimate that our catchment management programme could achieve up to 1,767,961 CFU(10^9)/yr reduction, a 36% reduction from the baseline. **The top reduction methods will provide 27% of the reduction in the Avon, with the top two measures providing 18%:**

- Fence off rivers and streams from livestock
- Compost solid manure
- Reduce the length of the grazing day / season
- Capture dirty water in a dirty water source
- Use slurry injection application techniques
- Establish and maintain artificial wetlands

Our costings assume that all top FIO reducing catchment interventions are applied.

The figure below shows the Leam catchment upstream of Leamington Spa. This catchment area is the same as our existing clean water Leam catchment scheme.

Figure: Leam catchment upstream of Leamington Spa

- 362 farms in the Leam catchment.
- A total of 18,656ha of agricultural land.
- An average farm size of 45ha and an average field size of 2.5ha.
- Lots of arable and mixed farms which make FIO reduction less achievable.

We estimate that we can achieve up to 641,416 CFU(10^9)/yr reduction, a 24% reduction from the baseline. **The top reduction methods will give a 20% reduction in the Leam:**

- Fence off rivers and streams from livestock
- Construct troughs with concrete base
- Move feeders at regular intervals
- Capture dirty water in a dirty water source
- Compost solid manure
- Establish and maintain artificial wetlands
- Reduce the length of the grazing day / grazing season

There are 35 other measures which can also reduce FIO; however, their impact is minimal and would likely only deliver an additional 4% reduction.

Intervention 4: Working in partnership to maximise the societal benefits

As discussed in Section 2, delivering successful bathing rivers that delight the local community and are a source of amenity and recreation will require extensive engagement and buy-in from the local authorities. We have started this engagement with an initial focus on the city of Stratford-upon-Avon and Warwick / Leamington Spa. We have held discussions with Warwick District council on our proposals and understand some of their concerns relating to erosion of the river banks where people access the water, whether there is any effect on their legal responsibilities from sites becoming known as bathing areas, and any increase in overheads from site management. However, they were supportive of the principle of improved river water quality and we have committed to work through the concerns with their Green Spaces team.

We have also engaged with Stratford District Council. Stratford-upon-Avon is currently publicly consulting on a regeneration project (the Riverside Green Corridor), for both the riverside and town as a whole. They will be using access to green space as an enabler to trigger behavioural change, and as a key driver for early economic recovery. The map here shows where the length of river we are improving relates to the project.

The riverside project aims to get people interested in the history of the town, and celebrate, in an accessible way, the unique heritage of Shakespeare's birthplace. Initial funding of £1.5m was secured from the Coventry and Warwickshire Local Enterprise in October 2020[58].

Our proposal has strong synergy with this project. Their aim of creating a world class riverside destination, encouraging people to visit and linger for longer, thus helping the local economy, and giving people a fun and exciting reason to visit the town chimes perfectly with our aspiration of having one of the first bathing quality rivers in the UK.

In more detail, the Stratford Riverside project aims to:

- Revitalise the river frontage and create new high quality public realm.
- Open new routes into town.
- Reduce congestion and improve air quality.
- Ensure the town maximises its potential in delivering post-Covid-19 economic recovery.

Some of the issues identified for the Riverside North area, where our proposed swimming area is located, are:

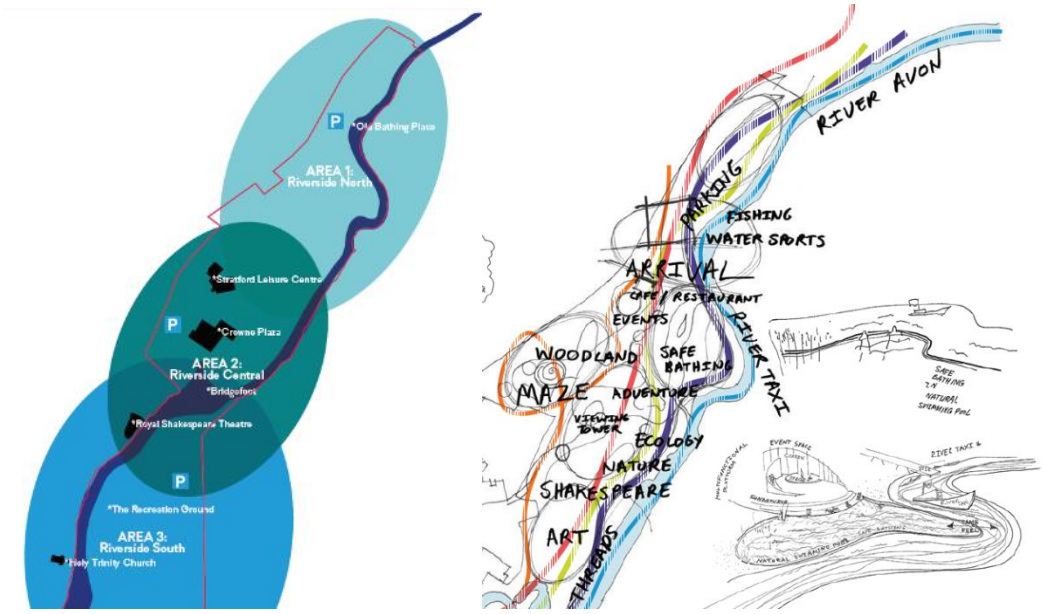
- The Fisherman's Car Park (close to the Old Bathing Place) is not well signposted and is too small for current demand.
- There are potential conflicts with different users: swimmers, fishermen and water sports.
- There is a lack of toilet facilities and places to eat.

[58] https://www.stratfordriverside.com/

- There is a lack of signage and interpretation.

These issues resonate with the feedback we heard in our co-design research. Our customers highlighted concerns about littering, access to the water and the need for signage on safety, especially if there is an increase in people using the river.

Figure: Proposed improvements being considered by the Stratford Riverside project



The opportunities the Stratford riverside regeneration project is considering include the following for the river stretch north of the city centre:

- Create a safe bathing area, including ensuring that conflict between different users is minimised using designated zones. This will have an artificial river beach with a shallow area for children and a deeper area for swimming.
- A new 500-space car park to intercept traffic along Warwick Road.
- Providing a new café / restaurant / information point.
- Creating wider footpaths and circular routes for walking, running and cycling, and a country park with a range of facilities and activities for all.

The costs of these would be covered from the funding they have from the LEP (not our proposal). Feedback from the initial consultation with the Stratford Town Trust suggested that an expanded safe river bathing area would be an asset. The need for supporting facilities including a visitors' centre, toilets and changing facilities was identified. We have been engaging with the Deputy CEO of Stratford-upon-Avon District Council about our proposals, and exploring how we can work together.

Intervention 5: Providing real-time information on water quality

As part of both pilots, we intend to explore how to provide customers with real-time information on water quality that helps them make an informed decision about whether to use the water. See Section 2 for further details.

No regrets investment (River Avon)

For the River Avon pilot we have assessed which asset interventions represent "no regrets options", based on our current knowledge, and which deliver environmental benefits that either respond to customer expectations or future legislation. We estimate that of the £138m that constitutes the Avon scheme up to £42m is shorter term "no regrets" investment.

Table: Analysis of the investment drivers for the components of the Avon pilot to identify no regrets investment

Intervention	Investment drivers				
	WFD (AMP8)	UWWTD / SOAF	Base maintenance and growth	Customer expectations	Future legislation
Storm overflows	✓	✓		✓	✓
Sewage works (final effluent disinfection)				✓	✓
Sewage works (Warwick rebuild)			✓		
Catchment management	✓				

Storm overflows

In the Avon catchment area there are 3 waterbodies where the Environment Agency list intermittent sewage discharges as being a cause of WFD failure. These are:

- River Sowe – confluence Withy Brook to confluence River Avon;
- River Leam – confluence River Itchen to confluence River Avon; and
- River Avon – confluence River Leam to Tramway Bridge in Stratford.

Two of these are within the proposed bathing river and the third (the River Sowe, immediately downstream of Coventry STW is just upstream, and therefore will impact the proposed bathing river). The EA dataset isn't specific as to which overflows are responsible for the WFD failure, but it will be at least some of those that need improving to meet bathing quality standards.

In addition, EDM data and/or sewer model spill frequency data has identified that a number of the overflows covered by this business case will have a spill frequency high enough to trigger a SOAF investigation and (if cost beneficial) intervention will be required to reduce spills.

We estimate that of the [redacted] being invested on the storm overflows [redacted] represents "no regrets" investment (or investment we have a reasonable degree of certainty would have to be undertaken in AMP8) to address WFD failure and help deliver the government's 25 year environment plan objectives. Whilst we have noted the EA's dataset doesn't identify the specific overflows that are responsible for WFD failure, in all probability it will be those with the highest spill volumes and frequencies, namely Leamington Princes Drive pumping station overflow, the two Finham STW storm tank discharges and Warwick STW storm tanks. This does not preclude the possibility that some of the other overflows will also need improvement.

Sewage works

As discussed in Section 1, the provision of ozone disinfection is a much longer term no regrets investment as well as being required to respond to changing customer expectations in terms of how they want to interact with their local watercourses.

In terms of the investment at Warwick Longbridge STW [redacted], about £5.8m would have been investment either in AMP8 (or through the Accelerated WINEP Green Recovery business case) on WFD quality improvements. In addition to this we anticipate growth and capital maintenance investment at Warwick Longbridge in AMP8. These costs are not included in this Green Recovery proposal (i.e. not included in the [redacted] above), although the work will be delivered as a holistic rebuild project. Appendix E demonstrates how we have allocated the costs between this proposal and the growth and capital maintenance requirements that we anticipate in AMP8.

Catchment management

We have classed the catchment management work proposed for the Avon and Leam catchments [redacted] as no regrets investment. We know that both Stanford and Draycote reservoirs fail to meet WFD standards for total phosphate due to the levels present in these rivers at the associated abstraction points. The catchment management interventions proposed for meeting bathing water standards will also reduce diffuse agricultural phosphate pollution. We have AMP7 WINEP investigation obligations to determine the extent to which our wastewater activities contribute to these phosphate failures and also identify what mitigating interventions will be required. We expect these AMP7 investigations to recommend WINEP improvement obligations in AMP8, the need for which could be offset by the bathing rivers catchment work – in effect, a catchment nutrient balancing solution in place of point source sewage works upgrades. Notwithstanding the reservoir nutrient issue, we also regard measures that help to safeguard raw water quality for a two key water treatment works (Draycote and Campion Hills) as being no regrets investment.

3.2 Rural pilot: the River Teme

Our vision for the River Teme is a catchment where we have tackled all the causes of adverse impact on water quality through a holistic programme of interventions on our assets and catchment management, thus delivering visible improvements to water quality, led by the change in customer expectations.

For a total cost of £14m we will:

- Achieve bathing water standard water quality between Leintwardine and Tenbury Wells.
- Deliver the WFD objective of good ecological status in this stretch of the river.
- Remove pharmaceutical residues and some other chemicals of concern at Ludlow STW.
- Tackle the emerging issue of antimicrobial resistant (AMR) bacteria in sewage effluent.
- Offset the increased carbon and electricity impact by a programme of renewables and tree planting.
- Develop systems for working in partnership with other sectors to help deliver the above objectives.

The stretch of the river improved, as shown in the Figure below, is determined primarily by the geography, the catchment characteristics and the location of our STW discharges and overflows. The Teme is a rural catchment with relatively few impacts from Severn Trent assets. This means that by

tackling the sources of agricultural pollution and the wastewater assets in Ludlow we will improve the river as far down as Tenbury Wells, providing up to 32 km of improved river for customers to enjoy, upstream and downstream of Ludlow. We have highlighted one of the many current popular bathing locations on the map.

Figure: Schematic diagram of the river length to be improved on the Teme and indicative locations of our assets

Determining the interventions required

As described in Section 2, there are five key interventions that will enable us to deliver bathing water standards. In this section, we discuss each part of the solution for the River Teme.

We have undertaken a modelling exercise to identify which assets have the potential to impact upon bathing water quality. Our calculations are not quite as accurate as those for the Avon, because the only measured river flow data available for the Teme is from a gauging station some distance downstream of Ludlow. This means that the actual impacts are likely to be slightly greater than the calculations show, as river flows in Ludlow will be slightly lower.

Table: Analysis to identify that Ludlow STW requires improvement to deliver bathing rivers

Site name	Sewage works data				River flows		E. coli concentrations CFU/dl	
	Discharge type	Flow to full treatment (m^3/s)	Dry weather flow (m^3/s)	Bacterial conc. (EC/100ml)	River flow dry weather	River flow wet weather	Dry weather	Wet weather
Ludlow (STW)	Fully treated effluent	0.12	0.05	5000	1.99	21.10	128	28

For two of the storm overflows in Ludlow that spill into the River Corve, we have been able to use river flow data from a nearby gauging station. Further details are given in Appendix F.

Intervention 1: Installing advanced treatment at our sewage works

Our modelling exercise has only identified one sewage works (Ludlow STW) that is likely to be discharging a meaningful level of harmful bacteria. We intend to provide ozone disinfection at Ludlow STW to deliver the improved effluent standards required.

Intervention 2: Improving storm overflow performance

We have identified five storm overflows that, when operating in isolation, appear capable of causing a breach of the required standard. One other overflow is close to this level and hence problematic if there are significant background levels of E.coli from upstream sources (or if any other overflow is operating). We have therefore based our package of interventions on spill reduction measures at all six. Detailed feasibility work (including a full assessment on what can be delivered through diffuse pollution control), may enable some scaling back on these measures. However, we expect that spill frequencies will need to be kept to a low level to satisfy customer expectations. We have analysed the spill data and are confident the overflows spill at times of the year when most customers want to enjoy the water. The data for 2019 and 2020 shows that in the period May – September (the bathing "season") there were a total of 77 spill events in the Teme pilot area, for a duration of 276 hours.

Table: Spill events and duration for the overflows in our pilot during summer months

Catchment	Number of spill events	Duration of spill events
Teme	77	276

We have also analysed whether investment is required at any of the upstream assets but expect this to be minimal as the two most significant works already have tertiary treatment so the bacterial loads should be low.

Intervention 3: Enhancing catchment management

In addition to these interventions we will require a significant programme of catchment management to deal with the extensive diffuse pollution, especially as this is a very rural catchment. This farmer engagement work will build upon measures already taken as part of our drinking water source protection activities. We plan to continue to work in partnership with the Severn Rivers Trust to deliver this.

The figure below shows the Teme catchment upstream of Ludlow. This area is not part of our current catchment scheme, which targets the region highlighted in purple downstream of Ludlow.

Figure: Teme catchment upstream of Ludlow

- 1452 farms in the catchment.
- A total of 104,165ha of agricultural land.
- An average farm size of 72ha and an average field size of 3.7ha.
- Mainly livestock farms.

We believe we can achieve up to 2,483,974 CFU(10^9)/yr reduction, a 42% reduction from the baseline. **The top reduction methods will give 35% reduction alone in the Teme:**

- Fence off rivers and streams from livestock
- Construct troughs with concrete bases
- Move feeders at regular intervals
- Capture dirty water in a dirty water source
- Establish and maintain artificial wetlands
- Reduce the length of the grazing day / grazing season

There are 35 other measures which can also reduce FIO; however, their impact is minimal and would only deliver an additional 7% reduction. Our catchment management costs assume all top reduction methods will be delivered.

Intervention 4: Working in partnership to create riverside guardians

As discussed in Section 2, delivering successful bathing rivers that delight the local community and are a source of amenity and recreation will require extensive engagement and buy-in for the local authorities. We have started this engagement with the Town Council, who have expressed initial positive feedback on our plans and provided helpful insight about where people tend to access the river currently. We have also engaged widely with the local MP, Philip Dunne, who is also a landowner and farmer in the region. As well as supporting our plans, he is happy to take an active role in coordinating a launch event with local stakeholders and landowners, and has helped us identify a long list of organisations to engage with to deliver the proposals.

Intervention 5: Providing real-time information on water quality

As part of the Teme pilot, we intend to explore how to provide customers with real-time information on water quality that helps them make an informed decision about whether to use the water. See Section 2 for further details.

No regrets investment (River Teme)

As per the Avon, we have assessed the drivers of the £14m investment for the Teme pilot, as highlighted in the Table below. We estimate that up to £1.6m is shorter term "no regrets" investment.

Table: Analysis of the investment drivers for the components of the Teme pilot to identify no regrets investment

Intervention	Investment drivers				
	WFD (AMP8)	UWWTD / SOAF	Base maintenance and growth	Customer expectations	Future legislation
Storm overflows		✓		✓	✓
Sewage works (final effluent disinfection)				✓	✓

Of the 6 storm overflows on the Teme where we are proposing interventions there are at least 2 which meet the SOAF criteria for investigation of high spilling overflows – the storm tank discharge at Ludlow

sewage treatment works and the overflow at Temeside pumping station. If SOAF assessments deem that spill reductions are cost beneficial, we estimate that this would require around [redacted] of investment.

In addition to this the river is a SSSI that is currently failing to meet conservation standards, therefore we believe that any intervention on the other storm overflows that discharge into this sensitive water course will have a positive environmental benefit.

The investment at the sewage works is purely to respond to future legislation and customer expectations of rivers they can safely use for recreation including swimming. As discussed, we feel this is a no regrets investment in the much longer term, even though there is uncertainty about future legislative requirements.

3.3 A Net-zero carbon proposal

Our bathing river proposals have a carbon impact, which we will need to mitigate to deliver our net-zero carbon emissions pledge by 2030.

The project involves building large pipelines and storage for storm water, and process extensions at our sewage treatment works. There is therefore a significant **embodied carbon footprint**. The need to move and treat large volumes of wastewater to tighter standards means there is also a large **operational carbon footprint**. The biggest carbon mitigation opportunities lie with the work at Finham and Longbridge sewage treatment works, as these sites are the biggest contributors to the carbon impact.

To deliver a Net-zero proposal we have included mitigation activities in the form of renewables and tree planting. The electricity generated from the renewables offsets the increase in opex from the additional treatment and pumping.

Table: Interventions required to deliver a net-zero carbon proposal

[redacted]

Further details of our approach to mitigating the carbon impact of this project are outlined in the Net-zero carbon Annex A06.

4. Robustness and efficiency of costs

In this section we discuss how our costs for the River Avon and Teme pilots are both are efficient and have been robustly derived. We also discuss the delivery profile for our proposals.

This section is supported by Annex A09 (Cost Robustness and Efficiency), in which we describe the basis of our cost estimates and how our business continually seeks efficient costs through embedded business as usual activities, and how these activities and lessons have shaped the Green Recovery proposals.

Confirming and therefore costing the optimum suite of interventions to deliver bathing water quality will require river sampling, detailed design and feasibility work and on the ground engagement with stakeholders and partners. This critical activity will form the first phase of our programme of work. Consequently, costs will be reviewed and challenged through the duration of the pilot as design and feasibility evolves.

To cost our pilots for the Rivers Avon and Teme we have largely used the same process we used at PR19. The full methodology and examples were presented in chapter 8 of our PR19 plan. In addition to this we have used specialist consultants Turner and Townsend and Arup to review our approach.

The Arup review focused on the following asset groups:

1. Ozone disinfection plant for sewage effluent
2. Storm water tank (for sewage works and within the network)
3. Large diameter sewers.

Arup have noted that "Overall, we are of the view that for the purpose of business planning forecasting, ST's approach is reasonable and consistent with their standard methodology". They did note that our initial estimate for ozone disinfection equipment was "on the low end of the benchmark range indicating that this is likely to be unjustifiably too efficient" – we have taken steps to address this concern and their report now states that our estimate is appropriate at this stage.

All costs are in 17/18 prices and we have included the company burden of [redacted].

4.1 Sewage treatment interventions

Our pilots on the Rivers Avon and Teme include the installation of disinfection treatment. We have selected ozone as the most appropriate technology, as discussed in Section 2, because it provides the most holistic solution addressing multiple challenges.

The following table shows the assets required and the costing method used.

Table: Disinfection assets and costing method

Asset	Costing methodology
Ozone M&E (ozone generator, injector, destructor for residual ozone)	Costs from the UKWIR Chemical Investigations Programme 2 (Feasibility and Pilot trials) report and benchmarking from Arup
Contact tank (Civils)	STUCA cost curve (for chlorine contact tank)

Whilst there is a higher level of uncertainty surrounding the ozone plant pricing, this only accounts for approximately 12% of the overall estimate for storm overflows and sewage works interventions.

4.2 Storm overflow improvements

As discussed in Section 3, sewer hydraulic modelling has been used to generate maximum spill volumes from the storm overflows identified and these volumes have been used to generate cost estimates in the STUCA project estimator. The costs included are a mix of storage and increasing sewer capacity to deliver zero spills per year. Arup state that they are "satisfied that the approach provides a higher degree of confidence" and that the "sizing is acceptable at this stage of the project lifecycle".

4.3 Catchment management

As discussed in Section 3, we have assessed the catchment characteristics for the Avon, Leam and Teme catchments and identified the interventions which would deliver a reduction in Faecal Indicator Organisms (FIO). The costs of catchment management for reducing faecal indicators are significantly higher than those for other pollutants (hence this programme represents an uplift compared to our current AMP7 plan). We have costed up three scenarios based on the following assumptions:

1. All top FIO-reducing catchment interventions are applied.
2. AMP6 level of uptake.
3. Only the top FIO-reducing catchment intervention is applied.

The costs also include the employment of four catchment officers to deliver the programme.

We have included the costs for the first scenario as part of this business case, assuming all the top FIO-reducing interventions are applied, because we believe this is the level that would be required to deliver safe bathing waters**. We have assumed a 50% funded programme**, in line with the approach we have successfully taken in AMP7. As part of our work we want to ensure that we have full buy in from the farmers we work with, as we find that this supports any required behavioural change and maintenance -we believe a 50% funded programme is the best enabler for this. Some of the interventions that we will be doing are the same as those we have in our AMP7 programme, and the 50% contribution is working well.

We will seek all possible opportunities of working with third parties to reduce these costs and / or deliver the interventions in the most efficient and effective way. For example, for the Teme catchment, we are talking with the Severn Rivers Trust (SRT) who are currently looking for partners to support a proposal working with landowners on works such as wetland creation, farm infrastructure improvement, soil management, water quality, woodland planting, hedgerow creation and community engagement.

We have benchmarked catchment measures cost for the River Teme against some detailed, bottom up estimates produced for us by our catchment protection partner, the SRT. They have produced farm specific proposals for approximately 25% of the farms in the upper Teme catchment, costed using the standard rates from the government's Countryside Stewardship scheme. When scaled up to cover the whole catchment area, the cost of these interventions comes to [redacted]. In addition, SRT have provided a cost for providing three of their expert catchment advisors (from September 2021 through to March 2025) to facilitate implementation of the proposed measures with farmers, which comes to[redacted]. The scaled up SRT estimate of [redacted] is comparable with the [redacted] estimate produced by our catchment protection experts, so we are confident that the allowance made in our business case accurately reflects the amount of intervention required.

We have also considered any overlap with the new Environmental Land Management (ELM) scheme, which we sit on a number of the co-design boards for. ELM is designed to help achieve the goals of the 25 Year Environment Plan and will reward farmers and other land managers for delivering public goods that improve the environment. However, it will only start to be rolled out in late 2024 (we are currently in a transition period), will take until 2030 to roll out completely and there remains uncertainty about the scheme design. We will adapt our proposals as we learn more.

4.4 Summary of costs

The following tables summarises the costs and interventions for the Avon and Teme pilots.

Table: Costs and interventions for the Avon pilot

Project element	Description	CAPEX £k	OPEX £k
Leamington storm overflows	Sewer system reinforcement	redacted	
Coventry storm overflows	Additional storm tanks at Canley and Kenilworth Dalehouse lane TPS		
Warwick storm overflows	Storm water storage at 2 storm overflows		
Stratford storm overflows	Stormwater Storage at 4 storm overflows Uprate Paddock lane TPS		
Coventry STW storm overflows	Additional storm tanks		
Wellesbourne STW storm overflow	Additional storm tanks		
Coventry STW disinfection	Ozone disinfection		
Rugby STW disinfection	Ozone disinfection		
Itchen Bank STW disinfection	Ozone disinfection		
Frankton STW disinfection	Ozone disinfection		
Warwick STW upgrade (excluding capital maintenance and growth costs)	Works rebuild, WFD Phosphate removal, additional stormwater storage, Ozone disinfection		
Contingency for Rugby STW storm overflows	Still collecting the data to model the impact and price an intervention		
Catchment management	Interventions required to deliver the reduction in FIO		
Provision of real time information and community engagement	For both pilot area we will engage to deliver a community friendly solution and provide real time information		
Carbon offsetting	Tree planting and renewables to deliver a Net-zero solution		
Capital burden			
Totals			

Figure: Costs and interventions for the Teme pilot

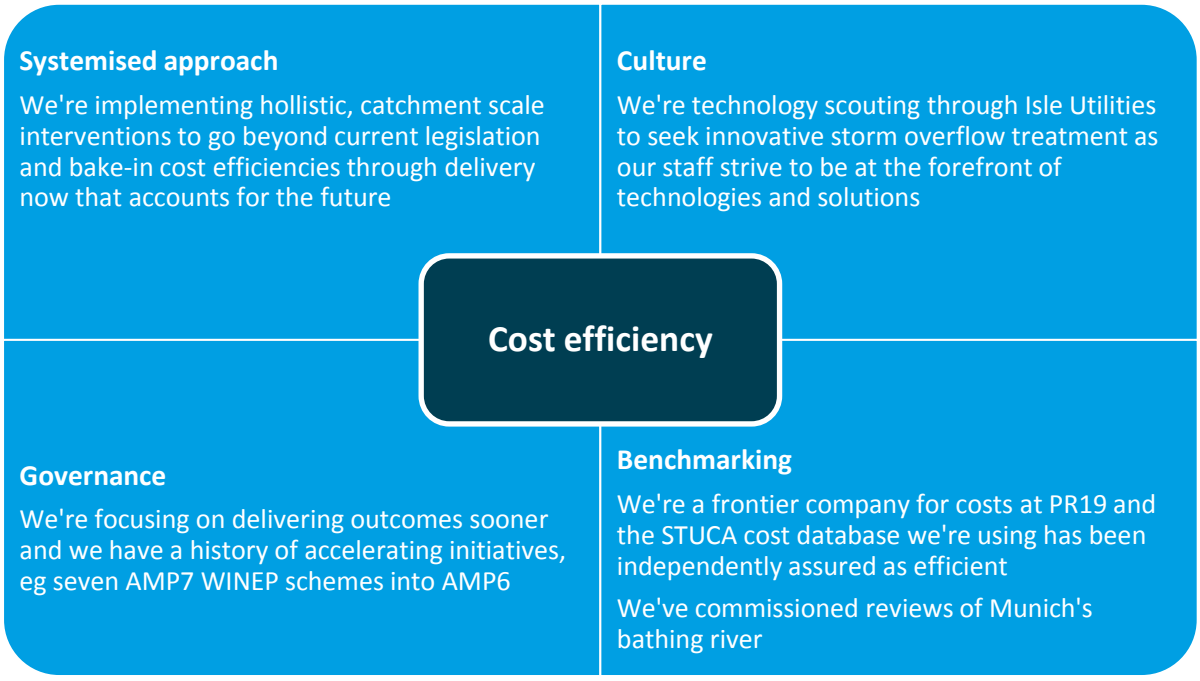
Project element	Description	CAPEX £k	OPEX £k
Ludlow Temeside SPS	Uprate pumps and rising main capacity	redacted	
Ludlow Old Street storm overflow	Provision of storm water storage		
Ludlow The Linney storm overflow	Provision of storm water storage		

Ludlow Fishmore view storm overflow	Provision of storm water storage	
Ludlow Ludford bridge storm overflow	Provision of storm water storage	
Ludlow STW	Ozone disinfection and additional stormwater storage	
Catchment management	Deliver reduction in FIO through catchment interventions	
Carbon	Tree planting and renewables to deliver a Net-zero solution	
Capital burden		
Totals		

4.5 Efficiency of costs

In Annex A09 we describe how we continually seek efficient scheme costs through a systemised approach, our culture, our governance and through benchmarking. For the bathing river pilots we have summarized this in the Figure below.

Figure: Our approach to cost efficiency



As discussed in Appendix C we have learned from the past that it is inefficient to revisit sites each AMP period as the legislative requirements in the National Environment Programme change. We believe that delivering a holistic catchment wide environmental programme will be more efficient in the longer term than a piecemeal approach.

Our **culture** is to drive efficiency, including through innovation. As part of developing this proposal our technology scouts, Isle Utilities, have helped us to understand innovative solutions to reduce the impact of storm overflows. we will evaluate these options further throughout the design and feasibility stage.

In terms of **benchmarking**, we are a frontier company for costs at PR19 and our STUCA cost estimation process has been independently assured as efficient. The standard items derived from our STUCA cost estimation process were independently benchmarked at PR14 and PR19 by EC Harris/Arcadis and shown to be efficient.

Where possible we have used the STUCA tools to estimate the costs of this proposal. STUCA is the default basis for pricing across out capital programme, supplemented by unit rates / data from historic projects for non-standard items. Cost data is based on outturn costs from previous AMPs, updates are undertaken annually and a formal independent audit each AMP. As we have developed efficiencies in our programme delivery, we have seen a corresponding reduction in the STUCA unit cost curves over time. This essentially bakes in the efficiency gains delivered into our future cost estimates. The latest cost curves have factored in contractor's AMP7 tenders. Company overhead is included in addition to the STUCA estimates, as well as project specifics such as power supply / traffic management.

The figure below shows the input cost curves from STUCA for a range of assets (used in the costing of our business case) over time, and how our process has driven efficiency across the board.

Figure: STUCA cost curve efficiency over time (relative to PR14 values)

[redacted]

As discussed, our bathing rivers costs have been independently reviewed by Arup. The review concluded that:

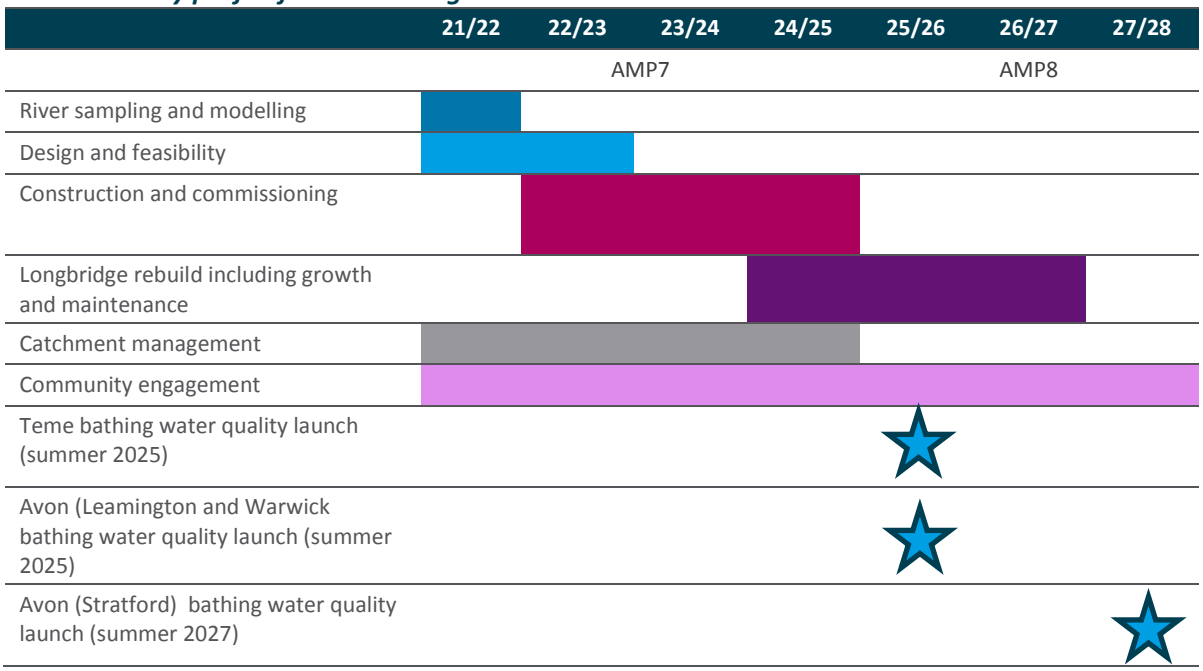
- We have a standard approach to estimating that is consistent with approaches from other sectors. Assurance on the STUCA cost curves is evident, with robust controls in place to ensure data integrity.
- For the purposes of business plan forecasting our approach is reasonable and consistent with our standard estimating methodology.
- Pricing is a combination of STUCA curves and unit rates / benchmarks from historic projects, with the exception of the ozone disinfection plant which is based on pilot projects. For the estimates for the storm water tanks and large diameter sewers Arup state they are "satisfied that the approach provides a higher degree of confidence".
- There is no overlap with the PR19 business plan.
- Our initial estimate for ozone disinfection equipment was "on the low end of the benchmark range indicating that this is likely to be unjustifiably too efficient" – we have taken steps to address this concern. As a result the report now finds that "the level of uncertainty is acceptable at this stage" and "Severn Trent have included contingency in the estimate which we [Arup] deem acceptable".

- The business case provides evidence to justify the preferred option and the selection of the specific trail areas that would support justification of these offering best value for customers.

4.6 Delivery

Our proposed spend and delivery profile for the project is illustrated in the table below. Our aim is to 'open' Ludlow, Leamington and Warwick bathing areas for summer 2025, and Stratford-upon-Avon in 2026/27. We have proposed a spend profile which delivers all of Green Recovery investment in AMP7, and completes the growth and maintenance rebuild at Longbridge in the first two years of AMP8.

Table: Delivery profile for the bathing rivers business case



4.7 Assessing Direct Procurement opportunities

We are supportive of the use of Direct Procurement for Customer (DPC) where it benefits customers and have therefore assessed our Green Recovery proposals using the transparent, repeatable framework that we developed at PR19 with KPMG.

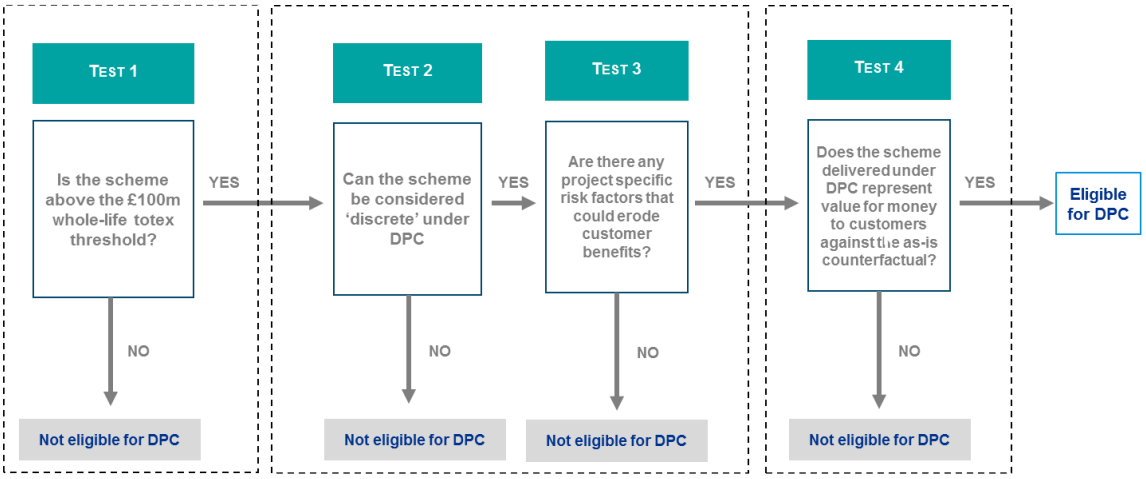
Our conclusion is that the proposals for bathing rivers schemes on the River Avon and River Teme are not suitable for delivery by DPC because they are not sufficiently discrete.

Approach

Our methodology for assessing whether our capital schemes were potentially suitable for DPC was based on the Ofwat guidance[59] on what constitutes an eligible DPC project, and through the PR19 process was accepted as a reasonable approach. The Figure below sets out this four-stage process.

[59] https://www.ofwat.gov.uk/wp-content/uploads/2017/12/Appendix-9-Direct-procurement-FM.pdf

Figure: Direct Procurement approach overview



Totex threshold (Test 1): Due to the compressed timescales of our Green Recovery process we had to run the DPC assessment in parallel with scheme development and selection. In other words, the Totex filtering process started without having certainty over costs or knowing whether they would pass through our cost benefit analysis and so we considered a reasonably wide sample of potential schemes.

The River Avon bathing quality scheme was above threshold and taken forward to the discreteness stage. The River Teme scheme is below the threshold and therefore not eligible.

Discreteness test (Test 2): We assessed the extent to which the scheme when operational is integrated as part of network management and considered the potential implications of third party delivery and operation. We evaluated the schemes against the six criteria developed for the PR19 submission.

The criteria were developed acknowledging the characteristics that Ofwat noted to impact discreteness as shown in the Figure below.

Table: Discreteness test criteria and considerations

Criteria	*Considerations*
1 Physical asset location	Is the scheme an extension to an existing asset or a new asset constructed on a separate site? Does the asset have its own function or is it highly integrated with SVT's current processes? Does the construction impact the operation of SVTs existing assets?
2 Interfaces	Does the asset have interfaces with SVT's wider network? If so, is it an information or physical interface with one or multiple assets and parties? Are any sensitive information, customer data involved requiring robust security and confidentiality arrangements?
3 Process	For similar type assets are raw material and energy sourced centrally or locally? Is there an automated control over the asset and if so is it run centrally or locally? Are resources shared with the wider SVT's operation? Does the operation require multi-skilled labour? Is the asset an explicit process stage with a clear input and output?
4 Impact on service delivery	Does the service delivery impact SVT's statutory and performance obligations (e.g. ODIs)? If so does it have an impact on quality or reliability metrics? Is the asset part of the water or the wastewater value chain? Does the operation of the asset directly impact customers? Is impact of asset failure well understood?
5 Flexibility	Is the asset's usage likely to change over time? How likely is it that the asset becomes stranded or underutilised over time? Is the asset's operation scalable? Are there alternative usage options for the asset available? Can the operation be easily adapted to changing needs?
6 Control	Is the asset needed for the day-to-day operation? Does the asset have a frequent interaction with the wider network? Is the asset required for resilience purposes? Can the contracting arrangements be designed efficiently and effectively? How comfortable are SVT giving responsibilities for resilience to 3rd parties?

Points are award against each criterion to reflect the level of 'discreteness':

- three where the asset is highly independent;

- two where the asset is partially independent, and;
- one where the asset is highly integrated.

A total score of ten or more indicates the asset may be suitable for DPC. The River Avon scheme did not pass the discreteness test as it involves the co-ordination of multiple assets across multiple sites all of which need to work together to deliver the outcome.

Figure: Discreteness assessment

Criteria	River Avon & River Teme Bathing Waters	Score
Asset location	Highly dispersed and many integrated with SVT's ongoing operation.	1
Interfaces	Significant number of physical interfaces of varying types. Complex relationship with large number of stakeholders.	1
Process	High degree of coordination and complexity of control across wider network	1
Impact on service delivery	Asset failure would have significant impact on SVT's reputation.	2
Flexibility	Operational is potentially adaptable in response to changing requirements.	2
Control	Mix of assets, some that need frequent coordination with network and third parties.	2
	Total score	9

Project risks (Test 3) focuses on the deliverability by a third party of potential schemes at each stage of the project lifecycle. The test looks to ensure that only schemes with manageable risks are taken forward as potential DPC schemes. Where an 'unmanageable risk' is identified, this indicates that delivery by Severn Trent would be more beneficial to customers because of the increased risk profile.

Table: Project risk assessment

Lifecycle stage	*Risks*	*Description*
Design	• Planning/ consent permission • Design process, failure to build design • Operating costs	• The risk that the project has not been designed adequately for the purpose required. It spans from the feasibility study through the approval of designs up to changes to design.
Build	• Time and overrun • Subcontractor default/ bankruptcy • Poor project management	• Cost overruns during construction, or failure to complete the assets on time (or at all).
Finance	• Interest rate and inflation risk • Tax risk • Insurance risk	• The risk that certain financial rates change over the course of a scheme rendering a project or scheme un-financeable.
Operate	• Service performance risk • Resource/input/demand risk • Maintenance risk	• Ongoing operational risk for delivery of performance and service.
Transfer	• Asset condition and performance at asset handover	• Risks related to poor condition and performance of the asset; and uncertainty about its future performance and maintenance need.

Value for money (Test 4) compares the total cost to customers of a scheme delivered through DPC versus a scheme delivered in-house under PR19 assumptions. The test uses a financial model to compare the two procurement options, based on a set of key assumptions. We did not carry this test out as the first two tests are negative.

The overall outcome is summarised below.

Table: Overall outcome of DPC analysis

Scheme	Test 2: Discreteness		Test 3: Project risks		Test4: Value for money
River Avon and River Teme Bathing Waters	✗	9/18 – mix of assets including some passive, but on existing sites	✗	Significant construction risks from dispersed assets, and potential CAP exposure to EA regulations	Not carried out as the first two tests were negative

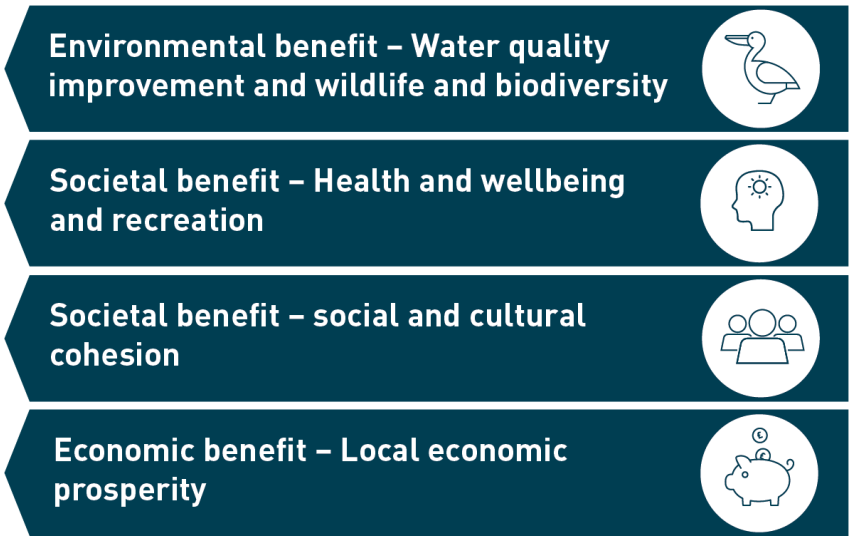
5. Benefits of the proposals

We strongly believe that clean, healthy rivers that support immersive activities will have a greater economic, environmental and societal value than the current situation. We have assessed both the quantifiable and qualitative benefits of our proposal and found that the benefits are significant.

Through our customer research, our analysis of third-party research, and inspiration from the case studies in Munich, Copenhagen and other European countries, we have a good understanding of the benefits that clean, healthy rivers deliver to customers and society. The box summarises the main benefits of the proposal.

We have assessed the benefits of this proposal to pilot bathing rivers at two locations in the following categories:

Figure: Benefit assessment categories



Our approach to benefit assessment has been more holistic, as we move towards developing a natural and social capital approach. Where possible, we have sought to monetise the benefits; otherwise, we have completed a qualitative analysis.

5.1 Environmental benefits

An **environmental benefit** represents any additional value to people, wildlife or the economy which arises from some action to improve the environment. As an example, improving the water quality and flow in a river might result in fish populations increasing and therefore deliver recreational benefits through angling. These benefits can be quantified in financial terms using economic valuation techniques.

Determining the most appropriate valuation of water quality improvement

Traditionally, we would assess the cost benefit analysis (CBA) of a river water quality improvement scheme using customer Willingness to Pay (WTP) research. We carried out such research as part of our PR19 plan, however we described the attribute as "an improvement to X km of river water quality" (see box below) with no reference to achieving bathing.

Traditionally, we would assess the cost benefit analysis (CBA) of a river water quality improvement scheme using customer Willingness to Pay (WTP) research. We carried out such research as part of our PR19 plan, however we described the attribute as "an improvement to X km of river water quality" (see box below) with no reference to achieving bathing water standards. Indeed, it is hard to expect customers to value something that could be a UK first. Therefore, we consider **that any river ecological improvement based WTP research would likely underestimate the value of the improvements this proposal will deliver** because it would not take the bathing quality driver into account.

water standards. Indeed, it is hard to expect customers to value something that could be a UK first. Therefore, we consider **that any river ecological improvement based WTP research would likely underestimate the value of the improvements this proposal will deliver** because it would not take the bathing quality driver into account.

Description of "improvement" in our PR19 WTP survey

Severn Trent Water can affect the quality of water in the rivers its sewage treatment works discharge to. Where river water quality is low, this could mean it is unable to sustain wildlife and plants in, and alongside, the river. There are around 2,500 miles of river in our region that require Severn Trent to play its part by improving its sewage treatment. By 2020, 960 miles of river will have benefitted from our investment. With further investment, Severn Trent Water could continue to improve quality on an additional 880 miles (1840 in total).

Our rich picture of PR19 Willingness to Pay research found that customers value river water quality improvements at a rate of £20,922 per mile. However, as discussed above, this is likely to undervalue the improvements to bathing standards or the recreation, health and wellbeing and amenity benefits of the proposal.

In comparison, the **National Water Environment Benefits Survey (NWEBS)** values for improvements in river water quality, do cover aesthetic, recreational and existence values (the value that people give to a resource without necessarily having the intention to visit or use it). However, these also do not take bathing water standards into account and are still therefore likely to undervalue the improvements we propose to make.

Therefore, we consider that the most appropriate method of valuing the river water quality improvement to bathing standards is using the WTP values that other water companies have derived from their research in relation to bathing waters. They are not a precise fit for our situation, as they typically refer to improving the water quality at a coastal or lake bathing site from one bathing water quality category to another (e.g. from 'sufficient' to 'good', or 'less than good' to 'good'). The values for improving a bathing water site to 'good' range from just over £900k to around £29.8m per site[60]. **This is likely to undervalue our improvements, because our bathing waters are currently expected to be at a much poorer standard than the usual starting points of 'sufficient'**.

Table: WTP valuation from companies at PR19

Study	Unit	Unit value (£/unit/year)		
		HH	NHH	Total
Bathing water quality – Good				
N	1 bathing water site improved from 'sufficient' to 'good'	£787,515	£3,251,674	£903,041
Q	1 bathing water site improved from 'less than good' to 'good'	£1,976,457		£1,976,457
M	1 bathing water site improved from 'sufficient' to 'good'	£2,337,141	£5,969,870	£2,527,170
G	1 bathing water site at beaches or lakes improved to 'good' or better	£3,072,772	£9,356,098	£3,414,712
K	1 bathing water site improved from 'Sufficient' to 'good' or 'excellent'	£3,456,278		£3,456,278
H	1 bathing water site at beaches or lakes improved to 'good' or better	£3,468,750	£9,768,152	£3,720,368
J	1 bathing water site improved from 'sufficient' to 'good' or 'excellent'	£4,522,395	£3,774,257	£4,477,389
O	1 bathing water site improved from 'sufficient' to 'good'	£27,105,750	£76,185,703	£29,840,611

Avoiding 'double counting' of benefits

In considering the WTP benefit, we need to be very mindful of any potential overlap with the other benefits delivered by the schemes. For example, it is likely that when valuing an improvement to bathing water quality customers are considering, to at least some extent, the benefits to recreation,

[60] Comparative Review of PR19 WTP Results. Accent and PJM Economics. Final Report. June 2018.

wildlife and reduced risk of gastrointestinal illness that would result from the improvement in water quality. Disentangling these benefits would be next to impossible, so we have taken a cautious approach in our benefit quantification to avoid 'double counting'.

Table: Assessment of risk of overlap between the environmental improvements (valued using the WTP valuation) and other benefits

Benefit categories	WTP for bathing water quality improvement	Comments
Water quality improvement	✓	Main benefit likely to be assessed by customers during WTP research
Wildlife and biodiversity	✗	Unlikely customers are considering the full biodiversity potential of our catchment programme in delivering improved bathing waters therefore we have used the WTP for biodiversity improvements to value this
Health, wellbeing and recreation	✓	Likely customers would consider the reduced risk of illness from improved water quality Possible that customers are at least partially considering the increase in health and wellbeing opportunities and recreation
Social and cultural cohesion	?	Unknown but unlikely customers are considering the full potential of our proposal
Local economic prosperity	?	Unknown but unlikely customers are considering the full potential of our proposal since bathing sites already exist

Valuing the biodiversity benefit

Cleaner rivers and in particular our catchment management interventions will drive improvements in biodiversity. For example, one of the measures in our catchment programme are wildflower buffer strips to help manage the runoff from fields into the river. These wildflower strips not only help protect the river from diffuse pollution, but also provide a refuge for wildlife. Our proposals would deliver a total of 4,900 hectares of biodiversity improvements.

Figure: A wild flower buffer strip which delivers both reduction in faecal pollution and biodiversity benefits

The hectares improved is calculated based on the following assumptions for the options which provide a direct biodiversity benefit:

- Fencing / buffer strips - Hectares based on 1m width biodiversity strip, average number of fields and average field length for the catchment of concern.
- Wetlands - assumes 0.1ha wetland on 10% of total farms.

None of the other options described in Section 2 that target faecal indicators have direct, quantifiable biodiversity benefits. This gives us the following hectares of biodiversity improvement.

- Teme – 3,233 ha
- Avon – 565 ha
- Leam – 1,110 ha

CBA analysis and Benefit cost ratio

To value the improvement in the water quality we have used an average of £2.9m per bathing site improved from the WTP values presented in the table above, discounting the outlier value from company O, and used this in our CBA. We have based the analysis on our understanding of the popular locations where customers currently use the river for swimming (at least six for the Avon and one for the Teme (although there are some further sites in the smaller villages). Rivers are quite different from coastal bathing waters in that the water flows downstream so we need to tackle all the sources of pollution in the catchment, rather than selecting which bathing sites to improve.

To value the biodiversity benefit we have used our PR19 WTP valuation (adjusted, as discussed in our business plan following Water Forum challenge). In the CBA we have used half the hectares of biodiversity benefit as we are only contributing 50% of the cost (the farmers and landowner will contribute the other 50%).

This gives the following CBA results:

Figure: CBA results

Pilot proposal	Net benefit – water quality improvement	Net benefit – biodiversity	Total net benefit	Benefit:cost ratio (BCR)
River Avon and Leam	£93m	£79m	£172m	2.35
River Teme	£22m	£143m	£165m	13.3

5.2 Societal benefits - health and wellbeing and recreation

Clean rivers provide multiple benefits in terms of health and wellbeing, from both a risk reduction perspective and contribution to positive improvements in both physical and mental health and wellbeing. We have done a **qualitative assessment** of these benefits for two reasons: firstly, it is possible that any valuation from 3rd party sources would overlap with the WTP benefit calculated in Section 5.1; and secondly, there could be considerable inaccuracy in a monetised assessment as we do not have accurate figures for current and future river users, and robustly quantifying a relationship between the improved water quality and the change in activity levels is not straightforward.

Data from the Sport England Active Lives survey tells us an average of 0.65% of the population in the West Midlands participate in outdoor swimming at least once a week[61], although this does not differentiate between river swimming and other outdoor venues. Applying this to the population in our catchment areas would mean around 6,500 people swimming every week. We expect there to be

[61] Data available here https://activepeople.sportengland.org/. The survey ran from 2005 to 2016.

a seasonal element, with outdoor swimming much more popular in the summer months, although cold water swimming is also increasingly popular. Organised swimming venues typically cost between £6 and £10 a session, so there is a possible financial benefit for swimmers if they move to lower cost recreation as a result of safer bathing rivers. In addition to outdoor swimming we know there are a number of rowing clubs of the river, tourist boats, stand up paddling courses and other river users.

To estimate **the increase in users following the water quality improvement** we have consulted data available on the Munich case study, which found that sin**ce the improvements, water and riverside sports increased by about 40% and 20% respectively, and nature observation, picnics and walking by 40%. Cultural and commercial activities also benefitted from a 25% increase**.

Table: Mental and physical wellbeing benefits

Supporting physical health	Supporting mental health and wellbeing	Reduced risk of gastric illness
•**What the proposal provides:** Better quality environmental setting for physical activity •**How is the benefit delivered?** Increase in number of active people •**Final welfare benefit:** health cost savings, reduced morbidity •**Who benefits?** Government, individuals, businesses	•**What the proposal provides:** Cleaner water •**How is the benefit delivered?** Increase in number of people getting a mental health and wellbeing benefit •**Final welfare benefit:** health cost savings, reduced time off work •**Who benefits?** Government, individuals, businesses	•**What the proposal provides:** Cleaner water •**How is the benefit delivered?** Reduced risk of gastric illness from water contact among river users •**Final welfare benefit:** health cost savings, reduced time off work •**Who benefits?** Individuals

Physical health

Poor physical health is associated with a higher risk of obesity, coronary heart disease, diabetes, stroke, some cancers and mental ill health – all of which impose a cost burden on society[62]. The overall cost to the economy of physical inactivity in England is estimated at £7.4 bn per year[63], so the potential value of encouraging people to be more active is huge. For example, reducing the sedentary population by 1% could reduce both morbidity and mortality rates at £1.44 bn per year[64].

The natural environment offers settings and opportunities for physical activity. In order to value the benefit precisely, we would need to make some assumptions on how the improvement in water quality will lead to an increase in physical activity supported by the river. However, **it is clear that bathing rivers provide a service that supports physical health outcomes**.

[62]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/832868/uk-chief-medical-officers-physical-activity-guidelines.pdf
[63] Ossa D and Hutton J (2002) The economic burden of physical inactivity in England.
[64] 2005 CJC Consulting, Willis, K., Osman, L., 2005. 'Economic benefits of accessible green spaces for physical and mental health: scoping study'. Forestry Commission

Mental health and wellbeing

The evidence supporting the positive impacts of blue spaces on wellbeing has been clear and consistent for over 20 years. The range of impacts are broad, ranging from reduction in stress to restoration of wellbeing and improvements in happiness. Exercising outdoors can help foster a more positive mindset and reduce feelings of fatigue and anxiety[65]. Swimming has been found to significantly reduce the symptoms of anxiety and depression for 1.4 m adults in Britain, as well as aiding relaxation[66]. **The benefits of cold-water swimming include those linked to dementia, mental and physical health, alleviating depression as well as more recently dealing with the symptoms of long Covid**[67].

As part of delivering the scheme, we will investigate the potential to link with local health services and trial 'social prescriptions' which facilitate access to the local natural environment. For example citizen science opportunities can help improve the wellbeing of people with mental ill-health.

Reduced risk of illness

Improved river water quality will result in a **reduced risk of gastrointestinal illness** for those using the river for immersive and non-immersive activities (such as swimming, rowing, stand-up paddling, canoeing, kayaking and simply enjoying the water). Whilst we do not know how many people currently use the Avon and Teme for such activities, we can safely assume that a certain percentage of those that do will suffer from illness as a result. For example, in 2012, Public Health England investigated an outbreak of gastrointestinal illness amongst participants of the Hampton Court Swim, in the River Thames, following over 30% of the 1,000 participants experiencing symptoms of illness.

Recreation

Pollution by waste from point sources (STWs and overflows) and diffuse pollution reduces the amenity for recreational users, potentially causing illness and indirectly affecting tourism businesses.

Natural capital guidance (ENCA) tells us that recreation is often implicated in bundled values such as water quality, landscape or amenity. Recreational value is an active use value and, depending upon the type of activity, will overlap with or mask less-tangible values such as community cohesion and education and learning about nature. The recreational value will include private physical and mental health benefits to the individual but may not include wider savings to the health service. We consider there is at least in part some overlap with the WTP valuation used in the environmental benefit assessment.

Levelling-up access to blue spaces

One of the benefits of our proposals is that they offer opportunities for riverside recreation in a part of the UK that is a long way from the coast. Residents near the River Avon will typically live around 80-120 miles from the coastline, and those in Ludlow (near the Teme) around 70 miles away.

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[65] Thompson Coon J, Boddy K, Stein K, Whear R, Barton J, Depledge MH. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. Environ Sci Technol. 2011 Mar 1;45(5):1761-72. doi: 10.1021/es102947t. Epub 2011 Feb 3. PMID: 21291246

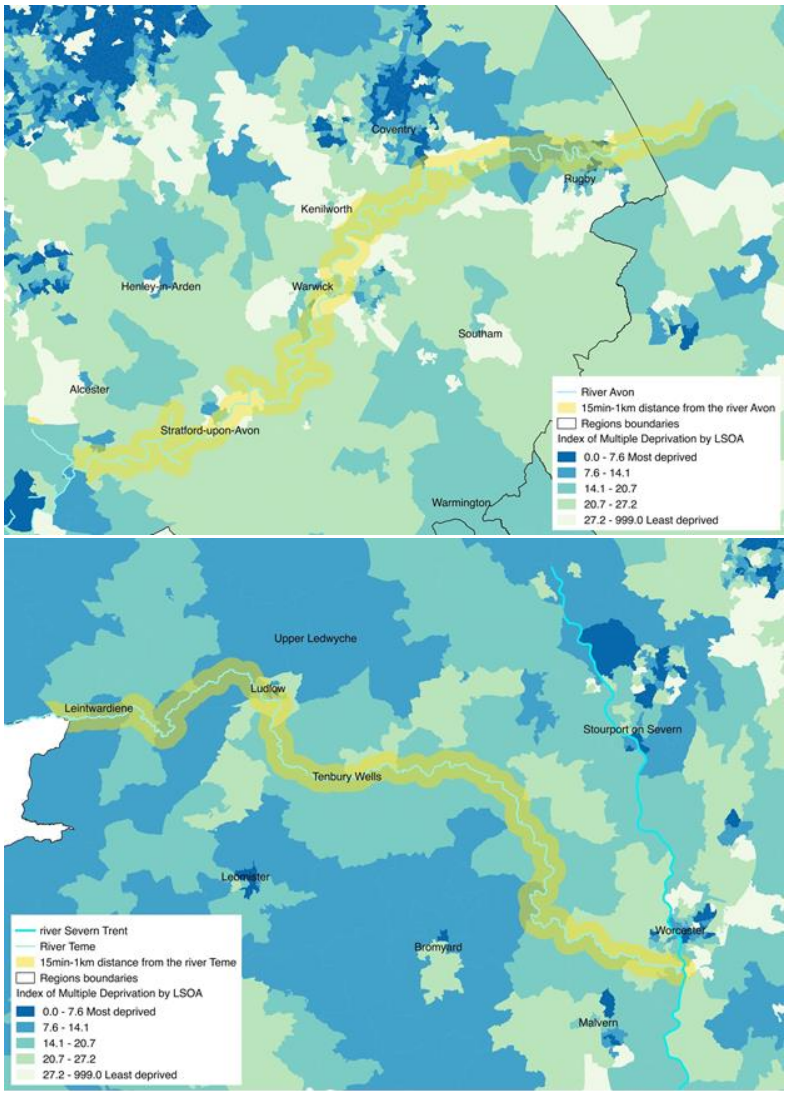
[66] Mental Health and Swimming Mind and Swim England Fact sheet - https://www.swimming.org/swimengland/health-and-wellbeing/

[67] https://www.iprshealth.com/news/8-benefits-of-cold-water-swimming/

Our interventions aim to improve equality of access to blue spaces across the country, with the associated societal benefits that will bring. In addition to this, river swimming is an affordable form of exercise, compared (for example) to open-water swimming at organised venues that would typically cost between £6 and £10 per session, or visits to local swimming pools which might cost £10-£20 for a family of four.

In the following maps, we have considered deprivation in the areas surrounding the Avon and Teme and overlaid this with a 15-minute walking radius. Relatively close to the Avon there are areas in the 20% of most deprived areas in the country, including neighbourhoods in Warwick, Stratford and to the south-east of Coventry. Similarly, areas close to the Teme to the west of and in Leintwardine are in the top 20% most deprived areas. As part of our proposals, we will undertake outreach work to ensure these communities benefit from the improvements.

Figure: Deprivation in the areas surrounding the Avon and Teme



More detail is provided in Wellbeing benefits Annex (A07).

5.3 Societal benefits - social and cultural cohesion

A potential benefit of an improved river environment could be an increase in community cohesion and the promotion of positive social relations. Involving the local community in the solution, for example through volunteering and citizen science, can reignite attachment to the natural world[68].

An improved environment also contributes to a sense of ownership and pride of place for local residents and communities. **Customers told us that the improvements proposed by our projects would increase awareness of what is on offer in their local community and foster pride in the region.** The European case studies detailed in Appendix B reported similar benefits.

"Having this would be somewhere to be proud of, especially as one of the first sites." Customer near the Avon, Britain Thinks research

These improvements could be particularly important in the more deprived communities near our pilot areas.

5.4 Economic benefits - local economic prosperity

Our Green Recovery investment proposals will stimulate economic recovery through the delivery and construction period, as well as through the sustained impact on the local area.

Creating jobs - delivery and construction impact

One key benefit of our proposal, particularly in the context of the Green Recovery, is that it will require significant employment of skills to design, construct and maintain high quality bathing rivers. This is in turn will **create new job opportunities (and/or safeguard jobs) in the supply chain which may have been jeopardised as the result of the pandemic.** We have provided more detail on the impact in the Jobs and Skills Annex A05, and included a short summary in this section.

We have carried out a robust review of projects of similar scale and cost to the bathing rivers proposals, in order to derive figures that reflect the number and type of jobs that can be created from this project. The figure below demonstrates the jobs created:

Table: Impact on jobs of our investment proposal

Total CAPEX (Avon and Teme schemes)	Job types	Quantity and duration
£153m	Environmental Surveyor	1 (full time equivalent) for 2 years
	Sampler – River/sewage sampling and analysis, and water quality modelling	3 (full time equivalent) for 2 years
	Catchment Advisors – Catchment management	4 catchment officers, full-time
	Design Engineer	15 based on the premise of 2 years of design work
	Process Engineer	3 based on the premise of 1 year's work
	Construction Worker	306 based on the premise of 3 years of construction work

[68] Understanding Citizen Science and Environmental Monitoring. Final report on behalf of the UK Environmental Observation Framework by Roy, H.E., Pocock, M.J.O, Preston, C.D., Roy, D.B. and Savage, J.. NERC Centre for Ecology and Hydrology. November 2012

In relation to the principles set out in the Jobs and Skills Annex A05, **this project provides the opportunity to promote engineering skills; a key skill requirement identified for the water industry in the Governments Skills for a Green Economy report**[69]. Furthermore, this project will provide engineering graduates with invaluable experience for the future as we make a step change towards blue/green infrastructure.

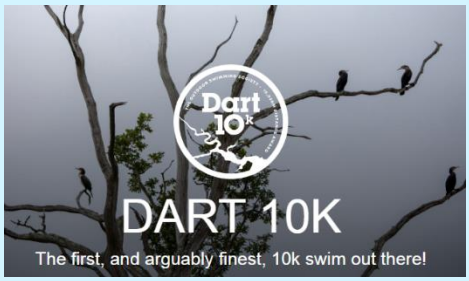
Local economic impact

A cleaner river and a consequent increase in river users should have a **beneficial economic impact on existing local businesses** and communities (such as riverside cafes, sports clubs, swim coaching, and those running activities on the river) and drive an increase in the number of businesses in the vicinity of the riverside.

The towns in our pilot areas **are all tourist hot spots and** have all suffered as a result of the pandemic. Stratford-upon-Avon attracts over 2.7 m day trippers annually**, with a total tourism value of over £233m and 3,100 full time jobs**[70], and has felt the effects of the loss of these visitors **due to the pandemic**. **Warwick district also has strong appeal for visitors, with 3.1 m trips per year generating more than £220m and over 4,865 jobs**[71]**.** Tourism is also one of the top five sectors for economic prosperity in Shropshire, which **as a county** attracts over 13 m visitors per year **and generates circa £800m for the local economy**[72]. This proposal may drive an increase in the number of visitors to the region **which has an economic value. For comparison,** the **current** economic value of seaside tourism across England is estimated at over £3 bn[73], and the value of day trips attributed to freshwater habitats is over £300 m[74] and river events (e.g. swimming events) could have a beneficial impact on the economy.

Sporting events can have a considerable economic impact, for example the economic impact of the 2010 inaugural Brighton Marathon was estimated at £3.6m, including the expenditure of spectators and runners[75].

Case study: Dart 10k swim



The Dart 10k is considered one of the finest open water swimming events (the 'London Marathon of the open water swimming world'), and has grown from 200 to 1,600 swimmers per year over the past ten years. Sporting events such as this have a positive impact on the local economy, from the money spent by swimmers and their supporters on accommodation and other services, to money raised for local charities.

[69] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/32373/11-1315-skills-for-a-green-economy.pdf
[70] Economic Impact of Tourism Stratford Town 2018
[71] Warwick District council Tourism Strategy, Appendix 1
[72] https://www.shropshirelive.com/news/2020/05/26/shropshires-tourism-sector-prepares-for-recovery/
[73] ENCA Assets Databook July 2020 update
[74] UK Natural Capital: ecosystem accounts for freshwater, farmland and woodland. Office for National Statistics. 2017
[75] A study of the economic impact of the inaugural Brighton marathon. On behalf of the Grounded Event Company and Brighton & Hove City Council. June 2010. TSE Research Services

Improved river water quality will also increase amenity value for local residents, which can be associated with a measurable premium in property values. This was seen in our Copenhagen case study (see Appendix B), where property values increased between 50% and 100%[76].

[76] Copenhagen Solutions for Sustainable Cities. State of Green report. www.cphcleantech.com. January 2014

6. Customer protection

We have considered a range of options for the development of performance commitments (PCs), outcome delivery incentives (ODIs) and wider approaches to ensuring that Severn Trent is accountable for the successful delivery of our Green Recovery proposals.

For each business case it will be necessary to ensure that it can be integrated into the regulatory framework, so that (i) customers are protected and avoid paying twice for service improvements and (ii) we are appropriately remunerated for successful delivery of the proposals. Our approach to managing these issues is set out in Annex 11 - Customer protections. This Annex explains:

- how we propose to be held accountable to deliver each green recovery proposal, and in turn be remunerated for successful delivery (and includes the description of each new PC we propose to implement this using the PR19 template)
- what overlaps exist across each of our existing suite of PCs and the green recovery schemes how we will adjust for these to avoid any double remuneration;
- how the totex costs sharing should be applied to better protect customers; and
- how the funding of the green recovery proposals could be implemented within the current AMP.

Appendix A: Looking back – a history of river swimming

River swimming can be a magical experience. There are hundreds of river swimming spots across the UK that have been used for generations, where children learnt to swim and families gathered on a summer day to paddle, picnic and play.

Historically, rivers across our region have been popular swimming venues. In Abbey Park in Leicester, triple Olympic champion John Jarvis trained in the River Soar – a bathing place enjoyed by adults and children throughout the year (photo on left below[77]). In Newark, swimming in the Trent continued until 1934 when an open-air swimming pool was built. In Coleshill, in the 1920s there was an established bathing place in the River Blythe (photo on right below[78]). By 1923, there were over 600 informal river swimming clubs around the country, and wild swimming was in its heyday.

Our proposed pilot areas have a heritage of river swimming. In **Ludlow**, the river has long been a centre of leisure activity for the town, serving as a playground and venue for swimming and boating clubs. In the early 1900s, people flocked from Birmingham by train to enjoy the annual regatta on the River Teme, which included rowing races, water polo and a barrel race (see photos below, from the Ludlow Civic Society Heritage News). More recently, Coracle regattas have been held in Leintwardine on the River Teme.

[77] From Hung Out to Dry, Swimming and British Culture, Chris Ayriss
[78] Reproduced from the "Our Warwickshire" website

Across **Warwickshire**, swimming clubs trace a history of swimming in the River Avon in the late 19th Century. In Stratford-upon-Avon, the river has always been an important place for leisure and recreation. In the 1920s and 1930s, the Old Bathing Place was a popular swimming area, and had diving boards, a water chute, changing huts and a swimmer's safety boom. Photos show how people flocked there to enjoy the river, as well as other major events such as the Stratford regatta.

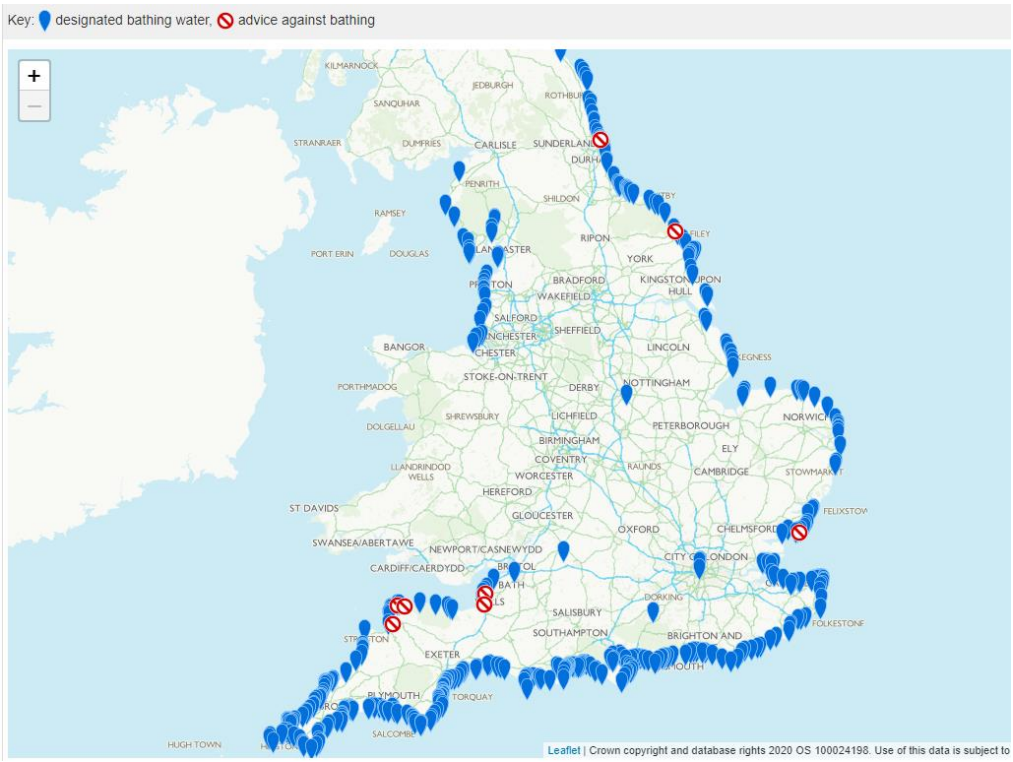
As concerns grew over water quality in public swimming baths (including the 1936 Public Health Act), attention also turned to the safety of river bathing. The industrial development of the post-war years meant rivers bore the brunt of increased pollution. In Leicester, swimmers continued to use the River Soar until 1959, when the Medical Health Officer reported on the pollution of the river and a prohibition order was enacted. Fears over polio were also at their peak at this time, despite the link with river bathing being unproven. Gradually, the practice of river swimming fell away and swimming pools became the norm.

Appendix B: Bathing waters now

The UK has 644 designated bathing waters, the majority of which are located along the coast as shown in the figure below. **Coastal bathing waters** have been popular for recreation and tourism for many years, and since the Bathing Water Directive was established in 1975 the water quality at our beaches has undergone a significant improvement. Coastal bathing waters deliver immense benefits to the local economy, for example through tourism, and also have a positive impact on the health and wellbeing of local communities. In the UK, an estimated 271 million recreational visits are made to coastal environments annually. The economic value of seaside tourism across England is estimated at over £3bn, whilst people living by the coast report better general health and more recreational physical activity, compared to those living inland. There is also some evidence of positive health outcomes for nature-based interventions in marine and coastal environments.

The map in the figure below shows the 644 designated bathing waters in England. Only 12 of these are inland waters, and none are rivers. In the 2021 bathing season the first river will be added to the designated bathing water – a stretch of the Wharfe in Ilkley, Yorkshire. In the Midlands there is only one designated bathing area, Colwick Country Park West Lake near Nottingham, where open-water swimming sessions are organised by WholeHealth.

Figure: Designated bathing sites in England



In comparison, the EU has many more designated rivers. For example, in France there are 420, in Germany 32, and in Spain 169. We have sought inspiration from European case studies in which improvements have been made over the past decades to sewage treatment in order to improve the recreation and amenity potential of inland waters.

Case study: The harbour at Copenhagen

Copenhagen is one of the only cities in Europe where the harbour water is clean enough to swim in, and this has become an iconic symbol of its recent pollution remediation efforts. 15 years ago, there were close to 100 overflow channels feeding wastewater into the harbour, resulting in heavily polluted water. The municipality made a decision to move polluting industry out of the harbour and to clean all wastewater before it reaches the sea.

This was achieved by:

- Installing mechanical, biological and chemical wastewater treatment to remove nutrients, salts and to minimise the discharge of heavy metals.
- Providing combined sewer reservoir capacity to store wastewater until there is capacity in the sewage system.
- Decoupling of rainwater from sewers: the utility provider operates a reimbursement scheme, in which a landowner connected to the sewage system is reimbursed a connection fee if the rainwater is decoupled and discharged locally.
- A strong focus on urban design and collaboration across different disciplines to create recreational spaces.

Overall, this has resulted in 55 overflow channels being closed, and wastewater is now only discharged to the harbour during particularly heavy rainfall. The city also provides an automatic warning system that identifies whether it is safe to swim by monitoring bacteria levels on a daily basis. The city website and app provide an online forecast of water quality.

Figure: Copenhagen harbour baths

In 2002 the first public harbour swimming bath, Islands Brygge, was opened. Swimming spots are popular with local families, regular swimmers and tourists, with more than 100,000 people swimming in the city's baths each year. Other recreational activities such as kayak-polo, canoeing and fishing are also popular, and there have been knock-on benefits for the local economy, including revitalisation of local business life and a doubling of property values in the area. The harbour area is now one of the trendiest spots in the city.

Figure: The sustainable benefits seen from the improvements in Copenhagen

Case study: Switzerland's strong commitment to micropollutant removal

Clean rivers haven't always been a Swiss norm – until the 1960s, only about 15% of the Swiss population was connected to a sewage treatment plant, and wastewater often flowed directly into rivers and lakes. Growing environmental awareness and pressure from the public has been the catalyst for policy change. In 1971 the treatment of wastewater became Swiss law. By 2005, 97% of the population was connected to a central sewage treatment plant.

Figure: Swimming in the river Limmat in Switzerland

Within Zurich the River Limmat is a focus for recreation in the city. There are a number of official swimming spots along the River Limmat, and many are popular leisure spots with facilities. The Limmat Swim is one of summer's highlights, a floating tour of the city from the water which attracts 4500 and sells out in record time.

Looking to the future, Switzerland has committed to remove micropollutants in wastewater by 2040, at an estimated cost of around £2 bn (as a net present value)[79], equipping 100 wastewater plants with technologies that can filter out 80% of all micropollutants.

[79] UWKIR report. Pharmaceutical reduction at WWTW – cost and effectiveness. Report Ref No. 20/WW/17/8

Appendix C: Inefficiencies of a piecemeal approach to legislative requirements

The case studies below show how a fragmented approach to delivering legislative requirements, such as WINEP, without reference to a long-term, overarching strategy can lead to inefficiencies.

Case study: Armthorpe sewage treatment works

We had an AMP5 NEP obligation to deliver a WFD driven ammonia improvement. In AMP7, we are revisiting the site under a WFD phosphate improvement driver. It could have been foreseen when the ammonia obligation was set that a substantial improvement for phosphate would also needed to meet WFD good status criteria. In terms of investment, it would have been far more efficient to have tackled both issues at the same time, not least because we would have adopted a different approach to meeting the ammonia standard if we were also tackling phosphate at the same time.

At the time the ammonia obligation was imposed, the technology for meeting the phosphate standard was still in development so it would not have been possible to tackle both issues in AMP5. Given the 'one out – all out' principle in WFD, just tackling the ammonia issue in RBMP cycle 1 was never going to change the overall waterbody classification. It would therefore have made more sense to delay the ammonia improvement until a holistic improvement plan was in place. This piecemeal approach perfectly demonstrates how it is possible to invest billions without delivering an increase in the number of waterbodies achieving WFD good status.

Case study: Lower Gornal and Trescott sewage treatment works

Both of these works were in the AMP5 business plan and NEP for improvements under UWWTD (phosphate) and WFD (phosphate and ammonia) drivers. However, as a result of Ofwat's PR09 final business plan evaluation, the WFD obligations at both these sites were removed to just leave 2mg/l phosphate obligations under the UWWTD. The funding allowance in the final determination was reduced accordingly to just cover these UWWTD obligations, without considering that further improvements at both these sites would be needed in future to meet the WFD objectives, including the need for sub 1mg/l phosphate standards.

The WFD improvements at Trescott STW were delivered in AMP6 and necessitated replacement of the tertiary sand filters installed in AMP5 under the UWWTD obligation (fortunately we were able to recycle these to another site). The WFD improvements at Lower Gornal will be delivered in AMP7 through a works closure. This will result in the abandonment of the assets installed in AMP5 (£2.6m). This fragmented approach to delivering legislative requirements without reference to a long term, overarching strategy has inevitably led to inefficiencies.

Appendix D: Potential bathing waters in our region

Bearing in mind our selection criteria (see Section 1), and assuming successful delivery of our pilot projects, we have identified several further candidates for bathing-quality water in both the Severn and Trent catchments. As with the pilots, the intention is to target specific sections for promoting river usage, whilst noting that the wider environmental benefits will extend well beyond the target areas. Our future strategy for our catchments is outlined in the following table. We have used a simple red-amber-green (RAG) status to identify the potential each river has for bathing water standards.

Catchment	Bathing Areas	Customers	Environment	Company	RAG
Upper Avon (to Stratford)	St Nicholas Park, Warwick The Old Bathing Place, Stratford-upon-Avon Jephson Gardens, Leamington Guys Cliff, 2km upstream of Warwick	Recognised, well-used sites. Slow-moving river under normal flow conditions. Large population within reasonable distance.	Proposed work with third parties (farms) to achieve bathing waters standard will also help to achieve WFD good status. Storm overflow improvements will remove 4 WFD RNAGs[80].	Significant work in AMP6 into water quality (Coventry and Rugby). Good tie into other investment drivers (Warwick). Potential for effluent reuse add-on – water resource benefit.	Pilot Area
Upper Teme (to Tenbury Wells)	Leintwardine The Linney, Ludlow Ashford Carbonel	Leintwardine site described as 'family friendly', as is Ashford Carbonel (although some concerns about trespassing). The Linney also looks to be a good site for all abilities.	River Teme is a SSSI which will benefit from treatment and overflow upgrades. (AMP7 investigation in WINEP) Already engaging with farmers for catchment protection and potential for partnership working with Severn Rivers Trust.	Significant work in previous AMPs into water quality (esp. Clun SAC) with more in AMP7, so unlikely to require major additional investment.	Pilot Area

[80] RNAG = Reason for not achieving good status

Catchment	Bathing Areas	Customers	Environment	Company	RAG
Lower Avon (to Tewkesbury)	Welford on Avon Bidford upon Avon Marlcliffe, near Alcester Eckington Bridge, Pershore Fladbury Fleet Inn, nr Tewkesbury	Significant number of bathing areas identified and within reasonable distance of significant numbers of customers. Possible conflict with navigation so need to consider carefully if all areas are suitable.	WFD improvements are likely to feature in AMP8 WINEP for a number of sewage works.	Likely to be increasingly challenging/expensive towards the lower end of the river. Good tie into other investment drivers. Good candidate for AMP8 in at least part of the catchment; remainder may be a longer-term proposition.	Good potential
Lower Teme (to Worcester)	Powick Bridge, Worcester Bransford bridge, nr Worcester Kingswood Common, nr Worcester	Powick bridge site described as 'not for inexperienced swimmers', therefore may not benefit many customers.	River Teme is a SSSI which will benefit from treatment and overflow upgrades. (AMP7 investigation in WINEP)	Logical tie in with upstream pilot and river is already in fairly good condition. There may be some more suitable areas (as yet unidentified), but further investigation needed.	Moderate potential
Upper Severn (to Ironbridge)	References to swimming upstream and downstream of Shrewsbury (inc. an annual swim in the town at Welsh bridge).	Not clear if river is suitable for everyone – some comments about currents. Possible conflict with anglers.	Water quality is already fairly good, with further investment in AMP7. Improvements to storm overflows could resolve 5 RNAGs.	Potentially some good candidate areas in this catchment if there is sufficient customer benefit. Moderate investment needed.	Moderate potential
Lower Severn (to estuary)	Lower Lode, Tewkesbury Ashleworth Key, Gloucester Odda's Chapel, nr Gloucester	Probably only suitable for experienced swimmers. River Severn is very wide/deep at these points. Likely to be limited customer benefit.	River is in reasonable condition and will benefit from further investment in AMP7. Storm overflows are not reported to be an issue on RNAG (possibly due to high dilution).	Likely to require very high levels of investment due to number of STWs and storm overflows in upstream catchment. Unlikely that benefits will be sufficient to justify investment needed.	Low potential

Catchment	Bathing Areas	Customers	Environment	Company	RAG
Derwent and Wye	River Wye near Bakewell River Bradford, Youlgreave Derwent at Chatsworth Derwent at Calver Bridge (upstream of Chatsworth) Matlock	Bakewell & Youlgreave both described as 'family friendly' and appear popular, as is the stretch at Chatsworth (although there are concerns about the impact on the river banks and landowners). Calver Bridge also looks suitable for less experienced swimmers. Not an area of high population density, but is a holiday location	River Wye upstream of Bakewell is an SAC which would benefit from storm overflow improvements. (AMP7 investigation in WINEP)	River quality already good so unlikely to require significant investment (possible exception being storm overflows in Matlock). No areas identified yet downstream of Matlock and meeting required standards in lower part of the catchment will require far more significant investment.	Good potential
Dove	Dovedale Ellastone Bridge, nr Uttoxeter Tutbury Castle, nr Burton on Trent	Dovedale is popular and family friendly. Located in the Peak District National Park. Upper catchment is low population density but in a holiday area. Bottom of catchment close to Burton & Derby.	River is generally in good condition with further investment in AMP7. Storm overflows are not a significant issue but there are a couple of RNAGs. Top end of river is SAC. (AMP7 investigation in WINEP)	Dovedale area unlikely to need much investment. Moderate investment required further down the river – quality is already good.	Good potential
Blythe	Used to be a popular location nr Coleshill however **we have no evidence that there are current spots.**	River is close to Birmingham, Solihull and Coventry. No evidence of current usage for recreation and swimming.	The Blythe is a SSSI and is already in fairly good condition after extensive investment, including catchment protection work to safeguard Whitacre WTW. AMP7 WINEP investigation may trigger further work. A couple of storm overflow related RNAGs reported.	Good tie in with other investment drivers. Potential for significant customer benefit if the demand is there.	Good potential (subject to establishing a customer demand and suitable access)
Tame (ex. Blythe)	Tame Valley wetlands / Kingsbury water park	Very close to Birmingham and Tamworth but unlikely to be suitable for bathing. The one site found is not directly linked to the river.	River is the poorest in our region and meeting WFD good status is technically unachievable. Significant number of RNAGs but most are covered off in AMP7.	In prolonged dry weather river downstream of Minworth is 80%+ sewage effluent. Huge volumes of urban runoff in wet weather. Achieving bathing water standard would be extremely expensive and probably not technically feasible	No potential

Catchment	Bathing Areas	Customers	Environment	Company	RAG
Soar	Abbey Park, Leicester Barrow/Quorn, downstream of Leicester Sutton Bonnington Normanton on Soar	High population density and Abbey Park used to be a popular swimming area. Limited data on current usage.	River upstream of Leicester benefiting from quality improvements in AMP6 and 7, with further work expected in AMP8. Significant number of RNAGs attributed to storm overflows.	Some tie into other investment drivers, especially at Wanlip STW. Storm overflow improvements are likely to require significant investment and a number of sewage works will require disinfection. Potential in the long term if sufficient customer demand.	Low potential
Idle and Torne	Kingsmill reservoir, Sutton in Ashfield	Only identified potential bathing water location in close proximity to Mansfield and Sutton in Ashfield.	AMP7 investigation and potential improvement to several storm overflows upstream of the reservoir. Environment Agency-produced measure specification form references reservoir being used for amenity activities and a potential bathing water designation application.	Much of the work required for Kingsmill reservoir may be carried out in AMP7, so has potential to be low cost with high potential benefit. Possible tie in with Flooding Resilience business case. Other opportunities further down the river (if identified) are likely to be a lot more expensive.	Good potential (one site)
Upper Trent (to Tame)	None identified	Significant population centres at Stoke and Stafford, but no obvious swimming locations identified.	Some AMP7/8 investment to address storm overflow issues in Stoke on Trent and to upgrade several STWs to improve WFD status.	Likely to require significant investment to bring storm overflow spills down to level consistent with bathing water standards, especially in Stoke. High levels of urban runoff to contend with at top of catchment.	No potential
Lower Trent (to estuary)	Numerous sites identified	Nottingham already served by designated bathing water at Colwick Park. Balanced Performance and Absolute Triathlon Club advise that only very experienced wild swimmers should test themselves in the Trent.	Lower river Trent is generally in poor condition and getting to good status may be technically unachievable. Storm overflows are not reported to be a major cause of non-compliance, possibly due to high available dilution.	Likely to be extremely expensive due to large number of large sewage works and storm overflows in this part of the catchment. No obvious tie into other investment requirements. Demand already served by designated bathing area.	No potential

Appendix E: Proportional allocation assessment for Warwick Longbridge sewage works

As part of the River Avon pilot, we intend to substantially rebuild the sewage works at Warwick Longbridge. This rebuild will deliver four separate objectives as follows:

- Provide the assets necessary to meet safe bathing river objective (final effluent disinfection and increased storm water storage).
- Upgrade the works to deliver WFD good status through enhanced phosphate removal (likely to be an AMP8 WINEP obligation).
- Deliver additional capacity to cater for population growth.
- Base maintenance – replacement of life-expired assets.

In the absence of the bathing rivers proposal, it was our intention to undertake the WFD enhancement, supply/demand capacity increase and the base maintenance as a holistic AMP8 project. No investment was proposed at the site in AMP7 and the WFD enhancement is not included in the current WINEP – we anticipate this being in the AMP8 WINEP and are satisfied that this is a cost-beneficial intervention.

The following assessment has been undertaken to disentangle what investment should be included in this business case as new investment and what should be deemed to be covered by the anticipated implicit allowance for wastewater maintenance in AMP8. Given that delivery of this part of the project will span across AMP7 into AMP8, the approach we are proposing is as follows:

- Enhancement investment in AMP7 to deliver bathing rivers and WFD good status objectives is in this business case.
- Investment to deliver the supply/demand and base maintenance elements is excluded on the presumption that it will be covered by the AMP8 implicit allowance.

Asset interventions required

Table: Assets at Warwick Longbridge works and how they will be treated as part of our proposal

Existing sewage works assets	Treatment of the existing assets
Inlet pumping station	Retain
Inlet works	Retain
Primary settlement tanks	Retain and repurpose
Two stage biological filtration	Abandon & replace
Secondary settlement	Retain and repurpose
Tertiary nitrifying filter	Abandon and replace
Tertiary sand filter	Retain – potential repurpose
Chemical dosing for P removal	Abandon and replace
Storm water tanks	Abandon and replace
Sludge holding tanks	Abandon and replace

The table above details the existing sewage works assets at Longbridge and what will happen to them as part of our proposal. As part of the wider bathing rivers project, a new trunk sewer from Leamington to Warwick is proposed in order to deliver storm overflow spill reductions. Additional inlet pumping capacity will be required. We propose to construct a new pumping station to feed the proposed new works and retain the existing one to deal with the increased storm water arising from the bathing waters outcome.

We also need to construct additional inlet works capacity to screen and de-grit the large increase in flow arriving at the works. Due to the layout of the site, we propose to construct a new inlet works to serve the new 'flow to full treatment' process and retain the existing assets to treat the storm water.

A significant increase in storm water capacity is required to bring storm spills down to a level required to meet bathing water standards. Rather than building a large amount of new storm water capacity, we propose to meet the bulk of this requirement through reuse of the existing primary and humus tanks. New primary settlement tanks (PST)s will be built as part of the new flow to full treatment process stream. Some additional storm tank capacity is required, partly to for bathing waters and partly to replace existing, life-expired capacity.

The existing biological treatment processes are life expired and undersized for future demand. They will be replaced with a new activated sludge plant (or equivalent).

The existing chemical dosing plant is life expired and requires like-for-like replacement.

Enhanced tertiary solids removal is required to meet a tight new phosphate limit of 0.25mg/l. The existing sandfilters are unable to deliver this level of performance and will be replaced with a Co-Mag ballasted coagulation process. We are giving consideration to retaining the existing sand filter plant to treat storm tank effluent, as solids removal can deliver a 2-log reduction in bacterial load.

Table: Breakdown of the project costs

Element	Cost £000	Allocation to drivers
Additional Inlet pumping station	redacted	Bathing rivers
Additional Inlet Works		Bathing rivers
New PSTs		Bathing rivers
Activated Sludge Plant		67% maintenance 33% Supply Demand
Comag plant		WFD Enhancement
Ozone disinfection		Bathing rivers
Storm tanks		18% capital maintenance 82% bathing rivers
Chemical dosing plant		Capital maintenance
Sludge tanks		Capital maintenance
Sub-total		
Non asset specific costs		Pro-rata
Total (£000)		

Table: Allocation of costs to the relevant investment driver

[Table redacted]

Appendix F: Modelling by Intertek to determine assets which require intervention

The modelling work by our specialist contractor Intertek has:

- Provided an initial assessment of bacterial loads from diffuse pollution (principally livestock farming) using data on the amount of livestock farming within the catchment and average bacterial loads arising from this type of activity.
- Confirmed which storm overflows will require investment to reduce spill frequency and volumes of sewage discharged.
- Confirmed which sewage works will require effluent disinfection.

Each of these inputs has been modelled separately to identify the individual measures required, with a final run to confirm that the package of measures will deliver the desired outcome. We will repeat the modelling work in far greater detail once actual bacteriological data becomes available.

The graphs below summarise the initial work that Intertek have undertaken on our behalf. As noted, this is 'illustrative' modelling undertaken using default data to give an indication of how the various sources of E.coli impact the river under both dry and wet weather conditions. Several scenarios have been modelled.

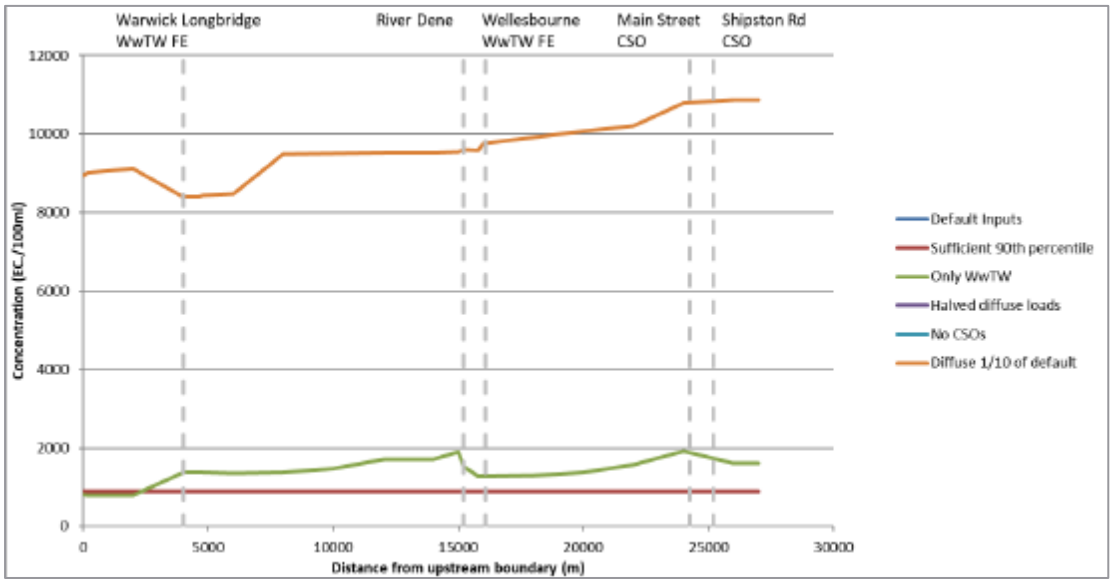
Table: Scenarios modelled to understand how sources of E.coli impact the river

Scenario	Description
All inputs	Cumulative impact of diffuse pollution, storm overflows and sewage works
50% of diffuse load	As above, but with just 50% of the default diffuse load
No CSOs	Full diffuse load, but impact of storm overflows removed
10% of diffuse load	Impact of sewage works + 10% of default diffuse load
Sewage works only	All other E.coli sources set to zero
Sufficient 90%ile	This is the minimum standard set for safe bathing water quality

The first of the two graphs below represents a long section of the River Avon from just upstream of Warwick to just downstream of Stratford-upon-Avon. This is our **dry weather illustration** and only includes E.coli inputs from sewage works + 10% of the default diffuse load. There will be some faecal bacteria input from livestock in dry weather (e.g. from animals directly accessing upstream watercourses for drinking water) but runoff from fields should be minimal.

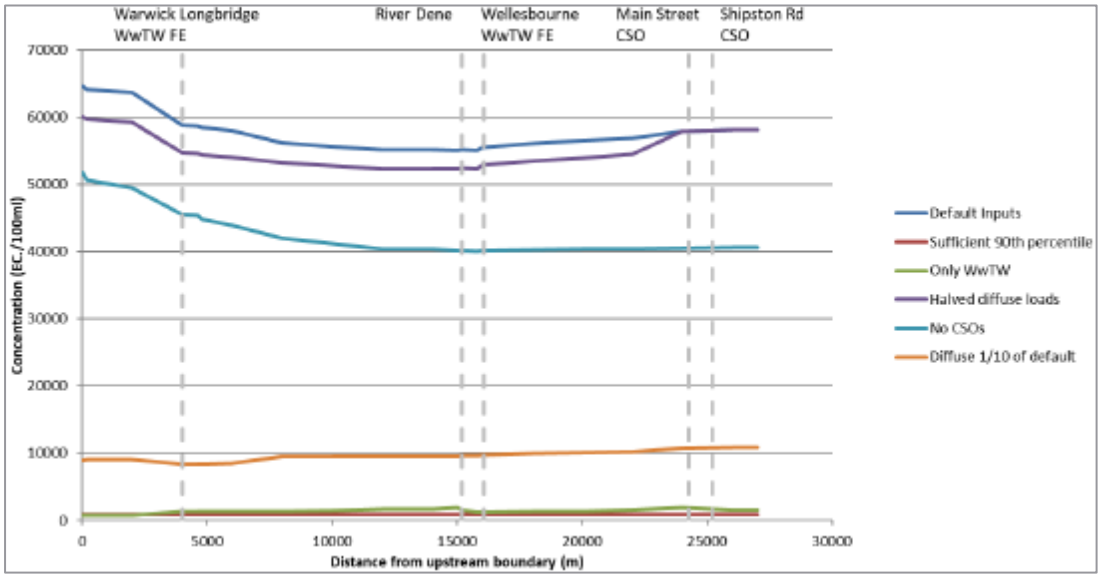
Key points to note are that inputs from sewage works alone are sufficient to breach the minimum bathing standard, although not by a large amount. This supports our initial assessment that **targeted interventions at a small number of large STWs should be sufficient and that the smaller STWs are largely immaterial**. The diffuse sources are more significant, resulting in exceedance of the required standard by around one order of magnitude. Whilst this may appear to represent a major challenge, it is important to note that untreated cow manure will contain E.coli levels that are around four orders of magnitude greater than in treated sewage – in other words, **well-targeted interventions (such as fencing off watercourses) can be expected to yield significant gains**.

Figure: Modelling of a section of the River Avon upstream of Warwick to downstream of Stratford



The second graph is a representation of river quality after a period of **prolonged wet weather**. This clearly demonstrates that storm overflows and agricultural diffuse loads cause a significant deterioration in water quality. There is an approximate four-fold increase in E.coli numbers from agricultural sources when compared to dry weather (the 'no CSOs' line). Adding storm overflow loads on top gives a near six-fold increase in E.coli concentrations. It is also interesting to note that when storm overflow inputs are fed into the model, the representation of a 50% agricultural load reduction makes very little difference. **This indicates that delivery of the safe bathing water objective requires significant improvements to both agricultural load and storm overflow inputs.**

Figure: Modelling river quality after a prolonged wet weather period



To assess which **storm overflows** require intervention we produced storm overflow spill volumes using our calibrated sewer hydraulic models. For this initial assessment, we used the 1-in-1-year events. Whilst it is likely that a small number of spill events per year will not prevent us from achieving our desired outcome, we have used the worst-case 1-in-1-year event as an allowance for the future impact of climate change, growth and urban creep.

To calculate available dilution, we used measured river flow data collected by the Environment Agency at their flow gauging stations. Flows in both the River Avon and the River Leam vary significantly, with peak flows being 10 to 20 times higher than in times of prolonged dry weather. We have therefore looked at the potential impact of each storm overflow under average and 80%ile flow conditions to identify those that are likely to cause a problem.

Table: Results of the mass-balance assessment for the Avon catchment

Overflow	Receiving river	Modelled CSO spill data			E coli loads			River flow m3/s		Dilution		High E. coli load		Medium E. coli load		Low E. coli load	
Asset Description	River	Modelled spill volume (Max) m3	storm duration hrs	Assumed spill vol. (m3/s)	High E. coli load (EC/100dl)	Medium E. coli load (EC/100dl)	Low E. coli load (EC/100dl)	River flow wet weather	river flow average	Dilution wet weather	dilution average flow	Wet weather concentration	Average flow concentration	Wet weather concentration	Average flow concentration	Wet weather concentration	Average flow concentration
Leamington - Adelaide Rd (CSO)	Leam	5444.28	8.00	0.19	5.00E+06	7.85E+05	1.56E+05	2.69	0.80	14.2	4.2	3.28E+05	9.60E+05	5.16E+04	1.51E+05	1.02E+04	2.99E+04
Leamington - Parade/Regent Grove (CSO)	Leam	3779.25	4.00	0.26	5.00E+06	7.85E+05	1.56E+05	2.69	0.80	10.2	3.0	4.45E+05	1.24E+06	6.98E+04	1.95E+05	1.39E+04	3.87E+04
Leamington - Princes DR (REF 19A) (CSO)	Leam	8598.78	8.00	0.30	5.00E+06	7.85E+05	1.56E+05	2.69	0.80	9.0	2.7	5.00E+05	1.36E+06	7.85E+04	2.14E+05	1.56E+04	4.26E+04
Leamington - Princes DR (REF 19B) (CSO)	Leam	1998.21	8.00	0.07	5.00E+06	7.85E+05	1.56E+05	2.69	0.80	38.8	11.5	1.26E+05	4.01E+05	1.97E+04	6.29E+04	3.92E+03	1.25E+04
Leamington - Stamford Gardens (CSO)	Leam	2056.50	8.00	0.07	5.00E+06	7.85E+05	1.56E+05	2.69	0.80	37.7	11.1	1.29E+05	4.12E+05	2.03E+04	6.46E+04	4.04E+03	1.28E+04
Warwick STW storm tanks	Avon	17391.76	8.00	0.60	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	15.8	7.9	2.97E+05	5.64E+05	4.66E+04	8.85E+04	9.26E+03	1.76E+04
Coventry Sowe storm tanks	Avon	51764.49	8.00	1.80	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	5.3	2.6	7.91E+05	1.37E+06	1.24E+05	2.15E+05	2.47E+04	4.28E+04
Coventry Sherbourne storm tanks	Avon	83104.35	8.00	2.89	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	3.3	1.6	1.16E+06	1.89E+06	1.82E+05	2.97E+05	3.62E+04	5.90E+04
Canley storm tanks	Avon	6040.80	8.00	0.21	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	45.6	22.6	1.07E+05	2.11E+05	1.68E+04	3.32E+04	3.35E+03	6.60E+03
Kenilworth TPS storm tanks	Avon	9392.31	8.00	0.33	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	29.3	14.6	1.65E+05	3.21E+05	2.59E+04	5.04E+04	5.14E+03	1.00E+04
Leamington - Lower Avenue (CSO)	Leam	2830.64	4.00	0.20	5.00E+06	7.85E+05	1.56E+05	2.69	0.80	13.7	4.0	3.41E+05	9.90E+05	5.35E+04	1.55E+05	1.06E+04	3.09E+04
Stratford - Shipston Road (CSO)	Avon	118.91	2.00	0.02	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	579.2	287.6	8.62E+03	1.73E+04	1.35E+03	2.72E+03	2.69E+02	5.41E+02
Stratford - Banbury Rd/Swans Nest (CSO)	Avon	207.67	1.00	0.06	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	165.8	82.3	3.00E+04	6.00E+04	4.71E+03	9.42E+03	9.35E+02	1.87E+03

Overflow	Receiving river	Modelled CSO spill data			E coli loads			River flow m3/s		Dilution		High E. coli load		Medium E. coli load		Low E. coli load	
Asset Description	River	Modelled spill volume (Max) m3	storm duration hrs	Assumed spill vol. (m3/s)	High E. coli load (EC/100dl)	Medium E. coli load (EC/100dl)	Low E. coli load (EC/100dl)	River flow wet weather	river flow average	Dilution wet weather	dilution average flow	Wet weather concentration	Average flow concentration	Wet weather concentration	Average flow concentration	Wet weather concentration	Average flow concentration
Stratford - Tiddington Road (CSO)	Avon	0.25	1.00	0.00	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	136435.2	67746.9	3.66E+01	7.38E+01	5.75E+00	1.16E+01	1.14E+00	2.30E+00
Tiddington - Main Street (CSO)	Avon	138.37	1.00	0.04	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	248.9	123.6	2.00E+04	4.01E+04	3.14E+03	6.30E+03	6.24E+02	1.25E+03
Snitterfield - Lodge Farm Drive (CSO)	Avon	266.68	1.00	0.07	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	129.1	64.1	3.84E+04	7.68E+04	6.03E+03	1.21E+04	1.20E+03	2.40E+03
Snitterfield STW	Avon	72.99	1.00	0.02	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	471.8	234.3	1.06E+04	2.13E+04	1.66E+03	3.34E+03	3.30E+02	6.63E+02
Stratford - Paddock Lane SPS	Avon	4553.94	8.00	0.16	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	60.5	30.0	8.13E+04	1.61E+05	1.28E+04	2.53E+04	2.54E+03	5.03E+03
Wellesbourne STW (CSO)	Avon	1944.58	4.00	0.14	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	70.8	35.2	6.96E+04	1.38E+05	1.09E+04	2.17E+04	2.17E+03	4.31E+03
Warwick - Charlecote (CSO)	Avon	351.17	1.00	0.10	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	98.1	48.7	5.05E+04	1.01E+05	7.92E+03	1.58E+04	1.57E+03	3.14E+03
Hampton Lucy (CSO)	Avon	72.99	1.00	0.02	5.00E+06	7.85E+05	1.56E+05	9.57	4.75	471.8	234.3	1.06E+04	2.13E+04	1.66E+03	3.34E+03	3.30E+02	6.63E+02

In summary, we have identified that the following intermittent discharges have a high potential, when operating in isolation, to cause a failure of the bathing water standard. There are a few more where the potential to cause a failure looks marginal and the volumes of sewage involved are very small. We have excluded these from the list below on the grounds that any intervention will be low cost (and there is every possibility that no work will be needed).

Table: storm overflow assets in the Avon catchment which require improvement

River Leam	River Avon	Sewage works storm tanks
Leamington - Adelaide Rd (CSO)	Canley storm tanks	Coventry STW (Sowe)
Leamington - Parade/Regent Grove (CSO)	Kenilworth TPS storm tanks	Coventry STW (Sherbourne)
Leamington - Princes Dr (REF 19A) (CSO)	Stratford - Shipston Road (CSO)	Warwick STW
Leamington - Princes Dr (REF 19B) (CSO)	Stratford - Banbury Rd/Swans Nest (CSO)	Wellesbourne STW
Leamington - Stamford Gardens (CSO)	Tiddington - Main Street (CSO)	
Leamington - Lower Avenue (CSO)	Snitterfield - Lodge Farm Drive (CSO)	
	Stratford - Paddock Lane SPS	
	Warwick - Charlecote (CSO)	
	Hampton Lucy (CSO)	

We have undertaken a similar modelling exercise on the River Teme to identify which assets have the potential to impact upon bathing water quality. This is not quite as accurate as the calculations undertaken on the Avon because the only measured river flow data available for the Teme is from a gauging station some distance downstream of Ludlow. This means that the actual impacts are likely to be slightly greater than the calculation show as river flows in Ludlow will be slightly lower.

For two of the storm overflows in Ludlow that spill into the River Corve, we have been able to use river flow data from a nearby gauging station.

Table: Data showing that intervention at Ludlow treatment works is required

Site name	Sewage works data				River flows		E. coli concentrations CFU/dl	
	Discharge type	Flow to full treatment (m3/s)	Dry weather flow (m3/s)	Bacterial conc. (EC/100ml)	River flow dry weather	River flow wet weather	Dry weather	Wet weather
Ludlow (STW)	Fully treated effluent	0.12	0.05	5000	1.99	21.10	128	28

As demonstrated in the table above this exercise has only identified one **sewage works** (Ludlow STW) that is likely to be discharging a meaningful level of harmful bacteria.

With regards to the **storm overflows** we have identified 5 that, when operating in isolation, appear capable of causing a breach of the required standard. One other overflow is close to this level and hence problematic if there are significant background levels of E.coli from upstream sources (or if any other overflow is operating). We have therefore based our package of interventions on spill reduction measures at all 6. Detailed feasibility work (including a full assessment on what can be delivered through diffuse pollution control), may enable some scaling back on these measures. However, we expect that spill frequencies will need to be kept to a low level to satisfy customer expectations.

Table: Mass balance calculations showing which overflows require improvement

Overflow	River	Modelled CSO spill data			E coli loads (CFU/100dl)			River Flow m3/s		Dilution		High E. coli load		Medium E. coli load		Low E. coli load	
Asset description	Receiving river	Spill volume m3	Storm duration mins	Assumed spill vol. (m3/s)	High	Medium	Low	Wet weather	Average flow	Wet weather	Average flow	Wet weather	Average flow	Wet weather	Average flow	Wet weather	Average flow
Ludlow - The Linney (CSO)	Corve	59	58	0.02	5.00E+06	7.85E+05	1.56E+05	1.38	0.54	81	32	6.07E+04	1.51E+05	9.53E+03	2.38E+04	1.89E+03	4.72E+03
Ludlow - Old Street (CSO)	Teme	515	439	0.02	5.00E+06	7.85E+05	1.56E+05	21.10	8.28	1080	424	4.63E+03	1.18E+04	7.26E+02	1.85E+03	1.44E+02	3.67E+02
Ludlow - Temeside (SSO)	Teme	6931	12644	0.01	5.00E+06	7.85E+05	1.56E+05	21.10	8.28	2310	906	2.16E+03	5.51E+03	3.40E+02	8.65E+02	6.75E+01	1.72E+02

Overflow	River	Modelled CSO spill data			E coli loads (CFU/100dl)			River Flow m3/s		Dilution		High E. coli load		Medium E. coli load		Low E. coli load	
Asset description	Receiving river	Spill volume m3	Storm duration mins	Assumed spill vol. (m3/s)	High	Medium	Low	Wet weather	Average flow	Wet weather	Average flow	Wet weather	Average flow	Wet weather	Average flow	Wet weather	Average flow
Ludlow - Ludford Bridge (SPS)	Teme	98	2314	0.00	5.00E+06	7.85E+05	1.56E+05	21.10	8.28	29978	11764	1.67E+02	4.25E+02	2.62E+01	6.67E+01	5.20E+00	1.33E+01
Ludlow (STW)	Teme	503	1704	0.00	5.00E+06	7.85E+05	1.56E+05	21.10	8.28	4285	1681	1.17E+03	2.97E+03	1.83E+02	4.67E+02	3.64E+01	9.27E+01
Ludlow - Fishmore View (CSO)	Corve	37	1129	0.00	5.00E+06	7.85E+05	1.56E+05	1.38	0.54	2520	993	1.98E+03	5.03E+03	3.11E+02	7.90E+02	6.19E+01	1.57E+02