Building sustainable, flood-resilient communities

Business case 03

Severn Trent
29 January 2021

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SEVERN TRENT

Executive summary

Flooding is a significant risk to the UK, surpassed on the national risk register only by the risk of a pandemic. Climate change, population growth and urban creep are all forecast to increase this risk over the coming years, meaning that flooding will affect more customers, more frequently, with greater severity. Flooding volumes from sewers nationally are predicted to increase by more than 50% over the next 30 years and, by 2050, an estimated 3.2 million people across the country will be at risk of flooding caused by surface water and urban drainage.

Although the water sector has made significant progress in tackling flooding in recent years, much of this work has focused on managing the symptoms of flooding rather than tackling the cause. The complex accountability of different types of flooding have likely hindered the widespread development of more innovative holistic solutions that attempt to manage flooding causes irrespective of effect. We know there are better ways to create futureproofed, flood-resilient communities – and that we can realise significant additional social, environmental and economic benefits while doing so. Using blue-green infrastructure – a nature-based flood solution – is fundamental to this aspiration. Many water companies, including Severn Trent, have been incorporating blue-green infrastructure into their wastewater strategies for several years, with positive results.

However, we currently only deliver these nature-based solutions where it makes short-term economic sense, meaning that the UK's use of blue-green infrastructure has remained small-scale. To unlock the transformation in flooding resilience that blue-green infrastructure promises, we need to deliver it at a far larger scale than has yet been tried, designing collaborative solutions with multiple stakeholders.

We propose to build the UK's first truly city catchment-scale flood resilience programme; a suite of blue-green interventions that will signal a radical change in our approach to managing surface water across a catchment and developing flood resilient communities. Our long-term vision is a transformed urban landscape that makes towns and cities more liveable in a changing climate (by providing shade and cooling in the summer and insulation in the winter). This will link urban wetlands and other wildlife-friendly spaces into blue and green corridors in our towns and cities to provide high-quality public space to relax, play and enjoy wildlife (see examples in Figure 1).

Figure 1: Blue-green infrastructure in Copenhagen (left) and Melbourne (right) actively manages surface water flows and provides wider regenerative and amenity benefits in urban settings

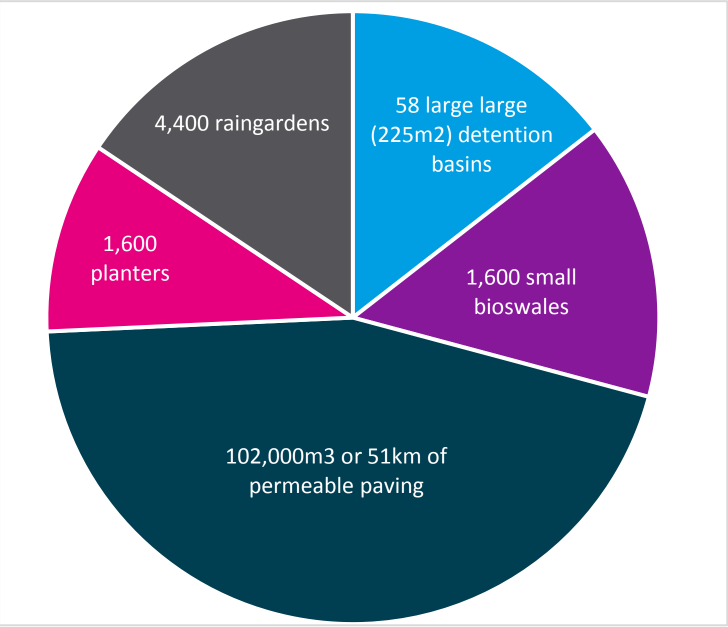
We will undertake the trial in our Mansfield catchment. It has the highest modelled flooding volume per population equivalent of all our major catchments, and this is forecast to increase by nearly 60%

through to 2050. In addition to the current flooding and sewer overflow vulnerabilities, we have chosen it because we are confident that it will deliver a meaningful trial at an appropriate scale; its catchment attributes should support the deployment of blue-green infrastructure; and the socio-economic circumstances mean it is well placed to benefit from wider community and environmental gains.

Assuming our modelled forecasts are robust, and our future duties will require us to deliver service at least in line with current levels, it is likely that we will need to deliver material network capacity improvements in Mansfield in AMP8 or 9. These proposals allow us to deliver required interventions using a more sustainable and efficient approach. Given that the proposed blue-green interventions also deliver net benefit to customers and communities, we consider that the business case is strongly in the customer interest.

A range of scenarios setting out how blue-green interventions might be deployed in Mansfield are set out in section 2. We are planning to deliver the equivalent of up to 60% (58,000m^3) of the future network storage that would be required in Mansfield up to 2050 (see Figure 2). This is equivalent to the volume of more than 23 Olympic swimming pools. Interventions will likely include the installation of more than 15,000 blue-green infrastructure features such as planted detention basins and bioswales, permeable paving, street planters and bioretention tree pits, verge rain gardens and rainwater downpipe planters. This could cover more than 15 hectares of the catchment, improving the urban fabric, providing high-quality green space for communities and boosting biodiversity.

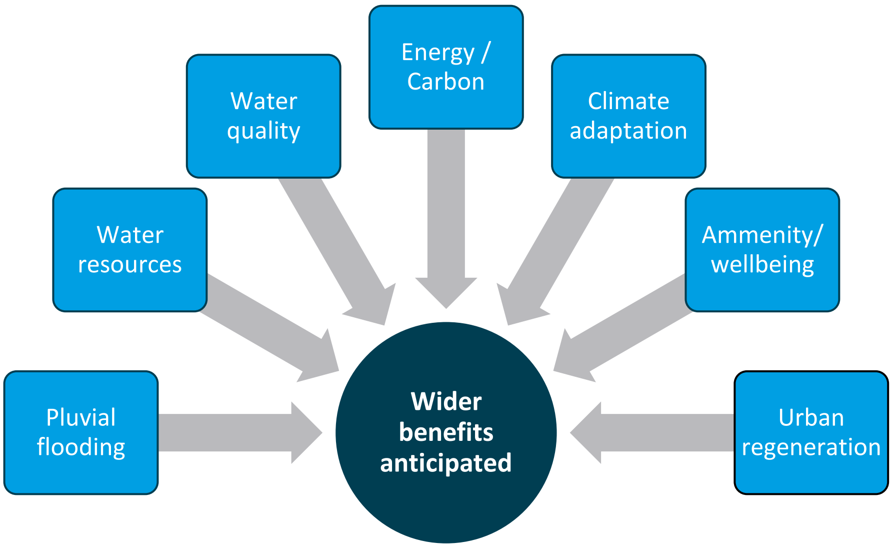
Figure 2: one of the scenarios we have developed and costed for the Mansfield catchment for blue-green infrastructure, equating to the equivalent 58,000m^3 of network storage



Our proposals are a material uplift to the scope of the blue-green interventions that we have delivered to date. They acknowledge that traditional network storage approaches will become increasingly expensive and ineffective in the face of future pressures. Our trial is seeking more sustainable and economic solutions that consider surface water management and flooding across catchments holistically rather than in separate accountability silos. Acting now should unlock the necessary system-wide allocative efficiencies and insights needed to move the UK to the forefront of affordably utilising large-scale nature-based flood management solutions. It will require extensive collaboration and exploration of new delivery models that deliver and maintain holistic interventions. The investment should also create up to 385 sustainable jobs to stimulate the Green Recovery. The way in which we plan to deliver our proposal is set out in section 3.

At a cost of up £85m, the programme will help to manage the holistic future surface water flooding pressures in the Mansfield catchment in a way that also satisfies our sewerage duties. Interventions will be delivered in partnership with other catchment stakeholders and the local community. This should drive results for flooding pathways currently managed separately by others (pluvial, groundwater, fluvial), improve local water quality by better managing sewer overflow spills, help water abstraction pressures and deliver wider societal benefits (including amenity, health and wellbeing, and urban regeneration). We have quantified that some of these wider benefits for customers and communities will have a present value of more than £30m (Figure 3).

Figure 3: our holistic proposals for blue-green interventions will create a wide range of benefits



In contrast, staying on our current course means a future spent trying to 'outbuild' the effects of climate change, population growth and urban creep, leading to a bloated and increasingly unaffordable 'grey' infrastructure underutilised most of the time, but placed under huge strain during storm events. The cost of this in Mansfield would be around £[redacted] for 100,000m^3 of extra network storage that would be required by 2050. Cost benefit analysis shows that our scenarios deliver net benefits of up to £[Redacted]m to customers and communities compared to this counterfactual approach. Target costs, interventions and benefits are identified in sections 4 and 5.

Costs and solutions are location-specific, and we want the solutions to be co-created with the community and stakeholders. This means that inherent uncertainty remains with the precise interventions, and therefore the overall costs of this business case. We have managed this risk through our robust estimating methodology, and it is further mitigated by the fact that customers will not pay for most of these improvements until the green infrastructure has been delivered. We have proposed enhanced assurance to ensure a high level of transparency of costs and benefits throughout the design and delivery of the proposal. Our approach to customer protection and cost recovery is set out in section 6.

Contents

1. The need for investment

Flooding is a major risk to communities and businesses in the UK. The increase in flood volumes predicted in the next 30 years will result in flooding affecting more customers, more frequently, with greater severity. The Green Recovery provides the perfect catalyst to accelerate our ambition for sustainable, resilient communities in the long term, while creating jobs and supporting economic growth in the short and medium term.

We are using this opportunity to rethink the traditional remits of the many agencies involved in flood resilience. We may never again find ourselves in a situation where agencies' timelines and remits are so closely aligned, or in which we can so rapidly create the space to trial new ways of working to help protect communities in the future.

We could wait another five years before investing in a trial programme of this scale. The primary long-term benefit, the creation of a flood-resilient community, in line with our legislative remit and Government priorities, would still be achievable. However, we believe that for the reasons set out under the following headings, now is the right time to move forward with this investment.

Locking in long-term benefit for customers

As climate change, population growth and urban creep increase the pressure on our sewerage network, we will need to accelerate our investment in the future to deliver current or improved levels of service. It will become more expensive to keep increasing physical sewerage network capacity. An early investment in nature-based flood management solutions (blue-green infrastructure), at a time when the cost of borrowing is low, will reduce the cost of this necessary transition, offering strong protection for customers.

This business case will offer protection to the population of 89,000 customers we currently serve in the Mansfield catchment. Through this investment we will also gain a better understanding of how to unlock new interventions, ways of working and efficiencies so that the approach can be effectively rolled out across the breadth of our customer base in the future. Taking this opportunity now will enable us to move quicker to unlock wider benefits in AMP8 and beyond. Given that the future challenges faced are not specific to Severn Trent, we will publish our findings to make sure that the knowledge and improvements we generate can be used more widely across the country.

Immediate, visible customer benefits

Flooding can disproportionately affect more vulnerable members of society, as they are less able to recover the attendant economic damage caused. Focusing the investment in Mansfield, with its elevated levels of deprivation, means we are supporting those that potentially have more to gain[1]. A catchment-scale trial of blue-green infrastructure will deliver increased access to urban green spaces and enhanced biodiversity, all of which have the broad support of customers. It will also be a visible proof-point that investment is being made to manage flooding and build sustainable communities. This is an important consideration in the context of customers' frustration with the current multi-agency approach, and their potential wariness surrounding the applicability of the innovative solutions to effectively manage flooding risk.

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[1] Mansfield is ranked 8th out of more than 60 local authorities that we serve based on the 2020 Index of multiple deprivation average scores.

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 up to 385 much-needed jobs within our region. Through the Severn Trent Academy, we will also focus on green skills development, increasing our capabilities in areas that are likely to be required increasingly in future. These include specialisms in designing, constructing and maintaining sustainable drainage and blue-green infrastructure features. We plan to target components of this upskilling programme at 18-24 year olds, who have been among the hardest hit during the pandemic.

Delivering on Government priorities

There are growing calls from Government to implement collaborative nature-based flood management solutions. The 25 Year Environment Plan challenges water companies to manage flood risk through collaborative nature-based solutions. The £200m fund for flood and coastal resilience innovation, open to local authorities, has a similar focus. Our trial programme will encourage collaboration at the scale and pace required to deliver on these priorities.

The Environment Bill will place a statutory requirement on water companies to produce drainage and sewerage management plans to help deliver more of the actions needed to address the risks sewerage assets may pose to the environment. This reinforces a growing policy focus on sewer overflow performance including the new Storm Overflows Taskforce which has to long term goal of eliminating harm from storm overflows[2].

The need to future-proof urban areas to climate stresses is also increasingly clear. Blue-green urban infrastructure has an important part to play in managing future flooding and drought, as well as controlling temperature by providing shade and evapo-transpirative cooling in the summer and building insulation in the winter.

Why do we need a catchment scale trial programme?

There is a growing evidence base emerging from abroad where sustainable drainage and blue-green infrastructure have been effectively deployed. Notable examples include Copenhagen, Barcelona, Rotterdam, Amsterdam and Melbourne[3]. In each case, multifunctional green infrastructures are being developed to treat, direct and retain water within urban landscapes. In addition to the direct water management deliverables, these cities have included and valued clear urban amenity benefits as part of the case for change. This links with growing urban planning and public health expectations relating to community mental and physical health provision.

We have a good record of delivering collaborative drainage using strong relationships with local stakeholders. However, we recognise that these projects are small scale, and we have not transitioned into delivering the catchment-wide solutions that will be needed to address forecast future challenges. Differing constraints, priorities and methods have meant that each case is bespoke, leading to a disaggregated development of sustainable drainage. Ensuring the ongoing maintenance and effectiveness of blue-green interventions has also been a historical weakness.

[2]https://www.gov.uk/government/news/taskforce-sets-goal-to-end-pollution-from-storm-overflows
[3]https://www.researchgate.net/publication/324455458_Understanding_the_role_of_the_water_sector_in_urban_liveability_and_greening_interventions_Case_studies_on_Barcelona_Rotterdam_Amsterdam_Copenhagen_and_Melbourne

The Green Recovery provides us with the opportunity to think boldly, and outside our traditional remit (the current remits and responsibilities for different aspects of flooding are set out in Appendix A). We are proposing the UK's first city catchment-scale flooding resilience trial programme. A key component is to work with partners, innovators and decision makers to remove current barriers to catchment-scale intervention, creating a marketplace for solutions and a blueprint for deploying at scale across wider catchments. This trial should specifically allow us to:

- Generate insights on costs, benefits, technology and approaches for building flood-resilient communities that will be relevant across the UK in the face of future environmental and social challenges, increasing resilience and driving down costs;
- Build the competencies and skills we need for the creation and maintenance of blue-green infrastructure and understand how it is best maintained and managed so that it remains fit for purpose over time;
- Provide a trial space for the relevant agencies to collaborate beyond their current remits and co-design solutions with the local community. (the regulatory frameworks of the cities listed above are different from the UK, so one of the key aspects of this programme will be to find ways of working collaboratively within the UK context);
- Allowing us to undertake more detailed, rapid and robust assessments of the opportunities for blue-green infrastructure, understanding and valuing benefits, and identifying appropriate adaptation pathways over time, enabling us to create a marketplace to drive down costs and speed up delivery so that blue-green interventions can be effectively rolled out at bigger scale in the future; and

Share the outputs of the trial so that we can play our part to stimulate the uptake of blue-green infrastructure for the purpose of surface water management across the UK and further afield.

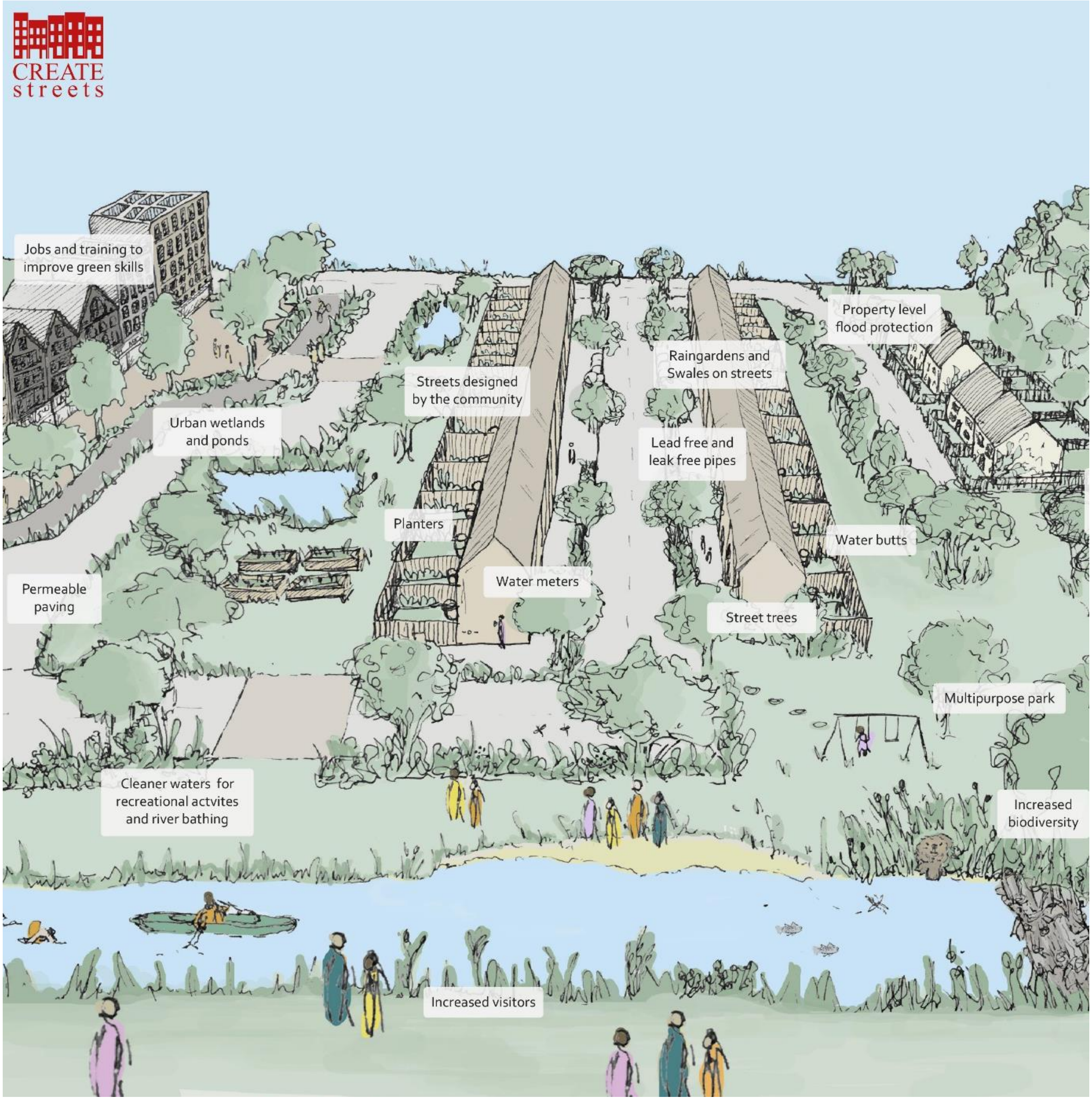
1.1 Our long-term plan for flood-resilient communities

Our proposed trial is the first step in refocusing our flood resilience strategy away from traditional grey infrastructure and towards blue-green infrastructure. The trial will help us to understand how we do this more quickly and efficiently than has been possible to date. We believe that this shift is critical for creating flood-resilient communities in the long term, protecting households and meeting the UK's social and environmental challenges.

1.1.1 Our vision for the future

Truly flood-resilient communities are those in which we manage the flow of surface water through urban catchments in a way that improves the natural, built and social environment that we all share.

Figure 4: Our vision for a future urban catchment reflecting deployment of the interventions assumed in this and our other Green Recovery business cases.



Our vision (as illustrated in figure 4) is for urban landscapes that mimic the processes of natural catchments. Large-scale use of blue-green infrastructure will mean that the landscape itself controls the flow and volume of surface water, reducing pollution downstream of development and promoting the recharging of groundwater. Increased natural vegetation helps attenuate flows, trap silts and pollutants, promotes infiltration and deters erosion. It also enhances evapotranspiration, removing significant volumes of water from the drainage basin to the atmosphere, and reduces the 'heat island' effect, making our cities more liveable in the face of climate change.

Blue-green infrastructure integrates surface water management and water quality improvements with community and biodiversity benefits. Urban wetlands and other wildlife-friendly spaces will form blue and green corridors in our towns and cities. In future, 'grey' solutions will be favoured only where blue-green interventions are not technologically or economically feasible.

There is a growing list of Government guidance and national strategies that all support our vision, i.e. the need to better manage flooding risks in a joined-up way using blue-green infrastructure. This is discussed in more detail in Appendix B.

1.1.2 Enabling acceleration of our strategy for the long term

Blue-green infrastructure is already a key component of our wastewater network strategy, and will play an increasing part in our mix of investments in future. Our experiences show that blue-green infrastructure is most likely to be beneficial where we work with partners to deliver joint benefits; there are many examples of this at small scale.

Our strategy is supported by our existing green communities and collaborative flood resilience Outcome Delivery Incentives (ODIs). The Green Communities and Collaborative Flood Resilience ODIs are discussed in more detail below (while they are a helpful way of making marginal improvements when delivering network interventions, they are not appropriate for delivering the catchment-wide interventions proposed in this business case).

We recognise the rate of progress of delivering these solutions is not currently fast enough, given the challenges we face to mitigate the risks of climate change. This is supported by the early findings from our Drainage and Wastewater Management Plan (DWMP) investigations.

This business case is a significant opportunity to identify and reduce constraints to this type of solution. Through these proposals we will accelerate the scale and pace at which we deliver the improvements that support our vision, and will generate benefits for other partners through effective management of surface water.

The proposed catchment-wide trial will test how to best update the way in which we deliver our strategy in the future. It will provide us with the evidence base, confidence and tools needed to move more rapidly to a delivery approach that more explicitly promotes blue-green interventions. This is described in Table 1:

Table 1: our approach to delivering benefits through our wastewater network strategy

Delivering our wastewater network strategy:
"Keep the rain away from the drain." When managing surface water that has historically – or could in future – enter our sewers, our default should be to seek to do this through blue-green infrastructure. Only where economics, technological or logistical constrains prevent this should we make traditional 'grey' interventions. This approach will also provide benefits to other partners where surface water flood risk is an issue.
"Keep only 'poo, pee and paper' in the pipe." Maintain the hydraulic capacity and performance of the flows that need to remain in the sewer. Namely: current foul flows, future growth and surface water where blue-green is not currently feasible (due to economics or technological/logistical constraint).
"Keep the plan sensitive to the possible." The capacity of blue-green infrastructure to manage surface water will change over time as our understanding of this new approach improves and the environment on which our catchments sit also change. We should make sure that our future planning is dynamic and adaptable so that we make increasing use of blue-green as: our ability to use it improves; the need increases (i.e. with accelerating climate change); and legislative changes and customer expectation demand it.

Many of our major urban catchments could benefit from such changes in the future, and the drivers of action are only going to increase. The knowledge we gain from a catchment-scale demonstration can be used to inform how greater benefit could be extracted from its implementation across additional catchments in AMP8, rather than delaying this learning into AMP8 and subsequent roll-out later into AMP9.

To illustrate the increase in ambition proposed, likely deployment of blue-green infrastructure through our existing green communities ODI equates to approximately 3% of our assumed AMP7 wastewater network capacity related expenditure (the committed performance level for the Green Communities ODI will be delivered through a £5m AMP7 programme). The Identified Mansfield trial will target 59% of future pressure managed by blue-green infrastructure (scenario 2 assumes 59% of the Mansfield 2050 pressure will be delivered through blue-green infrastructure, see section 5).

The Mansfield catchment reflects approximately 0.9% of the wastewater population that we serve, and the future pressures should impact on most of the catchments across our region in the future. Therefore, the trial should allow our level of ambition to increase further as we move towards 2050. We expect the trial to unlock some of the interventions and delivery economics that will be necessary to make this transition more affordable and sustainable. With this thinking, we anticipate that the deployment of blue-green infrastructure within catchments will be able to increase further (Scenario 3 shows the potential to deliver 94% of catchment pressure through blue-green infrastructure. However, the cost effectiveness of current interventions means that further learning (which we hope to leverage from our trial) will be required, see section 5).

Distinguishing the Collaborative Flood Resilience and Green Communities ODIs

At the highest level, the Collaborative Flood Resilience and Green Communities ODIs have similar aims to this business case. However, there are fundamental differences that would make the current ODIs overly restrictive and ill-suited to recovery of the costs set out in this document, which focuses on long-term sustainable surface water management.

The current Collaborative Flood Resilience ODI is focused more narrowly on delivering a required level of current flood risk reduction (from all sources) to specific properties. Consequently, it requires tightly defined sewer flooding improvements that are validated by models which are not relevant to wider surface water management. The ODI is also insensitive to how the benefit is delivered, whereas this business case focuses clearly on sustainable blue-green solutions. The current ODIs are not scaled to recover total incurred intervention costs; instead, they are incentives to do the right thing in the face of procedural barriers where it would be easier to act narrowly and in isolation.

The Collaborative Flood Resilience ODI incentive rate is based on the marginal cost saving of a Sustainable Drainage System (SuDS) scheme relative to a counterfactual storage solution. This ODI focuses on reassuring customers that we will act in a way that considers all flooding aspects and does not fully reflect the wider network and climate change resilience aspects of this business case (it pays no attention to the wider Green Recovery benefits we are assuming). Scaling up the current Collaborative Flood Resilience ODI could also create unintended consequences, such as driving us to install cheaper flood mitigations on properties which would not generate the longer-term holistic benefits desired.

The Green Communities ODI reflects only the marginal cost of improving interventions in a way that provides targeted wider benefit to the community. This ODI measures the natural and social capital benefit in the immediate location of the intervention. This encourages us to focus on the community benefits at a very localised level rather than driving the optimum solutions at a catchment level. The Collaborative Flood Resilience ODI requires collaboration at a granular intervention level, whereas a catchment-wide approach focuses on partnership working at the whole programme level.

1.2 Customer engagement and support

We have communicated with customers on flooding through our regular customer engagement mechanisms for many years, and have sought their feedback on this proposal specifically. Customers and wider communities show high concern for flooding and equally strong support for nature-based solutions.

1.2.1 How community expectations are changing

There is a growing awareness of the societal cost of flooding and its disproportionate impact on the most vulnerable. Flooding can have a major negative impact on people's health, relationships, and wellbeing[4]. The psychosocial impact of flooding is often heightened by secondary stressors (personal and property losses, relocation), which impact on personal social support networks[5]. The Joseph Rowntree Foundation identifies the need for flood risk management work to better support the most vulnerable sections of society[6]. National Infrastructure Commission research also shows that there is support for the delivery of a consistent level of flood resilience[7]. When developing and identifying the interventions assumed in this business plan, we have considered how they can actively improve the lives of vulnerable people and disadvantaged communities.

Communities are highly concerned about flooding; they find the cyclical nature of flooding and water resource stress perplexing and are disappointed when the multiple stakeholders deliver clear sub-optimal service as a result of working in isolation. Individuals do not identify separately as water customers, taxpayers, council residents, homeowners or infrastructure users, so the management of community flooding in discrete units makes little sense to them.

1.2.2 What our customers tell us about flood resilience

When our wastewater service fails, the impact is significant, often resulting in a discharge of sewage either to the environment or into customers' homes and gardens. Our PR19 research identified that this is a significant driver of dissatisfaction and distrust amongst our customers.

We also found that customers recognise that other forms of flooding, such as highways flooding or river flooding, can impact on people's lives just as much. Customers consider that we have a part to play here and can lead initiatives that may benefit wider society and the environment in some way. These findings led to us expanding our commitments for AMP7 with the introduction of the Public Sewer Flooding metric, the first of its kind in England and Wales.

During detailed deliberative research undertaken as part of the development of this business case, we began exploring in more detail the concept of sustainable urban drainage and the use of blue-green infrastructure. Through this research, we learned that our customers were positive about their potential (see Figure 5).

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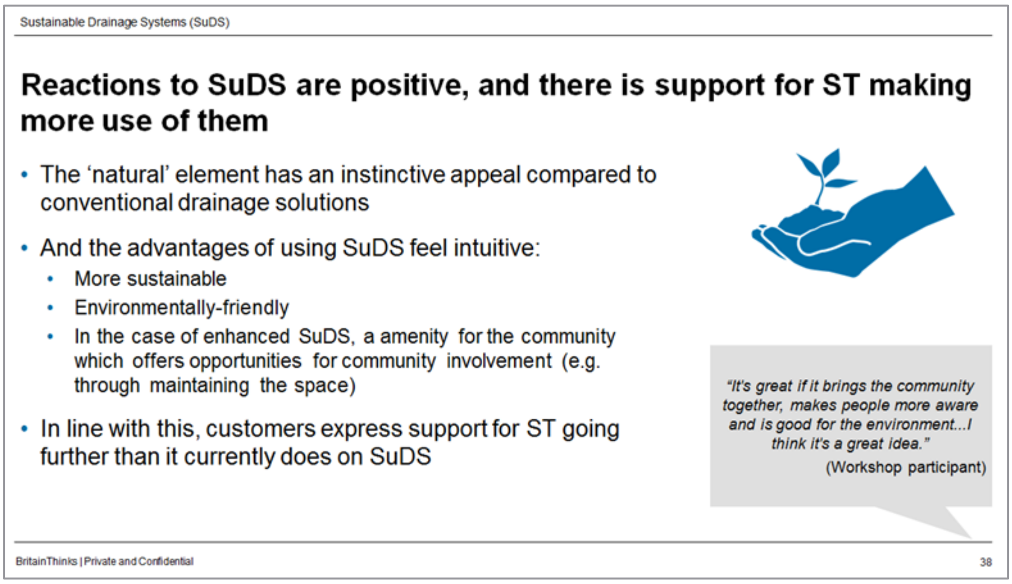
[4] North, C. S. (2014). Current research and recent breakthroughs on the mental health effects of disasters. Current Psychiatry Reports,16(10), 481.

[5] Stanke, C., Murray, V., Amlôt, R., Nurse, J., & Williams, R. (2012).The effects of flooding on mental health: Outcomes and recommendations from a review of the literature. PLoS Currents,4.

[6] https://www.jrf.org.uk/report/targeting-flood-investment-and-policy-minimise-flood-disadvantage

[7] The National Infrastructure Commission 2018. 59% of people agreed that everyone should have the same standard of flood resilience, even though some properties cost more to protect. Only 16% were against.

Figure 5: We have gathered customer views on blue-green infrastructure, which show support for their use



1.2.3 Our customers' experiences of flooding

In developing this business case, we held two online focus groups; one amongst customers who had experienced flooding in their home (mix of flooding due to rainwater, sewage and river water), and one amongst customers living near to blue-green SuDS features that have already been installed.

For those with experience of flooding, future floods are a real concern.

Most feel the problems that caused their flooding have not been addressed and that they have not received adequate support to protect their properties in future.

"People who live in areas that can get flooded, it can be quite distressing. You can't get to work. You can't get to the hospital." - Experience of Flooding focus group

There is a feeling amongst both groups that no one is taking responsibility for flooding, as so many agencies and organisations are involved in flood prevention. This view was especially strongly expressed by victims of flooding, who perceived they had been passed around organisations without getting much help. Customers said they would be happy for Severn Trent to take the lead on this.

"We've had this problem once so far, surface water flooding. We contacted Severn Trent but then found out it wasn't their responsibility. So we went to the council and they weren't much help." - Experience of flooding focus group

"What's the difference between a normal river and a main river? It feels like it's all a grey area where the responsibility is." - Live near SuDS focus group

Awareness of blue-green infrastructure and SuDS is low, even amongst those who live near them.

As a result, those living in communities where SuDS had been installed perceive there has been little information and engagement with communities about their installation and impact.

"I think always getting the local community involved right from the beginning is very important, in terms of consultation and empowering them, having that sense of belonging and responsibility." - Live near SuDS focus group

1.2.4 Customer feedback on our proposal

Customers are positive about our proposal.

Our proposal to introduce more SuDS to prevent flooding was well received, because of the perceived benefits to the environment, to neighbourhood amenity and prevention of some flooding.

"I'm really interested [in this proposal] because my sister has a green roof and I hadn't thought of that as a flood defence. I think it would improve the area and be really enjoyable." - Experience of Flooding focus group

"You would think [this proposal means] there would be less flooding and they would be pleasing to urban settings." - Experience of Flooding focus group

"You think flood barriers are horrible plastic things that are built as high as possible, but these actually look quite nice." - Experience of Flooding focus group

"I'd like to see more green space [like these SuDS]. It would have other benefits for mental health and get more bees which we need." - Live near SuDS focus group

We also explored the options with our online engagement forum, TapChat. The proposed nature-based solutions, such as new ponds and trenches and tree planting, are widely held to be a good idea, not only because they help to alleviate flooding, but also because they enhance the environment and provide neighbourhood amenity.

"I definitely like the idea of using nature in flood defence. More trees, lakes, ponds and trenches will be beneficial to both the customer and the local environment." - Customer, Tap Chat

There are some concerns about efficacy of SuDs and the cost of the proposal.

Reassurances will need to be provided on effectiveness and maintenance to secure strong support.

"I have a feeling that just having green spaces wouldn't be enough [to stop my home flooding]." - Experience of Flooding focus group

The proposed investment in separate sewers for rainwater and for sewage is also considered positively, but some are concerned about the cost of this. Some expected that Severn Trent would already be doing this.

"Separating sewage and rainwater sounds sensible but the cost would be huge." - Customer, Tap Chat

"I don't see your proposal as being anything new and it's something that STW should be doing anyway." - Customer, Tap Chat

Customers expect collaboration and levelling-up.

Customers wanted to see Severn Trent work with other agencies, prioritise high impact customers and engage with customers about their plans on both an individual and community level.

"Make sure you involve the community as they are more likely to have good ideas of what will work and if people feel included will be more invested in its success." - Experience of Flooding focus group

1.3 Best value for the long term

There is wide agreement – including from Government and industry regulators – that a futureproofed strategy for flooding resilience must become less reliant on traditional 'grey' infrastructure and embrace the wider benefits of blue-green infrastructure to manage surface water flows. Although 'grey' infrastructure will always have a place in wastewater management, a significant shift in strategy is needed to create truly flood-resilient communities.

1.3.1 Grey infrastructure: a losing battle

The maintenance and expansion of our foul sewer network and the use of traditional mitigations will remain important for the foreseeable future to effectively manage growth requirements. However, traditional network assets ('Grey infrastructure') are not well placed to respond to high return period storm events.

Designing fixed networks for low likelihood storm events means that, most of the time, assets are oversized. To address this, sewers have been traditionally sized to deliver against 1:20 return storms. However, surface water pressures mean that storms of a defined return period are now much larger than in the past. Therefore, the level of flood protection or sewer overflow performance assumed is dropping and traditional interventions are becoming an increasingly ineffective response. This is particularly the case for existing assets, which are difficult and expensive to retrospectively upsize.

It is predicted that 3.2 million people in the UK will be at risk of flooding from urban drainage provision by 2050[8], largely driven by:

- Climate change (increasing surface water entering combined systems);
- Population growth (more sewerage connections increasing foul flows); and
- Urban creep (increasing impermeable areas and therefore surface flows).

These future pressures are described in more detail in Appendix C. The consequence is that there is an increasing need for a step change in the use of blue-green infrastructure (or SuDS) solutions which is much more adaptable to a changing storm return baseline. Without such a change of approach, we face:

- A future spent trying to out-build increasingly larger, higher intensity and more frequent storm events anticipated due to climate change. This will lead to bloated infrastructure which remains unused most of the time but is then placed under extreme stress for short, sustained periods, and, in the long term, will not deliver the performance we need.
- Corresponding flooding and sewer overflow performance challenges as traditionally engineered 'grey' interventions and mitigations become less able to manage the increased volume of flows, and mitigate the water quality impacts (increasing road runoff is likely to discharge into water courses, increasing diffuse pollution).
- Networks that may be able to accommodate growth pressures in isolation but now require costly reinforcement which otherwise could have been avoided.
- Cost and carbon challenges from emissions embedded in large capital structures, as well as greater pumping and chemicals-related emissions due to moving and treating increasing amounts of sewerage.

1.3.2 Moving away from short-term economic appraisal

When designing our wastewater strategy, we focus on the costs and benefits that relate directly to our specific duties. This means that our emphasis has been on investing in our current network so that

8 Houston et al (2011): Pluvial (rain related) flooding in urban areas: the invisible hazard. Joseph Rowntree Foundation, York UK.

we can maintain the hydraulic capacity and performance of each catchment. Innovative blue-green interventions, which deliver wider future benefits, are increasingly seen to be more allocatively efficient from a wider catchment perspective. However, they are more complex and time consuming to deliver. This means that, on sewer flooding grounds alone, narrow economic appraisal is not likely to promote large-scale blue-green solutions. The Collaborative Flood Risk ODI provides a partial remedy to this issue at a local scale, but is not likely to facilitate transformative change at a catchment level – this has already been described in more detail above.

Our ability to maintain and drive productive efficiency is also being challenged. We have successfully targeted substantive hydraulic sewer flooding interventions where the risks are highest. Consequently, future solutions are likely to be increasingly dominated by short-term cost-effective flood mitigations rather than substantive network resolutions that solve rather than manage the identified issue. As an example, we currently build our wastewater network expenditure programmes with reference to the level of risk removed for the cost incurred (termed 'affordability'). We have seen the number of network intervention projects that meet this affordability threshold reduce from AMP6 to AMP7. Concurrently, we have seen the amount of short-term mitigation expenditure double in 2020/21 relative to our business plan forecasts.

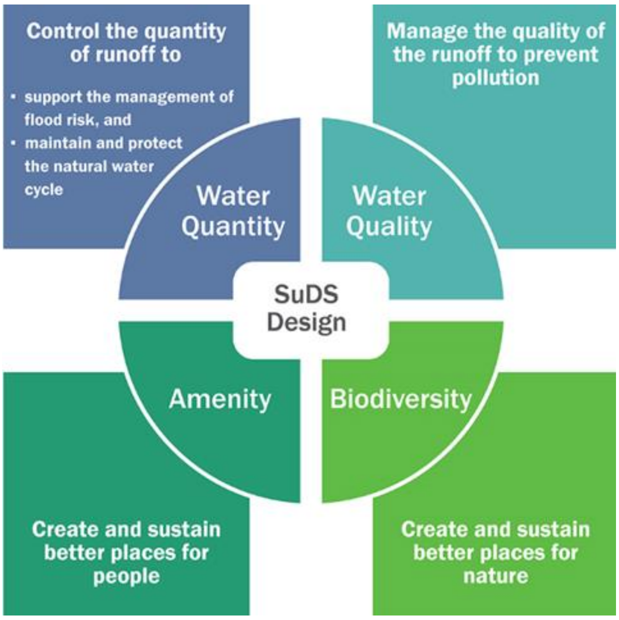
Therefore, to reduce sewer flooding more efficiently (both productively and allocatively) over the long term, we urgently need a joined-up approach to tackle the cause of our networks coming under strain. This means refocusing on the management of surface water flows across catchments, above and beyond the resultant sewer flooding it leads to. Holistically managing flooding using blue-green infrastructure at a catchment scale should unlock system-wide efficiencies. The logic for accounting for these wider benefits is reinforced by the fact that our water customers are also the same communities and citizens that will stand to benefit.

When considering the future pressures we will face – and the potential benefits to water customers, communities and citizens – there is a clear economic, societal and environmental case for increasing the deployment of blue-green infrastructure now (even though a short-term narrow economic appraisal might encourage us to maintain the status quo).

1.3.3 Realising additional social and environmental benefits

There is growing consensus that the use of collaborative blue-green interventions for management of surface water flows deliver benefits for water customers, are an effective way of managing wider flooding and water quality issues, and deliver wider community and societal benefits. These benefits can only be delivered if they are designed into the process from the beginning. This is core to the four pillars of SuDS design shown in Figure 6:

Figure 6: The 'four pillars' of SuDS design (source: CIRIA SuDS Manual)



Urban conurbations are predominately influenced by the built environment – including our 'grey infrastructure'. Quality of life, health and personal fulfilment are closely related to the provision of green space. Integrating the 'green' (soft areas, plants and trees) with the 'blue' (watercourses, ponds, lakes and storm drainage) elements makes our urban spaces more resilient, pleasant and healthy places to live, work and play.

Combining 'green' and 'blue' elements together is an effective way of providing a sustainable natural solution to urban and climatic challenges. Vegetation assists with air pollution removal, storm water management and heat island effects as well as creating places which are more pleasant and less stressful to live in.

More effective, holistic flood management, with thoughtful, community-led design that considers amenity benefits from the start, can unlock multiplier benefits that include:

- Long-term water resources planning and drought resilience.
- Biodiversity challenges that impact on the whole of society.
- Community-wide health, wellbeing and education / skills requirements.
- Regional / national economic growth / housing challenges (including household insurance).

We describe and set out the pathway of the wider benefits that can be anticipated from the deployment of blue-green infrastructure in Appendix D and section 5.

The Grey to Green project case study (Figure 7) describes how we set out to regenerate an area of urban Sheffield by working with acclaimed Chelsea Flower show designers and introducing sculpture that reflected the area's past[9]. The project objectives were to create an attractive setting for existing and new investment and jobs, improve the city's resilience to climate change, enhance the public realm, and boost connectivity of the area to the rest of the city centre.

9 http://www.greytogreen.org.uk/index.html

Figure 7: 'Before' and 'after' views of the Sheffield 'Grey to Green' project

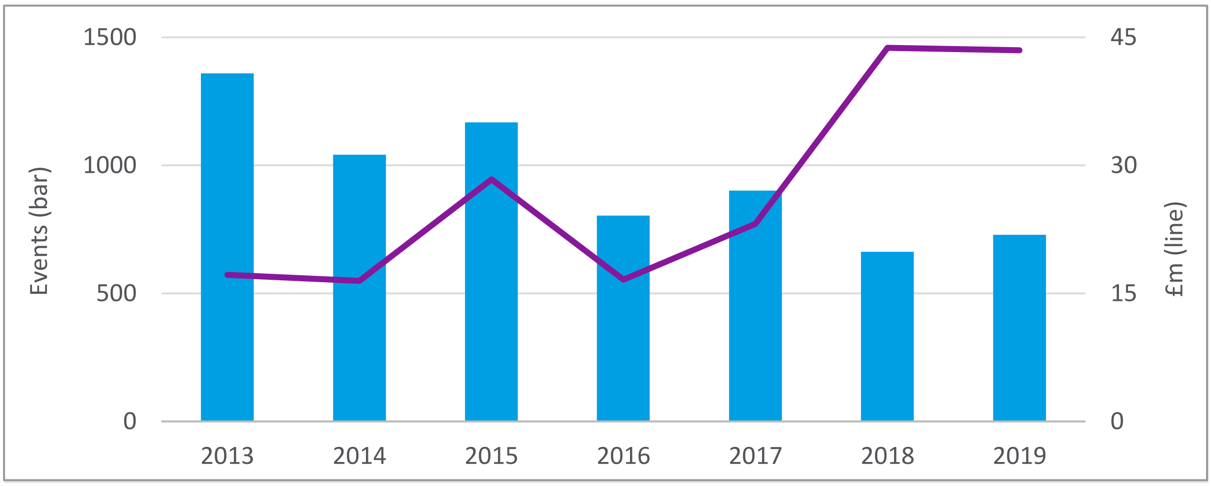
1.4 Accelerating the achievement of Government priorities

The Government and our industry regulators are increasingly calling for the use of blue-green infrastructure to build flooding resilience and realise wider benefits such as amenity value, health and wellbeing, and urban regeneration. In this section we explain how our Mansfield trial is a much-needed step to allow us to make this shift for the long term.

As guided by our duties, we currently consider surface water management through the lens of managing sewer flooding and controlled network releases at storm overflows.

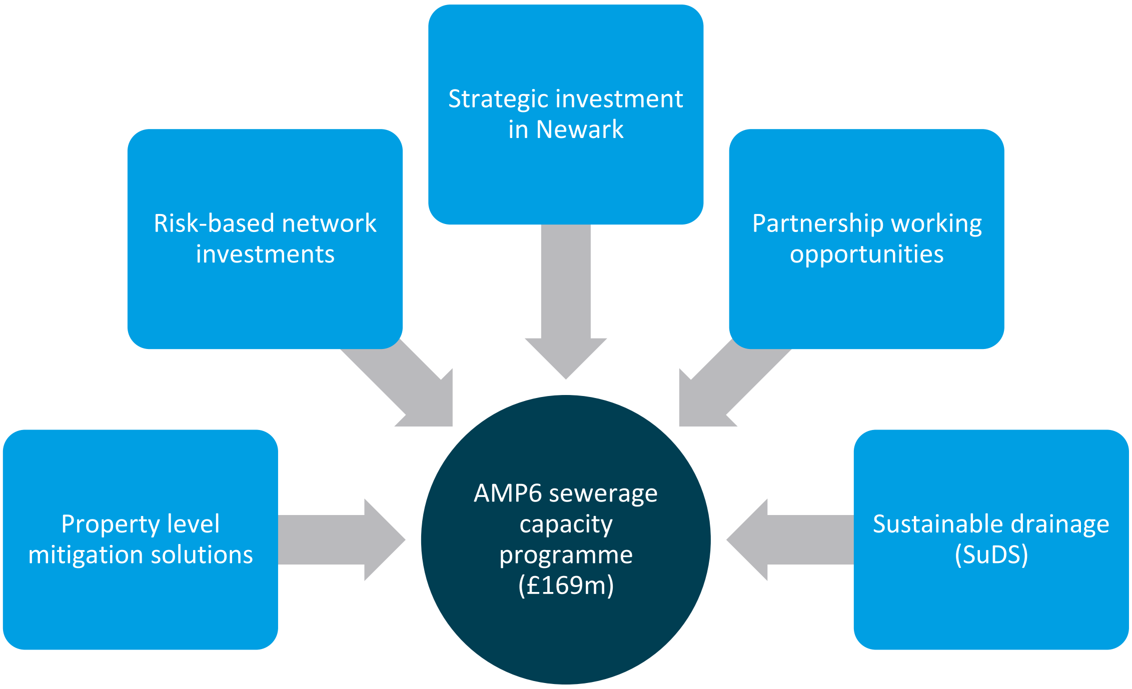
Our activities have delivered material flooding improvements and have identified us as an environmental leader. Sewer flooding performance has materially improved over the last two asset management periods. This is a result of increasing our investment levels substantially (shown in Figure 8). However, with this narrow focus, improving performance inevitably increases marginal costs as step change strategic interventions become harder to deliver.

Figure 8: Severn Trent Internal Sewer Flooding performance and expenditure. We have increased our investment in sewer flooding substantially in the last five years



Our wider environmental performance has also been recognised in our EPA 4-star status, which the Environment Agency (EA) has conferred on us for three of the last five years. In AMP6, we invested £169m in enhancement to increase sewerage capacity (see Figure 9).

Figure 9: Areas benefiting from our AMP6 investment in sewerage capacity enhancements



As part of our current approach, we already explore the potential of blue-green infrastructure (SuDS) at small scale, and deliver it where we can be certain that it can outperform 'grey' interventions on economic measures over the short term. Examples of interventions that we have already installed or contributed to collaboratively include those shown in Figure 10:

Figure 10: Examples of small-scale blue-green infrastructure schemes we have delivered or contributed to recently

Local water course re-naturalisation and attenuation (Day Brook blue-green infrastructure scheme, Nottingham)	**Offline flood storage lagoons attenuating flows to local water courses** (Jubilee Ponds, Nottingham)	**Above-ground permeable storage areas linked to increased offline storage** (Clarice Cliff School, Stoke-on-Trent, Chesholme Road, Coventry)
Combined sewer separation and associated surface water pumping in enlarged detention basins (Epinal Way, Loughborough)	**Swales, bunds and French drains linking to new detention basins** (Lodge Hill, Birmingham, Orchard Close, Telford, Gresham Avenue, Leamington)	**Curbside rain gardens** (Day Brook rain gardens, Nottingham)

However, if we want to make a strategic change to blue-green infrastructure, we need a larger trial programme (such as the one in this business case) to allow us to understand the benefits and challenges of a catchment-scale approach. Without an injection of new information – and a means to make blue-green interventions more affordable – the short-term certainty and familiarity of 'grey' interventions will likely mean that they continue to dominate our planning despite their longer-term risks and challenges.

The investment set out in this business case responds directly to growing calls from Government to implement collaborative blue-green infrastructure solutions for managing flood risks and long-term reduction on the reliance of storm overflows. Most notably, the Government's 25 Year Environment Plan, published in 2018, calls for Lead Local Flood Authorities, water and sewerage companies, highways authorities and other risk management authorities to work better together to manage the risks of sewer flooding and environmental pollution. Specifically, the Plan challenges water companies to develop a mix of solutions, including "improved partnership working with local authorities to manage flood risk", as well as the "adoption and maintenance of SuDS". See Appendix B for further examples of Government priorities on managing flooding risk.

1.5 Specific need in Mansfield, our identified trial area

We are proposing to undertake the catchment-scale trial in Mansfield. The approach we have followed to identify the location is described in section 2 and in detail in Appendix E. This is the ideal location to trial the UK's first catchment-scale flood resilience programme. It is of an appropriate size to meaningfully demonstrate how to deploy blue-green infrastructure at scale, and its geology and geography are likely to be amenable to sustainable drainage interventions. There is also a clear future flooding pressure to manage, and the relative socio-economic deprivation of the area means that it should be well-placed to benefit from the wider community benefits that will be generated.

1.5.1 Flooding and overflow vulnerability

Table 2 shows that, on a per population basis, Mansfield is one of the most vulnerable of our 23 largest sewerage catchments for both modelled network escape volumes and Combined Sewer Overflow (CSO) spill volumes (data shows major catchment ranks, 1 being the worst). Depending on the specific location of the network escape and the antecedent conditions, these vulnerabilities could manifest as sewer flooding of homes, gardens or public spaces or potentially pollution events in local watercourses. This will continue to be the case as future pressures materialise.

Table 2: data showing Mansfield is the most vulnerable of our 23 largest sewerage catchments

Major Catchment Rank (1 = worst)	Current 1:10 flood volume / population	Current CSO spill volume / population	2050 1:10 flood volume / population	2050 CSO spill volume / population
Mansfield	1	3	1	3
Ilkeston	6	2	2	2
Monkmoor	3	10	3	11
Goscote	4	7	4	7
Barnhurst	5	22	5	22
Worcester	7	14	6	6
Kidderminster	2	16	7	16
Matlock Lea	10	4	8	4
Longbridge	8	12	9	12
Hayden	9	6	10	5

Our modelling also shows that the volume of sewer flooding in the Mansfield catchment during a 1:10 year storm event will increase by 57% by 2050.

Following on from Newark in AMP6, we are currently delivering a major strategic network capacity scheme in the Ilkeston catchment in AMP7. While our AMP8 business plan will be informed by our ongoing DWMP work, substantive interventions (whether traditional storage solutions or innovative blue-green interventions) are likely to be required in Mansfield and other vulnerable catchments in future. Our identification of flooding risks in Mansfield is set out in more detail in section 2.

1.5.2 Economic wellbeing and deprivation

Mansfield is in northern Nottinghamshire. The sewerage catchment that serves 89,000 people is largely contained within the Mansfield district council area, which has a population of 109,000. Mansfield has historically been a centre for coal mining, textiles and brewing. It is still the HQ of the Coal Authority. The district has been influenced heavily by its industrial past, but in common with the national economy the area has seen the decline of these sectors since the 1990s.

Mansfield has highest IMD (Index of Multiple Deprivation) score in Nottinghamshire and is ranked 46 out of 314 English Local authorities. At LSOA level, ten areas (out of 63 in Mansfield) are in the bottom 10% in England – with the lowest ranked 36 out of 32,844. Considering the 60 local authorities in our region, Mansfield is ranked the 8th most deprived area we serve based on 2020 IMD average scores. This is also reflected by that fact that we support more than 1,600 customers in the area through our vulnerable customer support schemes.

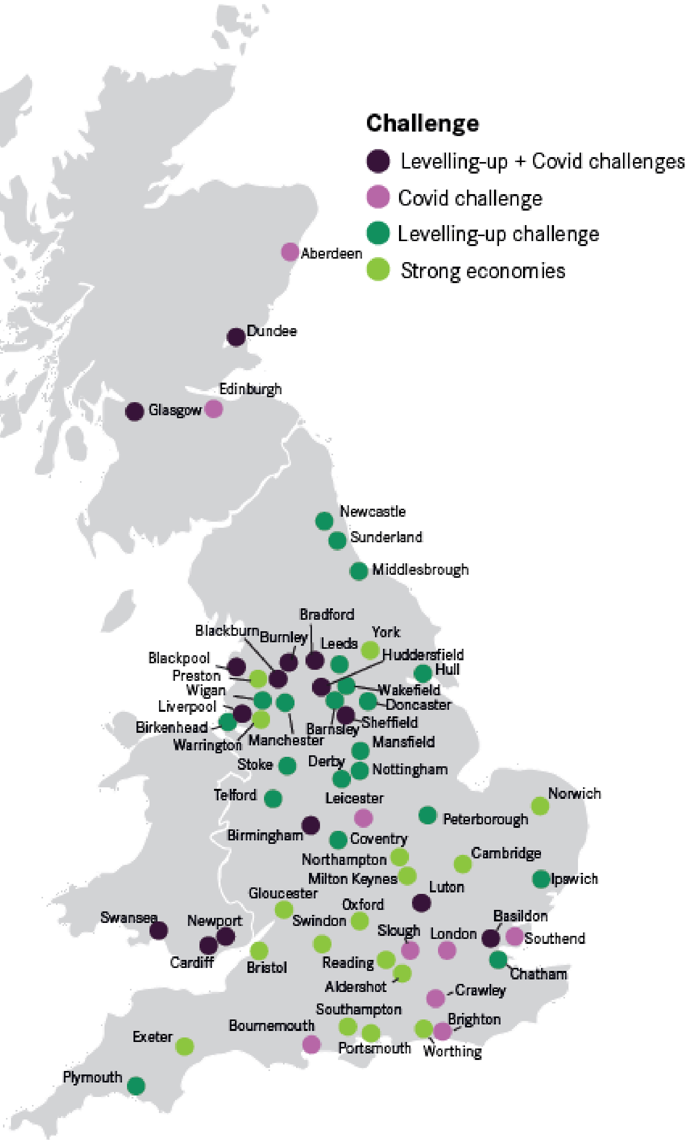
Mansfield has 13,000 of its working age population seeking key out of work benefits (NOMIS data). For 2019, unemployment data across Nottinghamshire, seven out of the top ten electoral wards were in Mansfield. These all have an unemployment rate of more than 4%. The highest is the Oaktree ward with 5.9%. A weighted income index (based on LSOA deciles) places Mansfield Borough 248th out of 314 local authorities (4.59 weighted decile). The average weekly pay of £453 is £77 lower than the East Midlands average and £118 below the Great Britain average.

As highlighted by the Centre for Cities, in its Cities Outlook 2021[10], Mansfield was already facing a levelling-up challenge before the additional complications of Covid-19 (see figure 11). The report states that whilst Mansfield is better placed than others to come back from the challenges of Covid-19, even a full recovery to before the pandemic will return only to a position of relatively weak economic performance.

Given the economic and deprivation challenges that Mansfield faces, we consider that it will be well placed to take advantage of some of the wider benefits generated by the installation of blue-green infrastructure.

[10] https://www.centreforcities.org/wp-content/uploads/2021/01/Cities-Outlook-2021.pdf

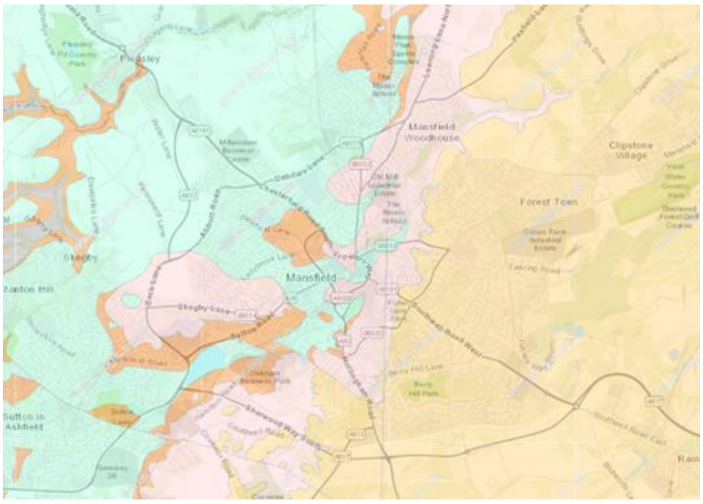
Figure 11: Distribution of challenges currently faced by towns and cities. Source: Centre for Cities: Cities Outlook 2021



1.5.3 Geology

The BGS geology map in Figure 12 shows that Mansfield is underlain by Permo-Triassic bedrock (between 250 and 260 million years old. The oldest rocks are the blue areas of Dolostone (Oolithic magnesian limestone) generally to the North and West of the River Maun. The pink and red areas north of the Kingsmill reservoir and in Mansfield Woodhouse are mudstones and fine sandstones. Finally, the yellow areas in the southern and eastern suburbs are the Chester formation of the Sherwood forest sandstone. These lithologies should all exhibit appropriate to good levels of permeability typically required for effective blue-green sustainable drainage interventions.

Figure 12: The geology of the Mansfield area is well-suited to a SuDS solution (Source: BGS).



1.5.4 Geography

Mansfield town centre is situated in a bowl within the River Maun valley, from which the town name is derived. The source of the River Maun is a couple of miles south-west of Mansfield in in Kirkby-in-Ashfield. Before entering the town, it flows through the Kingsmill reservoir, which was developed to provide a sufficient head to water to power a succession of mills in the town. The reservoir now forms a nature reserve and provides recreational and water sports facilities. Downstream of Mansfield, the Maun joins with the River Meden to form the River Idle, which continues to flow north before joining the River Trent close to the Nottinghamshire boundary. The ecological status of the Maun through Mansfield is categorised as 'moderate'. This is below the Water Framework directive 2027 target of all water bodies achieving 'good' status. More information on the drivers of the classification is presented in section 2.

A recent study shows that Mansfield enjoys a relatively good level of access to green space. A recent report commissioned by the Friends of the Earth[11] considered three metrics: the proportion of people within five minutes of two hectares of green space; the average amount of garden space per capita; and the total quantity of public green space per capita. Mansfield district has a green space deprivation score of 3.7 compared to an English average of 3.2 (with 1 being the least and 5 the most access to green space). This places Mansfield district 134th out of 314 local authorities. Availability of green space is an important requirement for developing large-scale blue-green infrastructure features.

1.6 This business case represents a 'no regrets' investment

This business case is attempting to understand how blue-green infrastructure can be best used at scale to help manage future sewer network capacity issues in the face of forecast external pressures. We are facing a material increase in the required level of investment in sewerage network capacity across our region through to 2050. As Mansfield is one of our more vulnerable catchments, material interventions will likely be required in AMP8 or 9. This business case brings those interventions forward, seeks to unlock ways of delivering against the wider challenge in a more sustainable and efficient way, and delivers net benefit to customers. Therefore, we consider that it is both 'no regret' investment and strongly in the customer interest.

11 https://policy.friendsoftheearth.uk/sites/files/policy/documents/2020-10/Green_space_gap_full_report_1.pdf

Making sure that the capacity of our sewerage network is sufficient to manage the flows that are likely to enter it is critical to making sure that we can deliver required wastewater service to customers. Through the Water Industry Act 1991, we are required to effectually drain our area and to clean the content of the sewers. This requires us to provide and maintain a network of sewers of appropriate size and robustness that can transport all the wastewater draining into them for onward treatment. In the face of increasing sewerage flows, we can essentially maintain this balance in two ways:

- Increase the size and capacity of our sewerage network (typically by providing network storage as increasing the size of existing sewers is prohibitive); or
- Find ways to manage the flows that actually enter the network (through the use of blue-green infrastructure as per this business case).

Our PR19 business plan did not include proposals for strategic or risk-based sewerage capacity interventions in the Mansfield catchment during AMP7. We have prioritised our recent strategic sewerage capacity interventions based on need and affordability. This saw the delivery of our £60m Newark scheme during AMP6, and we will be completing a similar strategic scheme in Ilkeston during AMP7.

Our analysis shows that Mansfield is one of our most vulnerable of our catchments. On a population equivalent basis, the Mansfield catchment has the highest modelled network escape volumes (for a 1:10 storm) and the third highest CSO spill volumes of our 23 largest catchments – both currently and as predicted in 2050. Modelling also shows that pressure on our network will increase drastically though to 2050, both in Mansfield and much more broadly across our region and the wider country (see section 2 and Appendix C). Our current modelling reflects only current and 2050 vulnerabilities. However, the risk to 2050 will grow in a relatively linear fashion. While our AMP8 business plan will be informed by our ongoing detailed DWMP modelling and analysis, it is evident that increasing interventions will be required much earlier than the 2050 DWMP endpoint (either through regular incremental increases or larger strategic interventions). Additionally, given that we will likely need to see material interventions across all of our major sewerage catchments through the planning period (see appendices 3 and 5), we will need to see an acceleration in our delivery of strategic interventions relative to our current rate.

While catchment modelling will always carry an element of uncertainty, the convergence of outputs across a wide range of catchments provides confidence that the forecasts are representative. Combined with the fact that our future duties will likely require us to deliver service at least in line with current levels, we can be confident that we will need to deliver the full storage equivalent set out in our analysis for Mansfield by 2050 and almost certainly a material uplift within the AMP8/9 timeframe. We have sought to test the level of sensitivity through the development of a wide range of scenarios and interventions. We have then identified a programme scale and ambition that is challenging yet provides strong confidence of delivering net benefit to customers (see section 5). This is further safeguarded by our customer protection mechanism (see section 6).

This catchment-wide trial acknowledges the future investment challenge and identifies that a more sustainable and economic solution is required given the size of the future challenge anticipated. Using current approaches and scaled to our entire region, the cost would rise to £billions of required investment by 2050, which is not affordable or deliverable within the current regulatory framework.

Therefore, we are confident that the interventions in this business case are 'no regret' – both in terms of the storage equivalent delivered and the information that will be provided on how to most effectively deliver blue-green infrastructure at scale and pace. As we have also demonstrated that the proposed blue-green interventions in Mansfield also deliver net benefit to customers and communities relative to our standard storage-based approach (see section 5), we consider that this business case is strongly in the customer interest.

2. Best option for customers

We have used our robust optioneering process (Figure 13), including modelling to quantify the future pressures on surface water flows, to select a suitable sewerage catchment – Mansfield – and a suite of interventions for our trial that we believe represent best value for customers in terms of the scale of benefits unlocked for the investment.

Figure 13: Our optioneering process enabled us to identify Mansfield as a suitable trial catchment

1. Identify a suitable sewerage catchment for our trial → 2. Quantify future pressure on the sewerage network → 3. Identify potential interventions → 4. Quantify an efficient and innovative set of interventions

This methodology has allowed us to identify the proposal set out below for the Mansfield sewerage catchment:

We are proposing to deliver a demonstrator trial of up to £85m on how to better manage surface water in the Mansfield sewerage catchment through blue-green infrastructure solutions.
This intervention will negate the need to deliver up to 60% (58,0000m^3) of the future network storage that would otherwise be required in Mansfield up to 2050. More importantly, it will provide valuable information on how we can better transition to a future where we efficiently use blue-green infrastructure at scale and deploy it at pace in many catchments across the country. This could provide transformative benefits to all future customers. The trial will oversee the planning, development and implementation of a broad suite of blue-green infrastructure measures in Mansfield. These will be focused on delivering holistic surface water management solutions rather than just treating the resultant sewer flooding impact. A key aspect of the trial will be to expose what is possible rather than predetermine solutions at this stage. However, interventions will likely include: regional separation and transfer to planted detention basins and bioswales; permeable paving; street planters and bioretention tree pits; verge rain gardens; and rainwater downpipe planters. Modelling suggests that the trial is likely to see the installation of more than 15,000 blue-green infrastructure features that would cover more than 15 hectares of the catchment. This should allow us to unlock system-wide allocative efficiencies, the way it is delivered will generate wider community, societal and environmental benefits. These include: protection from the economic damage caused by flooding, particularly in locations were the financially vulnerable are less well-equipped to cope; greater local biodiversity and ecology; improved community amenity mental health and wellbeing; and provision of a catalyst for place making and urban regeneration. It is important that current barriers and uncertainties – as well as the economics of the existing interventions that this trial is seeking to change – do not constrain the opportunity to deliver a meaningful trial. We also need to ensure that existing customer interests are protected. Therefore, we are proposing a revenue recovery and customer protection mechanism where outturn expenditure is recovered subject to limiting unit cost and programme constraints. This will acknowledge the current uncertainty and ensure that only interventions that will deliver net benefit to customers and communities relative to the counterfactual are implemented.

We have followed a thorough process to identify a suitable location to undertake an effective catchment-wide trial on how to best manage surface water with blue-green infrastructure (and identified Mansfield). It is an appropriate size to test how to best refocus delivery of our sewerage network obligations in the face of large future pressures. Mansfield will also be particularly well placed to benefit from the wider societal and community positives generated from blue-green infrastructure such as improving amenity and stimulating urban regeneration. The selection process we have followed is set out in detail in Appendix E.

The choice of Mansfield also links sensibly to wider current and future Water Framework Directive (WFD) activity in and around the catchment. The WFD waterbody to which most of the sewerage catchment drains (the River Maun from source to Vicar Water) is currently categorised as of 'moderate' ecological status. The EA reasoning for it not currently achieving the 2027 targeted 'good' status is summarised in Table 3.

Table 3: EA Reasoning for assessment of the River Maun from Source to Vicar Water

Sector and activity	Underlying issues
Agriculture: Farm infrastructure and soil management **Local and Central Government**: Flood protection and barriers **Urban and transport**: Transport drainage **Water sector**: Continuous discharges (Sewage works), Intermittent discharges (storm overflows)	• Fine sediment • Physical modification • Dissolved oxygen • Ammonia • Organic pollution • Phosphate

In AMP7 we are already committed to addressing some of the storm overflow issues that contribute to the waterbody. However, these are upstream of the Mansfield sewerage catchment in Sutton-in-Ashfield (above the Kingsmill reservoir). The blue-green interventions identified in this business case should drive improvements to the identified Mansfield storm overflow performance, as well as transport drainage and flood protection impacts, negating the need for more targeted interventions in AMP8. We are also targeting phosphate improvements at both Mansfield and Sutton-in-Ashfield sewage works through a separate Green Recovery business case that seeks accelerate WINEP activity currently scheduled for AMP8.

2.1 Quantifying future pressure on the Mansfield sewerage network

To set boundaries for our programme, we have quantified how the future pressures of climate change, population growth and urban creep will impact on the Mansfield sewerage catchment. We achieved this through detailed hydraulic modelling. This shows that we can expect a 57% increase in sewer flooding volume across the catchment by 2050 (more than 45,000m^3) and a similar volume increase from combined sewer overflows.

We have completed catchment modelling work to inform the BRAVA stage (Baseline Risk And Vulnerability Assessment) of our DWMP. This includes baseline modelling runs to understand current baseline performance. We have then stress-tested the catchment with 2050 inputs to assess the future impact from climate change, new development and urban creep.

Our sewerage duties require us to effectually drain our area. Customer expectations relating to sewer flooding and the EA's discharge permitting and pollution controls will also require us to maintain and likely enhance current performance in the future. This means that by 2050 we will need to have taken steps to manage these extra flows so that the current level of performance is at least maintained. Under our current strategy, this would largely be delivered through construction of an equivalent amount of network storage within the identified catchment.

2.1.1 Our approach to modelling

For the Mansfield catchment, we undertook modelling for a 10-, 30- and 50-year return period design storm. For each modelled node that is predicted to flood (e.g. a network manhole), our analysis shows: the location; the type of sewer (foul/combined or storm); the total flood volume; and the worst duration which the flood volume relates to. This analysis was undertaken for the current catchment input assumptions and then again to reflect 2050 inputs. This will identify the increasing impact of climate change, population growth and urban creep.

For this business case, we used the 1-in-10-year storm event information. During larger (higher return period) storms, inlet gully capacity can start to restrict the volume of water entering our network (sewer systems have historically been designed for a 1:20 year event). This means that the impact of higher return period storms on our network may be exaggerated and lead to double-counting with the surface water flood risk identified by the EA.

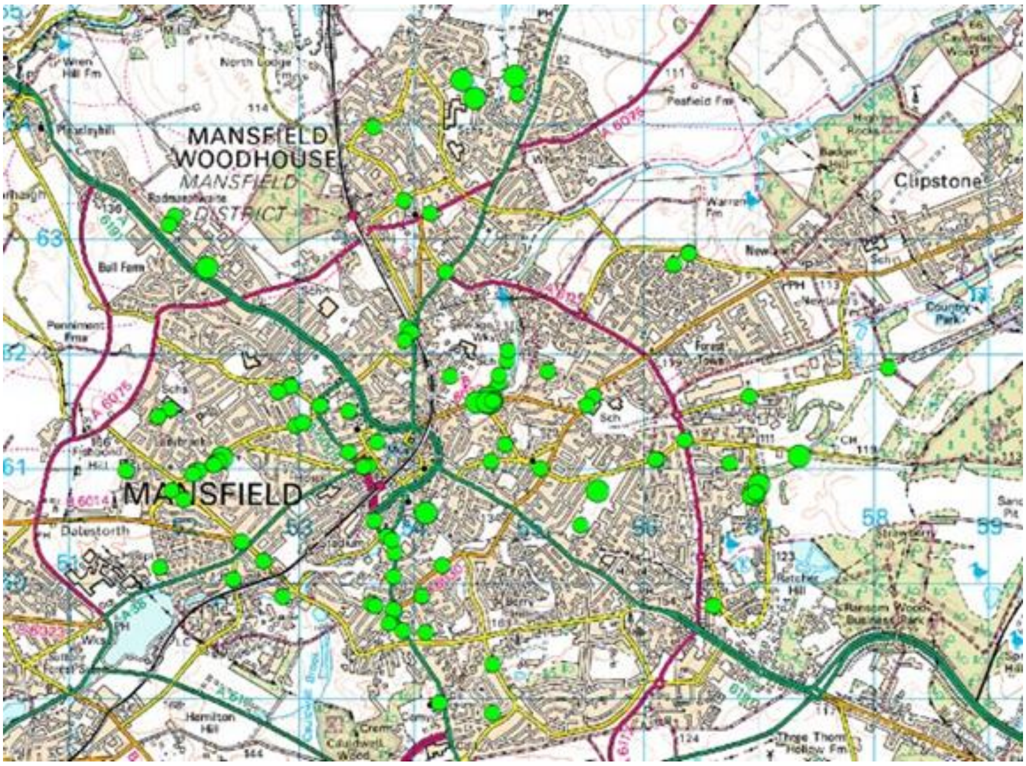
We also used the BRAVA modelling outputs to assess the potential impact on storm overflow spills in the Mansfield catchment that will also be impacted by these future pressures. Across the Mansfield catchment, we have 31 storm overflows (including the Wastewater Treatment Works storm tank overflows). To assess performance, we used the time series rainfall (TSR) of a typical year. To identify the impact by 2050, we then applied the same new development and creep assumptions as per the flooding analysis, but used the TSR rainfall event duration uplift ('TSR RedUp') tool from the 2017 UKWIR climate change project to show the climate change impact.

2.1.2 Forecast flooding in Mansfield

Modelled sewerage network escapes

Our analysis shows that 79,000m^3 of water is forecast to escape from our Mansfield network during a current 1-in-10-year storm. The modelling shows that the volume of sewer flooding in a 1:10 storm increases to 124,000m^3 when the modelling is updated for the 2050 input pressures. This increase of 45,000m^3 (or +57%) would be even greater during the higher 1-in-30-year and 1-in-50-year events. Figure 14 shows the location of the modelled increase in network escapes (greater than 50m^3) from baseline to 2050.

Figure 14: location of network escapes in Mansfield catchment, increasing from baseline to 2050



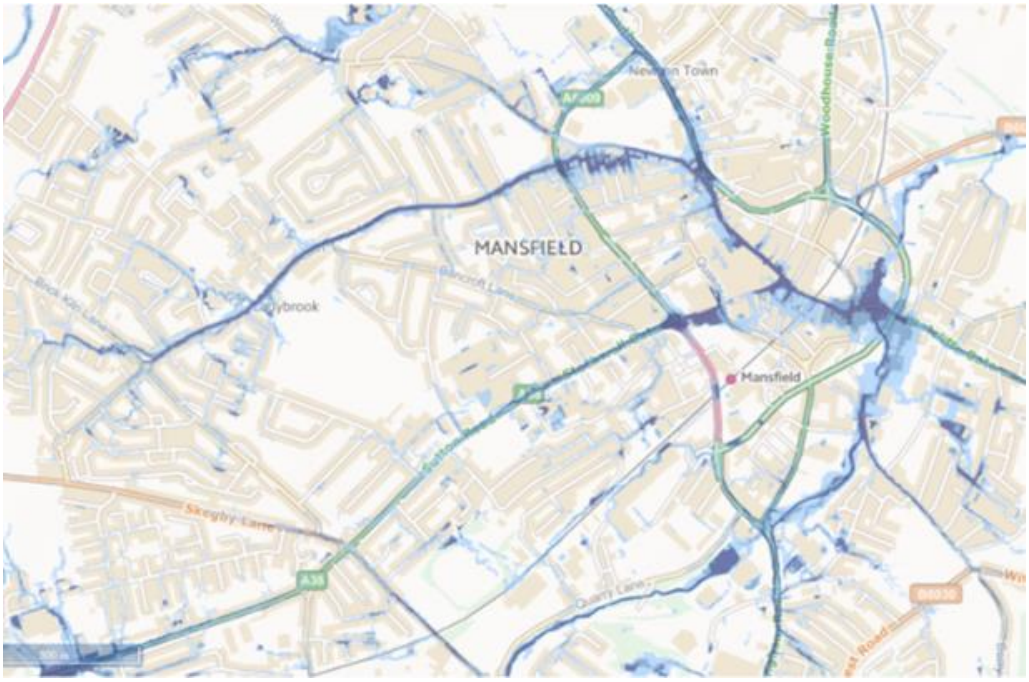
Storm overflow modelling

The current baseline for storm overflow performance shows 1,222 spills and a total spill volume of 1,272,000m^3. While the identified 2050 of spill count only increases slightly to 1,224 spills (+0.1%), the annual volume increases to 1,323,000m^3. This is an increase of 51,000m^3 (+4.0%). Adding the flooding and storm overflow escape volume increases together, this increases to around 98,000m^3 of additional volume would need to be managed by 2050 (provided the current flooding and storm overflow performance levels during a 1-in-10-year storm were to be maintained at current levels). Using our current interventions, this would require an equivalent amount of additional network storage (i.e. a minimum of 98,000m^3) to be provided across our Mansfield network by 2050.

Surface water flooding risk

The EA surface water flood risk maps illustrate the areas of the catchment that are more vulnerable to surface water flooding (Figure 15). This shows the anticipated flow of water over the surface (i.e. after consideration of the hydraulic capacity of the installed drainage system) during a current 1:30 storm (dark blue) and a 1:100 storm (medium blue). We are aware that these risks will increase in the future due to the effects of climate change and urban creep.

Figure 15: EA maps show how surface water is likely to flow from surrounding areas, such as the Ladybrook estate, and funnel into the town centre area



2.2 Identifying potential interventions

We have identified a selection of proven blue-green interventions that can be used to manage the identified future pressures in the Mansfield catchment caused by increased surface water flows – and generate wider benefit for communities, nature and wider society. We are proposing urban catchment-scale interventions analogous to those used in Copenhagen, Barcelona, Rotterdam, Amsterdam and Melbourne.

2.2.1 Intervention options

We have identified a balanced set of interventions which will:

- be deliverable at a sewerage catchment or urban centre scale;
- respond to the various sources of surface water entering our network;
- lead to the delivery of a holistic wider catchment solution rather than simply just transferring the problem to elsewhere (such as to fluvial and pluvial flooding); and
- provide wider benefit for the community.

We have developed the interventions (Table 4 and Figure 16) using a mix of approaches that we have undertaken already across our network, and wider national and international case studies where blue-green infrastructure and water-sensitive urban design principles have been successfully demonstrated. Our current analysis focuses on the interventions shown in bold in Table 4 (although we are still considering all the interventions for use within our catchment trial).

Table 4: We have identified a balanced set of interventions

Category	A. Large urban impermeable public spaces	B. New development	C. Separate sewers draining into combined sewer (quick wins)	D. Public space draining into combined sewer	E. Household level retrofit
Approach	Large scale water sensitive urban design	Surface water sewers linked to SuDS	Rerouting of existing surface water sewers away from combined network	Water intercepted/ attenuated/reused before entering combined network	Local disconnection / attenuation
Specific types	City centre squares / parks	SuDS integrated into new estates	Re-naturalised watercourses and wetlands **Planted bioswales and detention basins** Attenuation structures controlling onward flow rates	**Rain gardens / tree pits** **Street planters** Curb-side swales, trenches, ditches Green roofs **Permeable pavements**	Active rainwater harvesting **Downspouts to permeable surfaces** Soakaways/ infiltration trenches
Lifecycle	Co-creation	Adopted and maintained	Constructed (co-creation)/ adopted and maintained	Constructed (co-creation)/ adopted and maintained	Provided and maintained where appropriate
Case studies	Copenhagen Tasinge Platz	Severn Trent Connect policy	Day Brook BGI project, Nottingham. Clarice Cliffe School, Stoke-on-Trent	Day Brook Rain gardens, Nottingham	HDD active rainwater harvesting trials

Figure 16: Examples of blue-green interventions: Left: Street permeable paving edges. Centre: Street planters. Right: Detention basins/

2.2.2 Developing intervention scenarios for the Mansfield catchment

Our modelling shows that we will need to manage around 98,000m^3 of additional storm water by 2050 because of future surface water pressures. Based on the attributes of the catchment, and its suitability for different blue-green interventions, we have calculated the potential opportunities for sustainable drainage to be deployed in Mansfield. Possible blue-green interventions are considered in two broad categories:

- Source control opportunities (using blue-green infrastructure to manage surface water in the catchment and therefore prevent it from entering our sewerage network).
- Regional separation opportunities (identifying surface water that is currently in our network that could be effectively removed and rerouted in into sustainable drainage features).

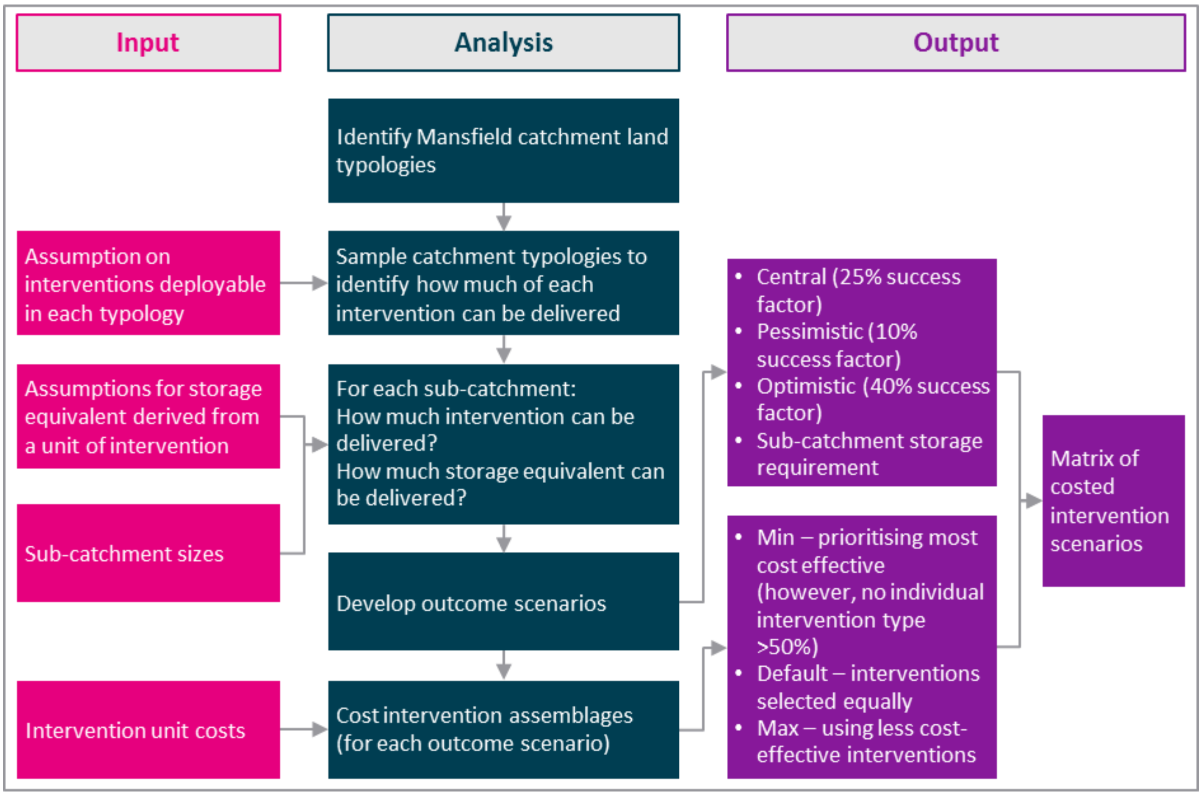
We have used the spatial distribution of both the identified blue-green opportunities, the modelled surface water pressures across the catchment, and the likely success rate for delivering the interventions to create scenarios showing how the Mansfield catchment trial could develop over AMP7.

We have developed these scenarios with support from Arup (more details are provided in its report in Appendix F). We have used these scenarios to generate a range of costs (see section 4), to confirm that a trial would be cost effective and generate appropriate net benefit, and to set the expenditure boundaries of the business case (see section 5).

Identifying source control opportunities

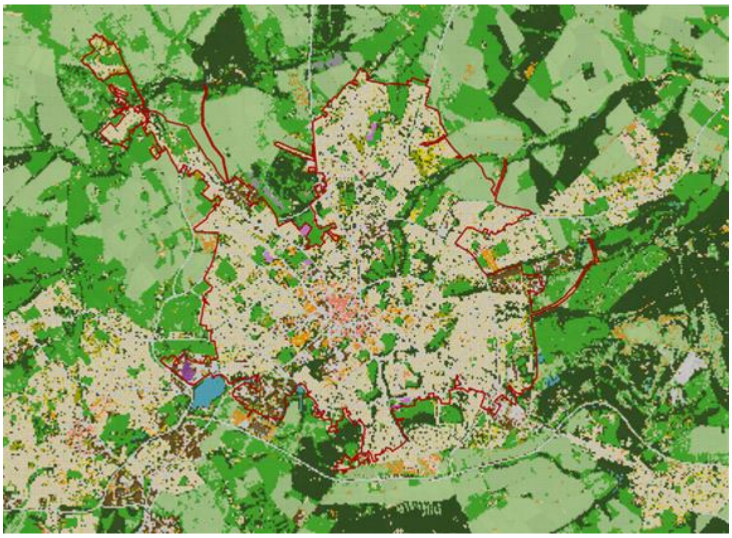
Source control interventions are those that seek to manage surface water more effectively in the catchment so that it does not enter our sewerage network. Figure 17 shows the approach we have followed to identify the source control aspects of the scenarios.

Figure 17: Our approach for identifying souce control opportunities



We have undertaken GIS and satellite imaging analysis of Mansfield (Figure 18) to isolate the different typologies and land uses across the catchment. We then used desk-based sampling of each typology in the Mansfield catchment to identify blue-green infrastructure opportunities (two hectares samples per typology, except residential where six hectares have been sampled). This is combined with the input assumptions set out in the matrix at Table 5 to identify storage equivalent opportunities by intervention type. We have used this information to build a range of possible intervention scenarios.

Figure 18: Identification of land use typologies in Mansfield using satellite imaging



Land use	Area (km^2)	%
Mature wild trees	20.0	18%
Urban park	24.9	23%
Allotment garden	2.6	2%
Farmland	27.3	25%
Solar farm	0.1	0%
Arterial road	1.5	1%
Commercial retail	0.8	0%
General industry	2.2	2%
Hospital	0.1	0%
Mobile homes	0.6	0%
Residential	20.1	18%
Rail line	0.3	0%
School or institution	0.1	0%
Secondary road	1.4	1%
Urban construction	0.8	0%
Car parks and open paving	3.1	2%
Victorian residential	0.7	0%
Water treatment	0.1	0%
Lake	0.4	0%
Total	107.1	100%

Table 5: Identification of storage equivalent opportunities by intervention type

Typology / intervention	Car parks	Industry	Urban Parks	Major roads	Schools	Commercial	Victorian Residential	Residential	Unit size m²	Storage volume benefit (m³ per m² deployed)
Grassed / planted detention basin	✗	✗	✓	✗	✗	✗	✗	✗	225	0.645
Planted bioswale	✗	✓	✓	✗	✓	✗	✗	✓	8	0.645
Permeable paving	✓	✗	✓	✗	✗	✓	✓	✓	8	0.255
Bioretention tree pits	✗	✗	✗	✓	✓	✗	✗	✗	6.25	0.37
Street planters	✗	✓	✗	✓	✓	✓	✓	✓	9.625	0.37
Verge rain gardens	✗	✗	✗	✓	✗	✓	✗	✓	5.5	0.37
Rainwater downpipe planters	✗	✗	✗	✗	✓	✗	✗	✗	3.75	0.855
Storage volume equivalent opportunity from typology sampling (m³/ha)	294	332	56	216	211	140	70	46		

Notes: Storage volume equivalents reflect the relative opportunities for different interventions identified within the catchment sampling. The unit size of the interventions reflects that size at which interventions have been assessed and unit costed. The intervention storage volume benefit compares the effective capacity of the different interventions to absorb surface water flows on a consistent basis.

Using the above analysis, the maximum potential source control opportunities by intervention type identified for the Mansfield catchment are set out in Table 6:

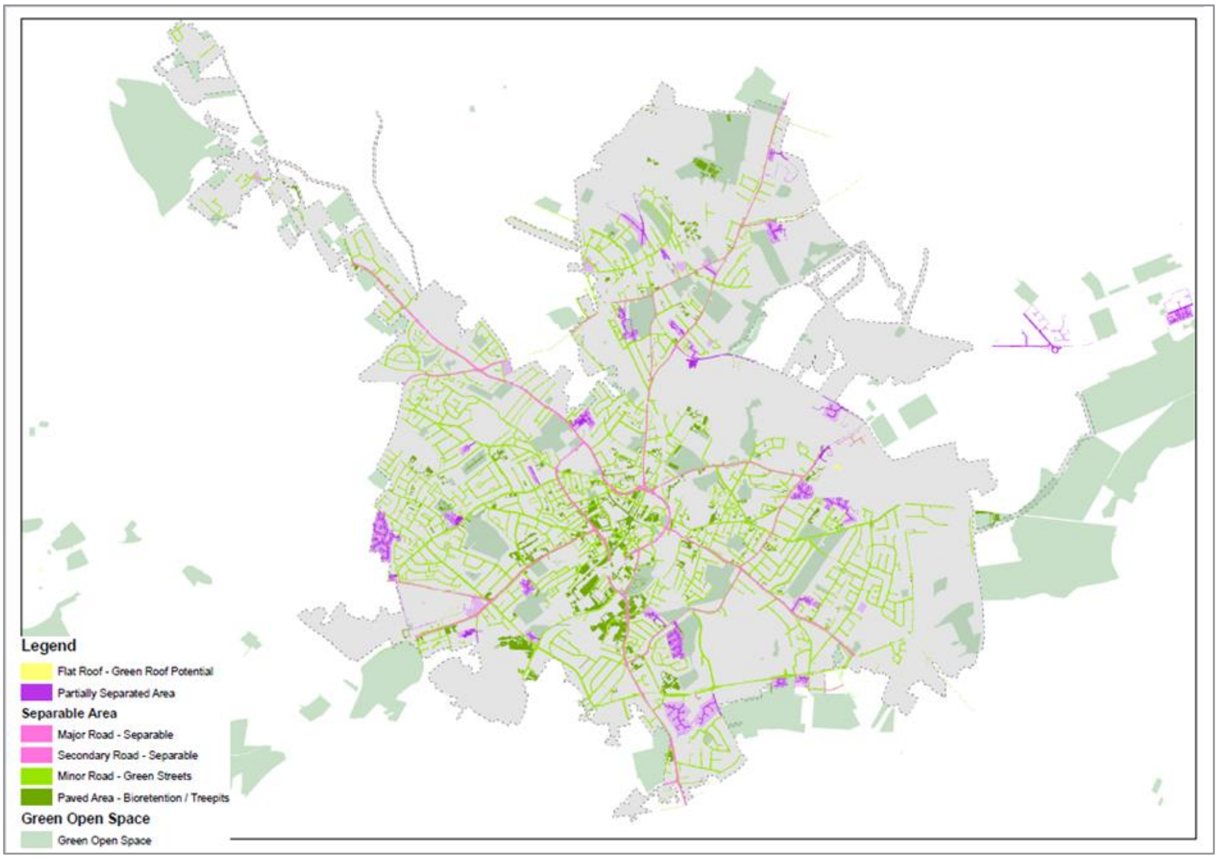
Table 6: Maximum potential source control opportunities in the Mansfield catchment by intervention type

Source control interventions	Planted detention basin	Planted bioswale	Permeable paving	Street planters	Verge raingardens	Downpipe planters & tree pits	Total
m^3 total potential	33,500	34,000	104,300	23,400	35,800	200	231,200

Regional separation opportunities

Regional separation interventions seek to better manage surface water that has already entered our sewerage network. The re-engineering of large sections of our existing network into a separate system is very costly and highly disruptive. Therefore, we have interrogated of our asset base to identify and focus on partially separated areas of the Mansfield catchment. Figure 19 identifies Partially Separated Areas (coloured Purple). These areas are already served by a surface water system that then discharges to the combined network.

Figure 19: identification of partially separated areas of the Mansfield catchment



These areas could provide quick win opportunities to potentially transfer flow from larger areas to nearby green open space and make use of detention basins and swales. The extent to which these are deliverable will depend on a more detailed 'on-the-ground' review of the catchment, the partnerships we can forge and the innovative solutions that we can identify.

Table 7 shows the outcome of our high-level review of the regional separation opportunities. This identifies the ten largest areas within the Mansfield catchment, determines the likely impermeable area that would be removed and assesses the high-level potential for it to be discharged into a sustainable drainage feature.

Table 7: results of our high-level review of regional separation opportunities

Top 10 regional separation opportunity (ha)	Assumed Impermeable area (ha)	Sub-catchment	Blue-green opportunity	Potential storage volume equivalent (m³)
9.3	4.5	FW2		1,300
6.8	4.4	FW1a		
3.9	2.3	FW2		600
2.7	1.8	FW4		500
2.6	1.7	FW6		500
2.5	1.5	FW4		
2.4	1.2	FW6		
2.2	1.1	FW6		300
2.1	1.2	FW7		
2.1	1.4	FW3		
			Total	**3,200**

Building spatially coherent scenarios for the Mansfield catchment

We have developed a range of scenarios that show how a catchment-scale trial in Mansfield could be realised. They consider how the 2050 counterfactual challenge (i.e. the equivalent of 98,000m³ of network storage) might be met through a balance of holistic blue-green infrastructure solutions and traditional grey storage interventions. This is based on top-down analysis of the catchment and the potential to deploy the different types of intervention identified above.

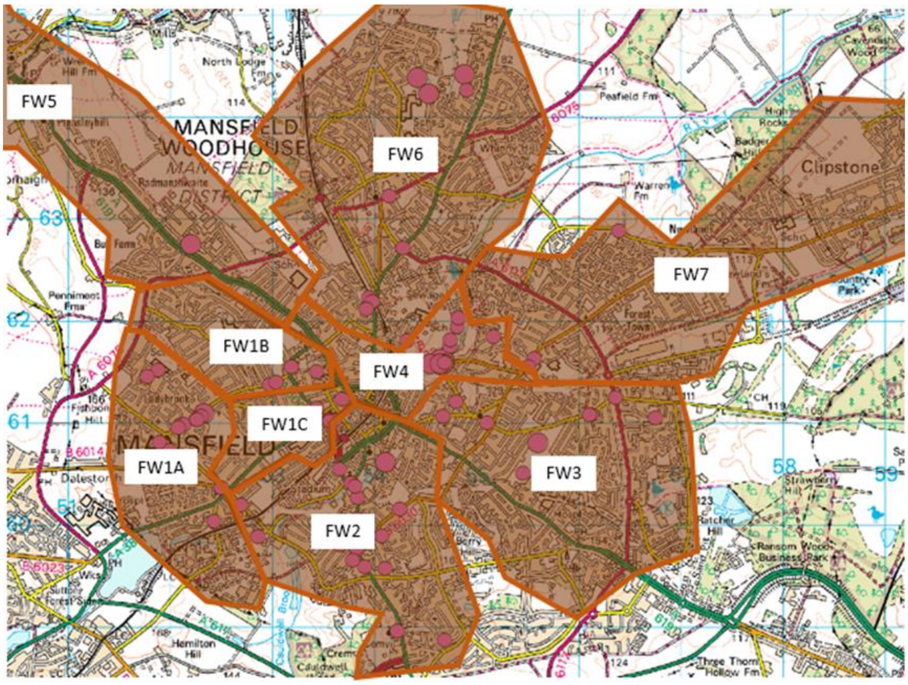
The identified scenarios use the above analyses coupled to plausible levels of ambition that may be realised. We term the extent that potential interventions can be delivered on the ground in each location, the 'success factor'.

The scenarios need to be spatially coherent. Blue-green infrastructure needs to be located at, or upstream, of where the pressures will manifest in the network. Therefore, we have developed the scenarios on a sub-catchment basis. The catchment has been split into nine areas based on hydrology of our combined/foul network. The identified 2050 catchment pressures by sub-catchment area (the increased volume (m³) of network escapes / CSO spills during a 1:10 storm) are set out in Table 8, with the catchment areas overlaid on the map in Figure 20.

Table 8: Identified 2050 catchment pressures, by sub-catchment area

Sub-catchment area	Combined/ foul (m³)	Surface (m³)	CSOs (m³)	Total
FW1a	1,000	4,500	510	6,010
FW1b	1,000			1,000
FW1c	500			500
FW2	2,000	150	1,380	3,530
FW3	1,200	8,200		9,400
FW4	21,000		27,700	48,700
FW5	100	500	1,200	1,800
FW6	2,100	1,450	6,230	9,780
FW7	200	2,010	15,960	18,170
Total	29,100	16,810	52,980	98,890

Figure 20: The nine catchment areas, split based on hydrology of our combined/foul network



The identified scenarios

The identified scenarios (Table 9) consider a range of success factors for the suite of interventions assumed in each sub-catchment area. Based on delivery of blue-green infrastructure in other case studies, we have considered:

- 10% a pessimistic success factor (scenario 1)
- 25% a central success factor (scenario 2)
- 40% an optimistic success factor (scenario 3)

Scenario 4 is different to the above three. It selects blue-green interventions up to the sub-catchment storage target, allowing the success factor to vary across the catchment.

Table 9: success factors for the suite of interventions assumed in each sub-catchment area

Scenario: number of unit interventions	Storage equiv. from BGI (target 98,000m^3)	Intervention assemblage	Grassed / planted detention basin	Planted bioswale	Permeable paving	Street planters	Verge raingardens	Downpipe planters & tree pits	Traditional storage assumed to 2050
Counter-factual	0%		0	0	0	0	0	0	101,000m^3 (103%)
Scenario 1: 10% success factor)	23,000m^3 (24%)	min	109	1,288	111	0	0	0	77,000m^3 (78%)
		default	23	658	5,114	656	1,760	8	
		max	0	0	18	3,281	5,648	9	
Scenario 2 and 2a: 25% success factor	58,000m^3 (59%)	min	115	3,290	12,137	0	0	32	Scenario 2: 57,000m^3 (58%)
		default	58	1,645	12,785	1,641	4,401	21	Scenario 2a:
		max	0	0	13,913	3,281	8,801	9	40,000m^3 (40%)

Scenario: number of unit interventions	Storage equiv. from BGI (target 98,000m³)	Intervention assemblage	Grassed / planted detention basin	Planted bioswale	Permeable paving	Street planters	Verge raingardens	Downpipe planters & tree pits	Traditional storage assumed to 2050
Scenario 3 and 3a: 40% success factor	92,000m³ (94%)	min	115	3,290	25,553	0	3,172	32	Scenario 3: 49,000m³ (50%)
		default	92	2,632	20,456	2,625	7,041	34	Scenario 3a
		max	6	1,901	25,450	3,281	8,801	41	9,000m³ (9%)
Scenario 4: Sub-catchment storage constraint	42,000m³ (42%)	min	106	2,681	5,832	0	0	15	57,000m³ (58%)
		default	44	1,158	9,307	1,178	3,041	14	
		max	0	0	7,596	3,281	6,850	9	

For each of the scenarios, the identified regional separation opportunities are assumed to be accounted for in the grassed / planted detention basin intervention – the most likely way in which the identified opportunities will be addressed.

Where there are sub-catchment areas that do not have sufficient opportunity to satisfy the identified 2050 storage equivalent target, we have assumed that the volume will be satisfied in the future through traditional grey storage (or as yet unknown blue-green interventions). These additional future interventions will not be considered as part of the AMP7 catchment trial.

However, where the success factor delivers a storage equivalent benefit greater than the sub-catchment target, this has been included in the scenario as it will deliver future flooding and wider community benefits. The effect is illustrated by scenario 3 delivering 146% of the catchment storage target (94% from blue-green interventions and 50% from future traditional 'grey' solutions).

For each scenario, we have considered three intervention combinations, which acknowledge the uncertainty of how the identified suite interventions will be realised. The default intervention mix assumes that each of the possible interventions will be deployed equally. Therefore, the uptake of each intervention will be the same as the overall success factor. The minimum intervention assemblage assumes that the most cost effective blue-green interventions are delivered in sequence (i.e. using up to 50% of the identified potential then moving to the next intervention in cost effective order). Conversely, the maximum intervention assemblage assumes that the required interventions are weighed more to the less cost effective blue-green interventions identified.

The above core scenarios have been supplemented by a further two variants that reflect the likely impact of sub-catchment benefits being transferred to other upstream areas of the catchment – scenario 2a and 3a. The blue-green interventions are identical to the associated core scenario above, with the difference being the amount of additional 'Grey storage' assumed to be required.

Scenarios 2a and 3a – assumed benefits from upstream sub-catchments

Sub-catchment analysis of the scenarios shows that there are material pressures in two areas of the Mansfield catchment – FW4 and FW6. These cannot be fully mitigated with blue-green interventions installed within the corresponding sub-catchment area. Scenarios 2 and 3 assume that grey storage will be installed to close the required gap in each sub-catchment area. However, interaction with other sub-catchments is likely to be significant for FW4. This is a small area that contains approximately half of the Mansfield target storage and includes the catchment's Bath Lane sewage works. Consequently, surface water entering the network in other sub-catchments will eventually flow to FW4 to arrive at the sewage works. In some upstream sub-catchments we are providing more than 100% of the required storage target. Upstream benefits of sub-catchments are not taken into account in scenarios 2 and 3. This would lead to more traditional 'grey' infrastructure than necessary.

We have modified the scenarios to take account of this in scenarios 2a and 3a. Additional storage equivalent delivered in peripheral sub-catchment areas over and above the local requirement should provide benefit downstream benefit to FW4. Scenarios 2a and 3a take account of this effect. While the blue-green interventions remain unchanged, the grey storage assumed for FW4 has been reduced. The grey storage assumed reduces by 17,000m^3 (to 40,000m^3) in scenario 2a and 40,000m^3 (to 9,000m^3) in scenario 3a. This has a material impact on the cost effectiveness of these scenarios (presented in section 5).

3. Delivering our proposal

Delivering the UK's first catchment-scale flood resilience programme will require innovative ways of working among stakeholders – and create new, sustainable jobs as part of the Green Recovery. The realisation of these benefits depends not only on what we deliver, but how we deliver it.

3.1 Working in partnership

Improving and developing holistic flood surface water management across catchments requires strong and effective collaboration. We have a strong track record of partnership working, and have already established the key partnerships needed to deliver this proposal. We have a good working relationship with Nottinghamshire County Council and have started to engage on how we would work together in Mansfield.

We have undertaken significant engagement with stakeholders and potential partners throughout the process of developing our Green Recovery response, using a three-part approach (Figure 21).

Figure 21: We have undertaken engagement at various levels to inform our proposals

Top-down engagement across our wider Green Recovery planning approach	Bottom-up engagement with existing partners on specific subject areas	Engaging with organisations that we might not traditionally partner with but could have a role to play

Partnerships and community involvement are particularly important in achieving flood-resilient communities. This is in keeping with the national policy direction. The 25 Year Environment Plan states that the Government is looking to: strengthen joint delivery across organisations considering current partnership arrangements ahead of future funding reviews; attract more non-public sector investment; and make sure all relevant agencies are able to respond quickly and effectively.

By delivering holistic solutions through partnerships and communities, we will increase the likelihood of providing flood resilience that:

- Is cost effective (particularly where all parties can contribute their fair share);
- Will adapt as the shocks and stresses facing the community change over time (because communities own it and hold all relevant parties to account in perpetuity); and
- Unlocks wider benefits than a singular flooding benefit (with extra thought and effort but not much additional cost, solutions can drive much needed wellbeing and environmental improvements even when it is not raining).

This proposed catchment-scale trial will involve gaining stakeholder buy-in, support and potentially co-delivery for interventions that deliver against our own remit and generate benefit for other duty holders (e.g. alleviating pluvial, fluvial flooding risks or contributing to wider urban regeneration). The current remits and responsibilities for different aspects of flooding are set out in Appendix A. We already engage with partners on the delivery of our existing flooding obligations and interventions, and are building on this network in the Mansfield catchment to make sure that the clear benefits of collaborative working are integrated into this business case.

We have spoken to, and received high-level support from, Nottinghamshire County Council. It is the Lead Local Flood Authority for the Mansfield catchment, with responsibility for surface water flooding and the management of public highways. Independently it has also identified a surface water flooding intervention need in Mansfield and earmarked £3.5m of future expenditure. This will provide a significant opportunity to deliver holistic interventions. We are seeking to understand the areas of the Mansfield catchment that the council considers as vulnerable from surface water (pluvial flooding) so that these can be reflected in the feasibility and design components of the trial.

We have presented our proposals to the Elected Mayor of Mansfield and associated officers from Mansfield District Council. They are strongly supportive of the trial and see clear links and collaboration opportunities with their ongoing urban regeneration proposals. This includes a £25m Central Government Towns Fund application that seeks to improve the district though a programme of investment between 2022 and 2026. This identifies interventions across town centre infrastructure, skills and growth, transport and connectivity, health and wellbeing and identity and brand. In addition, £1m has been secured by the council for the greening of the town centre and the creation of urban pocket parks. This will directly link with our blue-green infrastructure proposals, acting as an appropriate kick-starter for what is to follow.

Other key stakeholders in the catchment that we will be seeking to collaborate closely with are:

- The EA (which is responsible for fluvial flood management on and our discharges to the two main rivers in the catchment – the Maun and Meden). We have discussed our high-level proposals with senior EA representatives and will follow-up by liaising with the EA's regional teams in the Idle and Torne Catchment.
- Organisations that have a specific role to play in the provision of habitat and enhancement of biodiversity in the region. We have already initiated discussion with representatives from Nottinghamshire Wildlife Trust. They are very supportive of our proposals, particularly given the opportunity for water quality and flow improvements in the River Maun and tributaries. They see an opportunity of leveraging funding from developers that they currently access. They also have access to a wide range of community groups that will relish the opportunity to be involved with identifying and developing blue-green infrastructure interventions.
- The Trent Rivers Trust and local housing associations.

This business case has necessarily been costed top-down using our own analysis. However, as we progress though location-specific feasibility and design, partnership schemes that benefit from the opportunities already identified above will materially contribute to the delivery of flood-resilient communities. Therefore, they will almost certainly heavily contribute to the final confirmed set of interventions.

3.2 Creating jobs and developing skills

In the medium to long term, refocusing our sewerage strategy from grey to blue-green infrastructure will require a change in the competencies and skills needed across design, construction and maintenance of sustainable drainage and blue-green infrastructure interventions. We will need to employ or procure resource with tailored skills and understanding of the construction and ongoing maintenance of this new asset base.

Through demonstration at a catchment scale, we will gain insight in to how we can train and upskill our people, giving us invaluable learning for the effective delivery of blue-green infrastructure at even larger scales in the future. We foresee that our new Academy will be able to support this ongoing training and upskilling requirement.

In developing the Mansfield interventions scenarios and assuming an £85m programme of work, we have calculated that 385 jobs could be required across our region to design and deliver the trial, then ensure its ongoing maintenance. A breakdown is set out in Table 10. The design and construction manpower costs will be reflected in the programme capital expenditure (assumed as an annualised cost of £23m). However, the ongoing maintenance manpower expenditure will be additional to the capital costs and need to be accounted for in future operating expenditure (assumed to be £4m of REOC – revenue effect of capital).

Table 10: we anticipate creation of up to 385 new jobs to deliver the Mansfield trial

Job type	Jobs	Duration (years)
Design – Feasibility	10	1
Design – Concept/detailed design & engagement	8	4
Design – Construction design & support	14	1
Construction	290	4
Major maintenance	58	Ongoing – Not immediately (towards AMP9)
Routine maintenance	5	Ongoing – Required after installation (AMP8)
Total	**385**	

More information on our assumptions for employment and skills creation is set out in Appendix D. Additional information regarding the jobs figures can also be found in *Annex 05: Jobs and skills*.

3.3 Delivering blue-green infrastructure at scale and pace

Delivering innovative products at pace and scale will be challenging. The mandate to develop and maintain sustainable drainage systems has traditionally been a barrier to their deployment. We have already started to explore how we will resource and manage the trial so that it is sufficiently agile, while maintaining appropriate governance and expertise. We have initiated a deliverability review to give us confidence that:

- We have the appropriate mandate and authority to deliver the identified interventions, and have considered the whole product life cycle and not just construction; and
- Our supply chain has appropriate capacity to deliver in the anticipated timescales.

3.3.1 A mandate to deliver and maintain blue-green and SuDS assets

Historically, the adoption and future maintenance of blue-green infrastructure features has provided a major barrier to implementation. Challenges will also come from retrofitting sustainable drainage features on land we do not own. Partnership agreements will need to be developed and progressed. However, we consider that we now have a mandate to deliver and maintain blue-green infrastructure assets. Our own NAV company 'Severn Trent Connect' already requires developers to construct SuDS features to the CIRIA best practice standard. These assets are then adopted with the associated responsibility for future maintenance.

In April 2020, Ofwat approved the sewerage sector guidance documentation (SSG) standardising the Code for Adoption process and procedure across the country. This includes the mandatory 'Design & Construction Guidance' (DCG) which gives provision for Sewerage Undertakers to adopt SuDS facilities[12]. The guidance provides the mechanism by which sewerage companies can adopt a wide

12 https://www.water.org.uk/wp-content/uploads/2020/03/SSG-App-C-Des-Con-Guide-v-2-100320-C.pdf

range of SuDS components that are compliant with the legal definition of a sewer. This is a significant change which will deliver better managed and integrated surface water systems, that align more closely with the direction of Government and regulatory policy. It allows the four pillars of SuDS design (Water Quantity, Water Quality, Amenity and Biodiversity) to be properly considered and utilised, with the production of resilient surface water systems that integrate all four. Adoptable assets should have the following attributes:

- Constructed for the drainage of buildings and yards;
- Have a channel with a definite boundary;
- Convey and return flows to a sewer or to a surface water body or to groundwater; and
- Have an effective point of discharge (i.e. watercourse, water body or to land).

Adoption does not include assets for draining roads or land, or that are part of a building or yard. This includes permeable paving and other street features. However, the guidance confirms that these components may form part of the drainage design as part of a holistic design provided they are upstream of the adoptable components or form an exceedance flood route.

Adoptable blue-green infrastructure will require regular, occasional or remedial maintenance. For example, planting, wetlands and biodiverse (wildflower) grasslands require an over-arching management plan that defines how the vegetation will develop over time, and what the feature is seeking to achieve (across the four pillars of SuDS). The management plan should require the quality and condition of the blue-green infrastructure to be reviewed regularly and be adaptable as necessary to ensure their long-term development and effectiveness.

For the actual maintenance provision, we will seek interested partners that would also derive common benefit. Wider case studies show that encouraging community involvement in the future management of blue-green infrastructure assets is an excellent way of both propagating the wider benefits of place making, amenity and wellbeing and ensuring the assets continue to provide the design flood protection (see Appendix D for more information).

3.3.2 Delivering innovative interventions at scale and pace

We have a good track record of partnership delivery on wastewater network projects. A key learning from our experiences of partnership working in AMP5 and AMP6 is that successful alignment of funding streams and management of risks can require long lead times to deliver.

It is unlikely that we will be able to simply add the increased scope of work to our existing capital programme processes. Therefore, we are exploring alternative delivery methods. This identification of innovative and efficient ways of delivering such programmes is a key component of the trial. We have already engaged the Knowledge Transfer Network to run a tech scouting competition to try to find solutions for measuring how effective blue-green infrastructure is in capturing flood water, and how to effectively demonstrate and communicate this efficacy to local communities.

The planning and design of blue-green infrastructure interventions typically requires a greater level of catchment understanding than traditional interventions would require. Detailed modelling risk validation is of critical importance to ensure projects hydraulically deliver as intended. A wider range of consents may also be required, which often take time to evidence and process. Good planning with partners will be key to ensuring the best surface water management options are identified and the risks and opportunities explored before construction begins. Through a review of our past experiences and sharing experiences with potential partners through workshops, we have identified the following lessons and key challenges that we will explore through the trial:

- **Time to mobilise work**. Our current process to manage large capital interventions is to follow our five-stage gated process. This typically takes 39-45 months from inception to conclusion. To be able to deliver the substantive programmes of blue-green infrastructure that we have set out we will require a more agile and bespoke approach for us to be confident of delivery. This could involve decentralising some aspects of the programme into much smaller sets of interventions (analogous to the way in which we use expenditure blocks to manage ongoing reactive-type maintenance). We take confidence from the way in which we were able to deliver our Birmingham Resilience scheme at pace within a very constrained timescale.
- **Resourcing and skills**. As set out above, designing and constructing a material programme of blue-green infrastructure is likely to require a change to the skillsets that we traditionally deploy in our capital programme. This again points to the use of smaller and more specialist contractual support balanced with upskilling of our own workforce through specific training programmes.
- **New delivery models**. We will need to engage with our current framework contractors to understand the implications of letting new programmes of work. Options to explore include:
    - Looking at bespoke delivery programmes that will add additional design, construction and management resources from a Tier 1 style partner to speed up delivery; or
    - Using more innovative approaches such as contracting other organisations to complete their activity in a complementary manner (e.g. housing associations when managing their estates and highways authorities when developing traffic calming measures); or
    - Creating funding pots from which a broad range of stakeholders could apply for that would incentivise homeowners and even special interest groups to turn back urban creep (e.g. increasing the permeability of front gardens or allowing environmental charities to deliver complementary biodiversity enhancing interventions). This could take the form of a competition, a grant programme, or even a reverse auction.

Acknowledging the above challenges, we anticipate that the programme should be best managed through a substantive and dedicated project team rather than being integrated into our wider programme delivery pathway. This could be through a formal alliance with key partners. It would allow for more agile decision making, and provide clear focus and support for resourcing with specialists experienced in analogous programmes.

4. Robustness and efficiency of costs

This section provides cost estimates for the identified Mansfield catchment scenarios and the counterfactual of managing future pressures through traditional storage interventions.

Finding and therefore costing the optimum suite of interventions will require detailed design 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 trial as location-specific interventions are developed.

4.1 Cost robustness: Costing future requirements using traditional interventions

To set boundaries for our programme costs, we have defined a minimum counterfactual catchment requirement against which the proposed holistic blue-green infrastructure interventions in this business case can be compared. This identifies the traditional storage interventions that our modelling suggests we would need to install in the catchment. These have then been costed using our project estimator tool STUCA.

The required storage capacity for each identified sub-catchment polygon is derived from the change in modelled escapes during a 1-in-10-year storm from the current baseline to the 2050 scenario. This identifies the need for ten surface water network shaft tanks and nine foul/combined network storage shaft tanks. Each asset will require a civil engineering structure, a pumping station to empty the tank back into the network once the storm has passed and associated connecting pipework from the existing network.

Nineteen of the catchment storm overflows, and the emergency works overflow, also show significant increases when population growth, urban creep and climate change are applied to the time series rainfall (TSR). Again, an assumed storage requirement has been developed for each one. Like the network flooding locations, a shaft tank and associated pumping and linking pipework has been assumed (see Table 11).

Table 11: We have assessed the attributes and requirements for each asset

	Surface water sewer	Foul/combined sewer	Storm overflow
Number of shaft tanks	10	9	20
Total storage volume (and range): m^3	16,810 (10 – 8,200)	29,100 (100-21,000)	54,850 (30-19,000)
Pumping power range: Kw	5-60	10-60	10-60
Infrastructure requirement: metres (600mm 2m deep)	5,750	4,750	5,000
Manholes	69	56	57

The costs of each assumed civil asset were derived based on the storage capacity required. The size of the pumping assets is scaled to the civil asset, and the required linking infrastructure is scaled based on the size of the sub-catchment polygon. The costs were derived from our assured STUCA cost curves except for the largest shaft tanks (>4,000m^3), where a unit cost of [redacted] for the civil component has been assumed. Project 'on costs' reflect current programme rates. Given the notional volumes used, an appropriate [Redacted] risk/contingency has been included within the estimate. Counterfactual programme costs have been calculated as shown in Table 12:

Table 12: Calculation of counterfactual programme costs

[Table redacted]

4.2 Robustness of costs: Identified blue-green infrastructure interventions

We have costed the identified blue-green interventions using unit costs derived by Arup from its portfolio of prior work in both the UK and abroad. This allows us to expose both the cost to install and the cost per storage volume equivalent, which illustrates the relative cost effectiveness of each intervention. Coupled with the intervention assemblages used, this has allowed us to identify 12 potential scenario costs for the Mansfield catchment trial.

Interventions have been costed using Arup-sourced unit costs. More details of the cost estimation process followed are set out in Appendix F. Table 13 shows:

- the unit cost assumed to install the interventions (using a m^2 surface area as the unit);
- the sizes of intervention units that we have used in in our analysis; and
- the storage volume equivalent of each intervention unit (i.e. the volume of network storage that will be negated through the installation of one unit).
- a unit cost per storage volume equivalent derived from the intervention unit cost and storage volume equivalent.

Table 13: Interventions costed using Arup-sourced unit costs

Intervention (costs in 17/18 price base)	Unit cost (£/m2)	Surface area of one unit of intervention (m^2)	Storage volume equivalent per intervention (m^3)	Cost per storage volume equivalent (£/m^3)
Grassed / planted detention basin	127	225.0	145.1	197
Planted bioswale	185	8.0	5.2	288
Rainwater downpipe planters	637	3.8	3.2	745
Permeable paving	317	8.0	2.0	1245
Verge raingardens	466	5.5	2.0	1261
Street planters	480	9.6	3.6	1297
Bioretention tree pits	492	6.3	2.3	1331

Note: unit costs are direct costs and do not include project on costs or risk/contingency

The data shows that there is a wide range of intervention costs and that the effectiveness of each intervention to manage surface water also varies. Rainwater downpipe planters provide the most volume benefit per m^2 installed. However, they are more than twice as expensive on a storage volume negated basis than the large bioswale and detention basins.

By comparison, the comparable overall programme counterfactual unit cost is £[Redacted]/m^3 (rising to £[Redacted]/m^3 with on costs and risk allowance). Given that the blue-green interventions bracket this storage unit cost, this provides wider context for why large-scale catchment-wide use of blue-green infrastructure has not been seen to date. This unit cost disparity is a major barrier if decision making is only made considering cost effectiveness rather than cost benefit, and interventions are small-scale without the potential benefits of economies of scale.

Table 14 sets out the range of costs for each of the scenarios we have developed. These have been derived from the identified interventions and unit costs and the current 'on cost' assumptions. These costed scenarios have been used alongside analysis of the net benefit assumed to identify the target programme expenditure for this business case. This process is set out in section 5.

Table 14: costs for each scenario of interventions

Scenario (equivalent storage target of 98,000m³)	Storage equivalent from blue-green infrastructure	Cost of AMP7 blue-green interventions (17/18 price base)	Additional grey storage assumed to 2050
Counter-factual scenario	0%	£0	101,000m³ (103%) £[Redacted]m
Scenario 1: 10% success factor	23,000m³ (24%)	£8.3m (min) £34.9m (default) £46.7m (max)	77,000m³ (78%) £96.0m
Scenario 2 & 2a: 25% success factor	58,000m³ (59%)	£61.4m (min) £87.2m (default) £114.9m (max)	Scenario 2: 57,000m³ (58%) £72.9m Scenario 2a: 40,000m³ (40%) £50.9m
Scenario 3 and 3a: 40% success factor	92,000m³ (59%)	£127.8m (min) £139.5m (default) £165.8m (max)	Scenario 3: 49,000m³ (50%) £62.2m Scenario 3a: 9,000m³ (9%) £11.0m
Scenario 4: Sub-catchment storage constraint	42,000m³ (59%)	£34.4m (min) £62.7m (default) £81.8m (max)	57,000m³ (58%) £72.0m

4.3 Cost efficiency

A key objective of the proposed Mansfield catchment trial is to explore how we can improve the cost efficiency of blue-green interventions, particularly when being deployed at pace at a catchment scale. Therefore, we are confident that the investment will enable future productive and allocative cost efficiencies that can be transferred to wider catchments in the future. However, we consider that the way in which we have developed the costs in this business case, and the systems and processes we are proposing to deploy in the trial, mean that the outturn costs will be efficient relative to current unit costs.

4.3.1 Systematised approach and culture

We will be implementing in-programme reviews at regular intervals to maintain focus on costs, progress and efficiency.

We are tailoring deployment of industry best practice tools to capture wider costs and benefits of nature-based solutions.

We have initiated technology scouting through Isle Utilities to develop a system for measuring the capability of nature-based solutions to provide flood resilience, addressing customer concerns that these may not be as effective.

4.3.2 Governance

We will explore the optimum delivery methods to ensure the efficient delivery of blue-green infrastructure at scale and pace. This will include reviewing how to both simplify and improve flood resilience partnerships, and understand changes in risk that this would bring.

We have set customer protection mechanisms to reflect cost uncertainty and ensure that efficiencies generated within the trial delivery will flow straight to customers (see section 6 and appendix 7). Outturn unit costs (£ per m^3 of storage equivalent delivered) for cost recovery will be capped at a value of £1466/m^3 whereby net benefits assumed in the business case will transpire from the investment.

We have set a programme expenditure target that bakes in a further cost efficiency challenge relative to the majority of our costed scenarios (see section 6 for further information).

4.3.3 Benchmarking

The blue-green interventions within our costed scenarios have been costed using Arup-sourced unit costs. These have been derived from Arup's experience and involvement in planning and constructing blue-green infrastructure across the UK and further afield. This includes helping to successfully deliver the Greener Grangetown interventions in an urban area of Cardiff, and the planning for sustainable drainage systems in Hull.

The counterfactual costs which the scenarios have been compared to have been developed using our STUCA cost estimation process. Standard items derived from this process were independently benchmarked by EC Harris/Arcadis during PR14 and PR19 and shown to be efficient. They also formed the bottom-up costing tool for our PR19 business plan, which placed us as one of the frontier companies when compared to Ofwat's modelled cost baseline. 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. Figure 22 shows this evolution for some of the unit costs relevant to the counterfactual estimate.

Project 'on costs' for both the blue-green scenarios and counterfactual costs have been derived from our current programme performance. The risk allowance has been validated against an analogous sample of flooding programme interventions.

Figure 22: unit costs relevant to the counterfactual estimate over time

[redacted]

5. Benefits of our proposal

We are confident that our proposal will deliver better flooding protection for communities, alongside wider benefits for customers and society. This section sets out the steps we have taken to identify that the interventions eventually deployed through the catchment trial will be both cost effective and cost beneficial.

5.1 Cost effectiveness and cost benefit sensitivity

The cost effectiveness of the scenarios is tested by comparing them to the counterfactual traditional storage approach. This identifies where the blue-green scenarios are already cost effective before consideration of any wider incremental benefits. We also identify the scenarios that we are confident will be cost beneficial when wider benefits are considered.

Table 15 sets out an analysis of the cost effectiveness of the scenarios we have developed. This has been identified by adding the blue-green infrastructure cost (column 3 below) to the assumed grey storage that will also be required alongside the scenario (column 6 below). This is then compared to the counterfactual cost of £[redacted]. Where the combined scenario and grey storage costs are less than the counterfactual, the scenario is cost-effective. Where the scenario is within 10% of the counterfactual, it is categorised as marginal.

Table 15: Analysis of cost effectiveness of the different scenarios

Scenario (equivalent storage target of 98,000m³)	Storage equiv. From BGI	Cost (AMP7 blue-green interventions)	Cost effective relative to counterfactual (before benefits)	Wider benefits needed to make scenario cost beneficial	Additional Grey storage assumed to 2050
Counter-factual scenario	0%	**£0**	n.a.	n.a.	101,000m³ (103%) £[Redacted]m
Scenario 1: 10% success factor	23,000m³ (24%)	**£8.3m** (min)	Yes	Already cost effective	77,000m³ (78%) £96.0m
		£34.9m (default)	Yes	Already cost effective	
		£46.7m (max)	Marginal	£10.9m (8%)	
Scenario 2: 25% success factor	58,000m³ (59%)	**£61.4m** (min)	Marginal	£1.7m (1%)	57,000m³ (58%) £72.9m
		£87.2m (default)	No	28.2m (21%)	
		£114.9m (max)	No	55.9m (42%)	
Scenario 2a: 25% success factor – sub-catchment interaction	58,000m³ (59%)	**£61.4m** (min)	Yes	Already cost effective	40,000m³ (40%) £50.9m
		£87.2m (default)	Marginal	£6.5m (5%)	
		£114.9m (max)	No	£34.0m (26%)	
Scenario 3: 40% success factor	92,000m³ (94%)	**£127.8m** (min)	No	£58.4m (44%)	49,000m³ (50%) £62.2m
		£139.5m (default)	No	£70.1m (53%)	
		£165.8m (max)	No	£96.6m (73%)	
Scenario 3a: 40% success factor – sub-catchment interaction	92,000m³ (94%)	**£127.8m** (min)	Marginal	£7.0m (5%)	9,000m³ (9%) £11.0m
		£139.5m (default)	No	£18.9m (14%)	
		£165.8m (max)	No	£45.1m (34%)	
Scenario 4: Sub-catchment storage constraint	42,000m³ (42%)	**£34.4m** (min)	Yes	Already cost effective	57,000m³ (58%) £72.0m
		£62.7m (default)	Marginal	£3.1m (2%)	
		£81.8m (max)	No	£22.2m (17%)	

Blue-green infrastructure provides additional wider benefits relative to analogous traditional storage solutions. This means that the cost-effective scenarios will, by default, also be cost beneficial. Scenarios shown as marginal would require wider benefits of less than 10% of the counterfactual expenditure requirement to the deliver a cost beneficial outcome. While costs and benefits will need to be revealed as we develop the trial, we consider that it is highly likely that wider benefits will be greater than the 10% assumed here – this has been further tested in section 5.3 below.

Scenarios that are shown here as neither cost effective nor marginal would require wider benefits of greater than 10% to guarantee net benefit to customers and communities. While this is plausible, as the requirement to realise wider benefit increases, the likelihood of identifying appropriate solutions in the short term reduces.

A wider sensitivity analysis mapping how each of the major drivers of uncertainty are managed within the business case and customer protection mechanisms is set out in appendix 7.

5.2 Informing the target programme cost and indicative scope

The scenario cost effectiveness and benefit sensitivity analysis has been used to set a target programme size for the Mansfield catchment trial. This considered the need to deliver a meaningful catchment-wide trial, and a level of confidence that the trial will deliver net benefit to customers and communities. A programme of up to £85m is proposed. This would likely see up to 59% of the 2050 surface water pressures managed through blue-green infrastructure interventions.

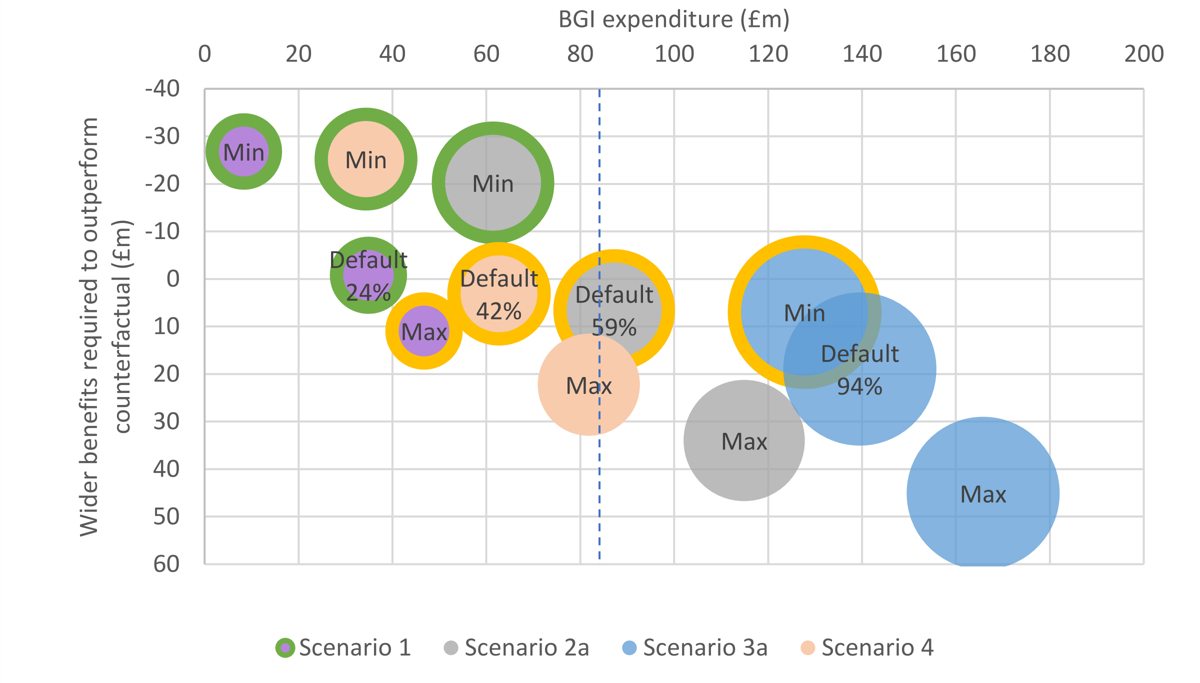
The basis for this Mansfield catchment trial is as follows:

- Demonstrate how blue-green interventions are best delivered at scale and pace. We know that the size of future pressures will make the traditional solutions less effective and whole-life efficient.
- Seek ways to improve the efficiency of known blue-green intervention unit costs, either by developing new interventions or by improving the effectiveness of existing solutions (e.g. through economies of scale). While the business case must use current unit costs, we hope the trial will deploy interventions using an improved set of unit costs.
- Bring in wider costs and benefits through delivery of holistic solutions that provide benefits to communities and the environment over and above the direct sewer flooding and CSO performance benefits.

To deliver against these objectives, we will maximise the amount of blue-green infrastructure delivered within the catchment. However, we also need to plan for a realistic scope that will deliver net benefit in the short term. The customer protection/cost recovery mechanisms proposed will protect customers by recovering expenditure through future revenues only where interventions will deliver net benefit – this is set out in more detail in section 6.

Given the need to balance the competing issues described above, the bubble chart in Figure 23 shows how we have identified the expenditure assumed in this business case. It shows the total blue-green infrastructure costs calculated for each scenario (x axis) and the extent to which the scenario is cost effective relative to the counterfactual (y axis). The sizes of the bubbles show the % of the 2050 storage equivalent target that would be delivered through blue-green infrastructure. The bubbles with a green border are already cost effective relative to the counterfactual traditional storage cost. Those with an amber border are marginal scenarios that have a total cost that is less than 10% greater than the counterfactual.

Figure 23: blue-green infrastructure costs for each scenario weighed against wider benefits



The analysis shows that, as the total amount of the blue-green interventions delivered increases, the relative cost-effectiveness of the programme reduces. This is because larger programmes must use an increasing proportion of interventions that are less cost effective. As demonstrated by scenario 3a, 94% of the Mansfield 2050 storage target could be delivered by blue-green infrastructure. However, to also ensure delivery of net benefit this would require:

- a favourable set of interventions (i.e. following the min intervention assemblage only);
- the generation of increasingly larger amounts of wider benefit;
- a material change to the economics of existing interventions; or
- a major roll-out of new interventions not currently considered.

Conversely, following scenario 1 would be very likely to deliver net benefit. However, the much smaller scale (only 24% of the future pressures) would significantly reduce the opportunity to learn about, and progress, the catchment scale deployment of blue-green infrastructure.

Based on the above analysis, we have identified the optimum balance for an £85m programme. This would allow us to deliver a suitably material catchment-wide trial – It would cover up to 59% of the 2050 catchment requirement. At the same time, we can have appropriate confidence that it will provide net benefit to customers and communities. Six of the seven intervention assemblages less than £85m are already cost effective relative to the counterfactual or marginal before wider benefits are considered. By contrast, for intervention assemblages greater than £85m, only two are marginal with the rest showing an increased level of uncertainty.

We have further tested the desirability of an £85m programme by reviewing the costs and benefits of the default intervention assemblages for the four identified scenarios (see section 5.3 below).

Table 16 sets out the anticipated profile of expenditure for the £85m programme. This includes an indicative disaggregation of direct costs, on costs, contingency and burdening in line with our counterfactual and blue-green infrastructure scenario costings.

Table 16: our anticipated profile of expenditure for the £85m programme

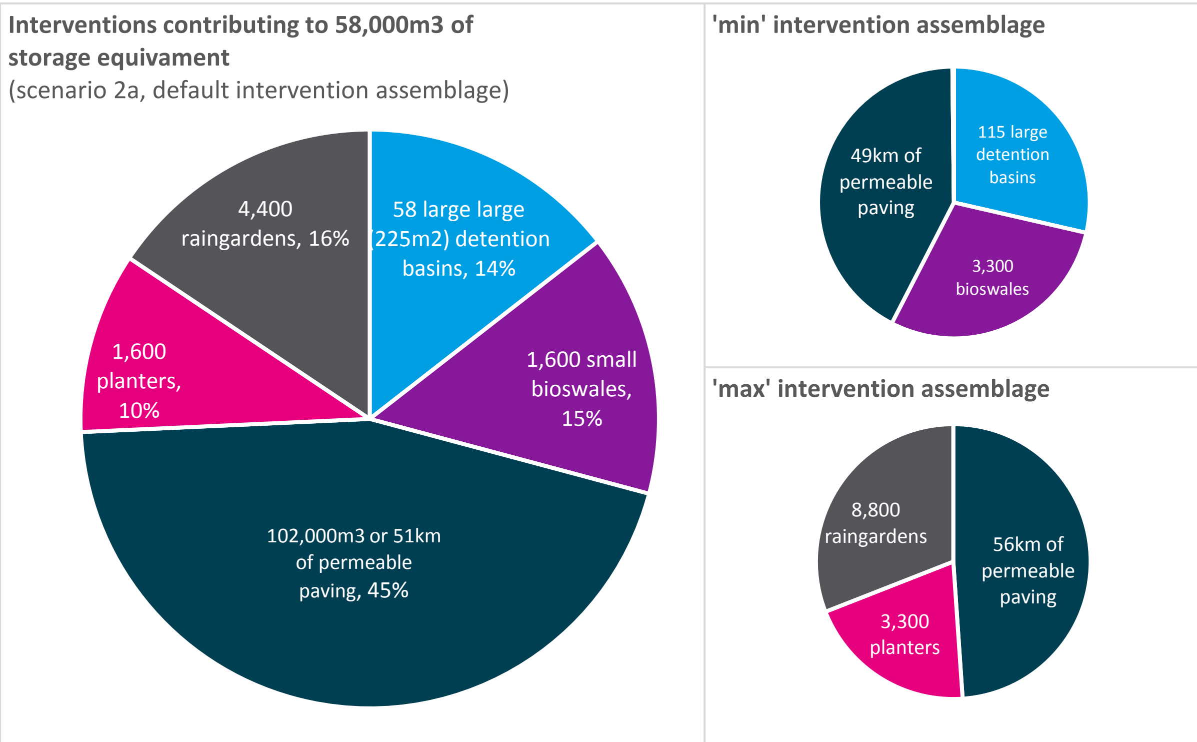
Description (£m 17/18 price base)	2021/22	2022/23	2023/24	2024/25	AMP7
Direct construction costs					
On-costs (e.g. design/feasibility, support, project management, contingency)			redacted		
Project Total (before burden)					
Project Total (with overhead and [redacted] burden)	5.0	10.0	30.0	40.0	85.0

5.2.1 Indicative scope of the target programme

Of the scenario intervention assemblages with costs of less than £85m, the largest deliverable identified for the Mansfield catchment is a blue-green infrastructure programme that equates to 58,000m^3 storage equivalent (scenario 2a). As we have set out in this business case, scenarios will remain indicative, with the appropriate set of interventions being revealed and unlocked as the pilot develops. This will be supported in the coming months by DWMP Baseline Risk and Vulnerability Assessment outputs, bottom-up 'on the ground' evidence from the catchment, and our continuing engagement with partners to closer align with wider flooding and community objectives.

However, our analysis shows how the scope may be delivered. The central 'default intervention assemblage' is illustrated in Figure 24 alongside the minimum and maximum assemblages.

Figure 24: Illustration of default, minimum and maximum intervention assemblages for Scenario 2 and 2a



The default intervention assemblage balances large-scale deployment of permeable paving with a balanced programme of interventions located directly in the streetscape (raingardens, street planters) and those in green spaces within the catchment (detention basins, bioswales). The minimum intervention assemblage increases the amount of green space interventions instead of those in the streetscape. The maximum intervention assemblage does the inverse, prioritising more costly streetscape over green space interventions.

The indicative costed intervention assemblages for scenario 2a are set out in Table 17. As described in section 4, the default and maximum assemblages are costed at more than £85m. Therefore, an efficiency will be required to deliver in line with the programme expenditure target (the approach to cost recovery is discussed further in section 6). The indicative intervention costs shown below assume that the efficiency will be derived equally across the intervention types.

Table 17: indicative costed intervention assemblages for scenario 2a

Scenario 2a Intervention assemblage	Costed Programme (£m 17/18 price base)	Required efficiency	Grassed / planted detention basin (£m)	Planted bioswale (£m)	Permeable paving (£m)	Street planters (£m)	Rain gardens, tree pits, downpipe planters (£m)	Intervention costs (assumed) (£m 17/18 price base)
Default	87.2	3%	2.5	3.7	49.7	11.6	17.4	85.0
Min	61.4	n.a.	5.2	7.7	48.4		0.1	61.4
Max	114.9	26%			41.1	17.6	26.3	85.0

5.3 Quantifying wider benefits and testing cost benefit

We have sought to understand the benefits that will accrue from the different interventions which then compound up to the costed scenarios. This will be a mix of quantified and qualitative benefit assessment. Comparing present value costs and benefits shows that each of the default intervention assemblages will deliver net benefit to customers and communities relative to the counterfactual.

We currently consider the case of deploying blue-green infrastructure quite narrowly from a drainage perspective, rather than how they might be adapted so that they can also deliver wider benefits. The most obvious example is that we have not set out to design assets in a way that would specifically enhance amenity benefit. However, this is increasingly being seen in other case studies, such as the water-sensitive urban design seen in Copenhagen (Figure 25) and Sheffield (Figure 26):

Figure 25: water-sensitive SuDS design in Sheffield

Figure 26: blue-green infrastructure in Copenhagen

It is becoming increasingly clear that the realisation of flood-resilient communities can deliver significant wider benefits that are in keeping with the aims of the Green Recovery, above and beyond primary benefits for water customers of reduced flooding incidents and CSO performance.

With support from Arup, we have reviewed wider uses and benefits of SuDS and blue-green infrastructure in urban catchments. We have identified and categorised how the benefits will likely transpire across the range of identified interventions, and the pathway via which the benefits will impact on identified beneficiaries.

Eight of the more material wider benefits have been quantified. These have been calculated for the developed scenarios by using the CIRIA B£ST benefits valuation tool, and additional datasets derived from projects Arup has supported elsewhere in the UK and abroad.

The primary flooding benefits that will accrue from the interventions have not been included in this analysis. This is because we assume that these will be delivered (in line with our wider sewerage duties) by both the identified blue-green scenarios and the counterfactual alternative. This means that the cost benefit analysis we have undertaken is to identify the amount of net benefit that will be delivered by the scenarios relative to our existing approach to managing future flooding pressures. The method we have used to quantify benefits is summarised in Figure 27:

Figure 27: our method for analysis of wider benefits related to blue-green infrastructure

Benefits	Value used to represent benefits	Methods of calculation
Air quality	Total health benefits associated with air quality improvements arising from reduction in pollution using damage cost method (estimates of the costs to society of the likely impacts of changes in emissions)	= Estimated no. of trees / ha of vegetation x annual pollutant removal levels (tonnes per tree per hectare) x unit damage costs
Amenity	Willingness to Pay (WTP) for street greening. Benefits captured by the survey not explicitly clear, but likely to cover range of benefits associated with street planting, including amenity, recreation, biodiversity and health	= Number of residents living in green streets (as a result of the interventions) x WTP for street greening per resident per year

Benefits	Value used to represent benefits	Methods of calculation
Biodiversity and Ecology	The total value of ecosystem services provided by different habitat types, in terms of current BAP (biodiversity action plan) spending to maintain these services	= (proposed habitat type (ha) x monetary value of habitat type (£)) – (existing habitat type (ha) x monetary value of habitat type (£))
Education	Cost of investing in nature-based school trips	= Estimated no. of students visiting per year x cost per student per trip
Ground water recharge	The environmental and social costs of obtaining water for public supply from a new replacement groundwater source	= Additional amount of groundwater (m3/yr) x the social cost of groundwater (£/m3)
Health	The value of having a view over green space from your house (no view to any view), established through linking changes in health utility score due to changes in environment to quality adjusted life years	= Estimated no. of adults having a direct view over green space from home (no view to any view) x unit value per person per year
Pumping	Energy cost saving from reduced pumping	= Volume of water retained per annum x energy cost to pump a volume of m3
Treating wastewater	Savings from operating cost, energy cost and process carbon emissions associated with wastewater treatment	= Estimated daily average flow (m3/d) change x unit cost of treatment (including cost, energy, carbon)

Table 18 shows the wider benefits that we have quantified for each of the Mansfield catchment scenarios. We have reviewed the present value benefits over 25-, 30- and 40-year periods. Figure 28 shows the breakdown of cumulative benefits over 25 years.

However, the discounting rate means that the varying observation period does not have a significant impact on the wider analysis. We anticipate that there could be overlaps between the biodiversity, amenity and health / wellbeing valuations. To prevent the risk of double counting, we have removed the biodiversity and amenity values from the analysis and assumed that the calculated health/wellbeing values will reflect all three. However, given that the benefits that have been quantified are only a subset of the wider benefits identified, we consider that the values presented will be minimum values.

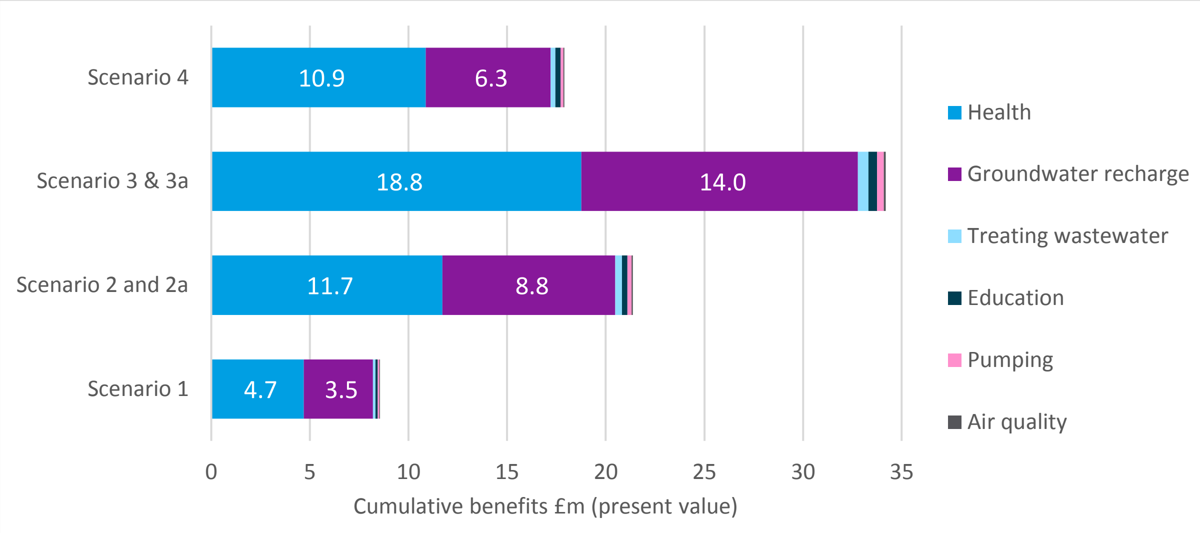
Appendix F provides more information on the approach we have followed to identify and quantify wider benefits.

Table 18: we have calculated the wider cost benefits for each of the Mansfield catchment scenarios

Assessment horizon: Present value benefits (£m)	25 years	30 years	40 years
Scenario 1	8.5	9.7	11.8
Scenario 2 and 2a	21.4	24.3	29.4
Scenario 3 and 3a	34.2	38.9	47.0
Scenario 4	17.9	20.4	24.8

N.B. Present value has been calculated using the social time preference discount rate (3.5% 1-30 years, 3% 30-40 years) and a separate health discount rate (1.5% 1-30 years, 1.29% 30-40 years).

Figure 28: cumulative benefits over 25 years for all Mansfield catchment scenarios



5.3.1 Testing the programme by calculating the net benefit of scenarios

To review the costs and benefits, we have quantified the whole life costs of the scenarios using:

- The intervention capital costs (as set out in section 4);
- Routine annual operating maintenance costs (as described in section 3.2);
- Capital maintenance in line with assumed asset lives as set out in the CIRIA SuDS manual; and
- A discount rate of 2.96% (regulatory cost of capital), observation periods of 25, 30 and 40 years.

Table 19 shows that each of the four scenarios will provide net benefit relative to the counterfactual traditional storage solution – with scenario 2a providing the greatest net benefit at £[Redacted].

Table 19: each of the scenarios will provide net benefit relative to the counterfactual

£m 17/18 price base (25-year observation period (default intervention assemblage))	**Whole life Present value cost***	**Present value benefit (wider benefits)**	**Net Present cost**	**Net benefit relative to counterfactual**
Scenario 1 - 10% success factor	129.9	8.5	121.4	[Redacted]
Scenario 2a - 25% success factor	135.2	21.4	113.9	[Redacted]
Scenario 3a - 40% success factor	153.4	34.2	119.2	[Redacted]
Scenario 4 – Sub-catchment storage constraint	134.8	17.9	116.9	[Redacted]
Counterfactual scenario/ Traditional solution	[Redacted]	n.a.	[Redacted]	n.a.

**To ensure comparability, this Includes blue-green intervention costs in scenario and additional traditional storage costs to manage residual catchment pressures (not in trial).*

This analysis is for the default intervention assemblages. Whilst the net benefit minimum intervention assemblages are not shown here, we can assume that these will deliver increased net benefit. This is because they include a greater proportion of planted bioswales and detention basins that will attract increased benefits in addition to their lower whole life costs. This analysis provides an increased level of confidence that a catchment trial comprising a programme of interventions up to £85m will deliver net benefit to customers in both the short and longer term.

6. Customer protection

There is a clear need to ensure that the regulatory treatment of this business case allows the flexibility that is essential to extracting the identified benefits from the trial, manages known uncertainties, protects the interest of customers and allows us to appropriately recover the costs that we incur. We have sought to balance this by developing a new delivery accountability mechanism.

It will be necessary to ensure that the business case 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 overarching approach to managing these issues is set out in *Annex 11: Customer protection*. There we explain:

- 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 Performance Commitment (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, and how we will adjust for these to avoid any double remuneration;
- How the totex cost sharing should be applied to better protect customers; and
- How the funding of the Green Recovery proposals could be implemented within the current AMP.

Contextual information on how we derived these mechanisms and what they mean for this business case is set out below. A sensitivity analysis setting out how the customer protection mechanisms combine with the business case proposals to manage the key drivers of uncertainty is set out in appendix 7.

Alongside the customer protection revenue recovery aspects, we will also commit to making the findings of the trial public. We will be proud to showcase what we deliver in the Mansfield trial and see this as a key moment for our sector. This will involve disseminating the information to planners, practitioners and policy makers. We want to make sure that the information we generate on how to efficiently deliver blue-green infrastructure at scale and pace can be used in other catchments across our region and further afield.

6.1 Calculating our proposed delivery accountability mechanism

In section 5 we have set out a target programme expenditure size of £85m. We have identified this should be sufficient to deliver a catchment-wide trial of an appropriate scale, at the same time as having appropriate confidence that customers will receive net benefit compared to managing future pressures through traditional interventions (i.e. relative to the counterfactual).

Of the scenario intervention assemblages with costs of less than £85m, the largest deliverable identified for the Mansfield catchment is a blue-green infrastructure programme that equates to 58,000m^3 storage equivalent (scenario 2a minimum). Therefore, we have set this as an output target. Together, these have been combined to create an assumed blue-green infrastructure unit cost of £1466/m^3 of storage equivalent (target expenditure (£85m) / target output (58,000m^3)).

We have combined the target programme expenditure value and the storage equivalent output target to derive a delivery accountability mechanism that will:

- Acknowledge and manage the current cost and scope uncertainty inherent within the business case (which the trial is attempting to overcome);
- Provide appropriate flexibility to design and implement interventions in the Mansfield catchment in accordance with necessary detailed analysis and engagement we will undertake in the opening phase of the trial; and
- Protect the interests of customers by providing appropriate confidence that they will receive net benefit from the wider programme and see the benefit of any efficiencies identified within the trial.

Successful interventions will be recoverable through future revenues or depreciation payments where we can provide independent assurance of the successful delivery of blue-green deliverables up to the output target (58,000m^3). This will use the assumed unit cost (£1466/m^3). Where the outturn unit cost is lower and this assumption, customers retain 100% of the benefits of any cost outperformance, i.e. future revenues will reflect the lower of the outturn unit cost or £1466/m^3.

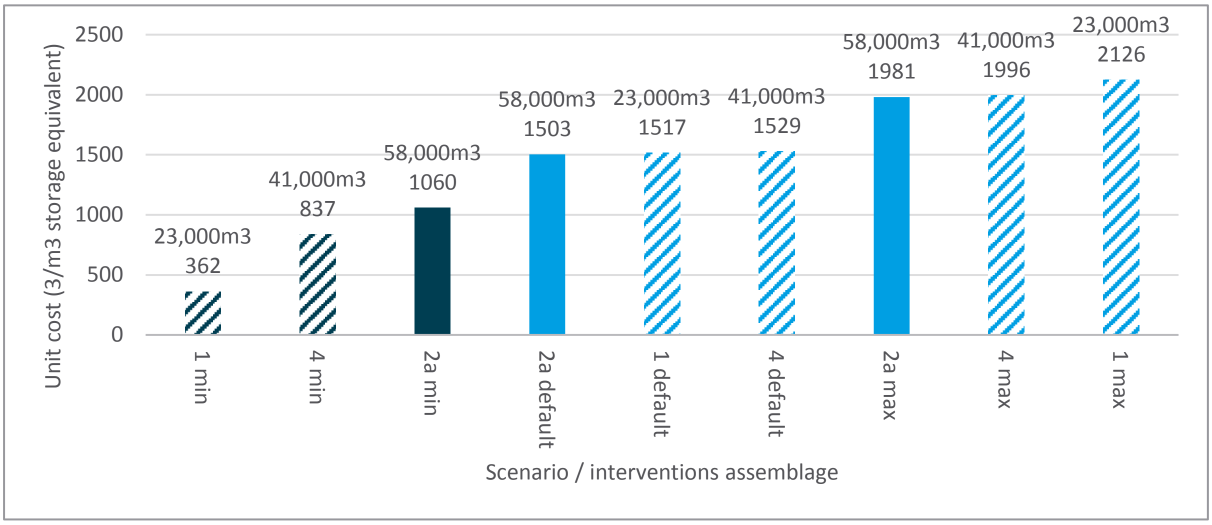
This delivery accountability mechanism will have the following benefits:

- It manages the scope uncertainty relating to determining what is deliverable in the catchment before detailed on the ground analysis is undertaken. Interventions can then be delivered in an orderly way based on specific engineering appraisal and community-based engagement. It maintains the opportunity for us to deliver a meaningful trial without facing a level disproportionate risk from our current input assumptions.
- Any outperformance of the £1466/m^3 unit cost (i.e. if we were to deliver a programme in line one of the identified minimum intervention assemblages) would be passed in back to customers rather than being subject to cost sharing.
- It incentivises us to identify innovative and efficient interventions within the trial. This is evidenced by the fact that most of the scenario intervention assemblage unit costs are greater than the committed £1466/m^3 unit cost. This essentially commits us to a further efficiency challenge against most of the potential intervention assemblages. This is in line with the objectives of the trial to find innovative solutions or improve the economics of current interventions so that we deliver more efficiently at scale and pace.

Figure 29 sets out how the delivery accountability mechanism would operate if we delivered in line with the various scenario intervention assemblages:

- Green columns show the intervention assemblages that have a unit cost below £1466/m^3. This efficiency would be passed to customers, as the outturn rather than target unit cost will eventually pass through to future revenues.
- The blue columns currently assume unit costs greater than £1466/m^3. The recoverable costs would be capped at £1466/m^3. This means that efficiencies will need to be realised through the delivery of the trial.
- The hatched columns identify scenarios where the size of the delivered programme would be less than the target output of 58,000m^3 storage equivalent. In these cases, the total recoverable costs would be less than the target programme expenditure of £85m.
- Scenario 3a has not been shown, as this would deliver more than the 58,000m^3 storage equivalent target.

Figure 29: illustration of scenario delivery against unit cost



Appendix A: Water companies' current flooding resilience remit and incentives

Currently in England, over 5.4 million homes are at risk from river and coastal flooding – around 1 in 6. The causes of inland flooding are increasingly complex and multi-faceted, with different organizations responsible for different types of flooding. The complex web of responsibilities makes collaborative solutions hard to deliver. Over time many of the simpler standalone-type issues get resolved, with the more complex, multi-agency responsibility issues forming an increasing fraction of the remaining problems for customers.

The complexity of flooding legislation and responsibilities was recognized in the Pitt review following the floods of 2007. This resulted in the Floods & Water Management Act 2010 bringing flooding issues under a single unifying act with clear responsibilities and obligations.

The main parties with responsibilities under the Floods & Water Management Act 2010 are:

Party	Responsibility
Defra	Overall national responsibility for policy on flood and coastal erosion risk management. Provides funding for Flood Risk Management Authorities.
Environment Agency	Takes a strategic overview of all sources of flooding & coastal erosion. Has operational responsibility for flooding from main rivers, reservoirs, estuaries & the sea.
Lead Local Flood Authorities (LLFAs)	Develop, maintain and apply local flood risk management strategies. Lead responsibility for managing risk of flooding from surface water, groundwater and ordinary watercourses.
District Councils	Can carry out flood risk management works on minor watercourses. Internal Drainage Boards (covering 10% of England) work in partnership with others to actively manage and reduce the risk of flooding.
Highway Authorities	Providing & managing highway drainage and roadside ditches.
Water & Sewerage Companies	Manage the risks of flooding from water and foul/combined sewer systems providing drainage from buildings and yards.

Sewer flooding and the interaction with wider surface water issues

Through our legislative remit, we currently have a clear but partial role to play in managing surface water flows across catchments. Through the Water Industry Act 1991, we are required to effectually drain our area and to clean the content of the sewers. This has required us to provide and maintain a network of sewers of appropriate size and robustness that can transport all the wastewater draining into them for onward treatment.

We are strongly incentivised to manage growth and maintenance driven sewer flooding events through the existing regulatory framework. This is driven by an unambiguous customer expectation and willingness to pay to avoid this unpleasant outcome.

However, sewer flooding is largely a function of surface water entering our network – most sewers act as both a means to transfer wastewater and to drain the wider catchment of surface water. During heavy rainfall – when communities are impacted the most – there is an increase in the interactions between different parts of the wider drainage system. Flooding in one part can cause issues elsewhere. This means that it can be difficult to apportion responsibility between different authorities.

Where the surface water inflow into our network is greater than the receiving system's capacity, the following hydraulic capacity issues may manifest:

- sewer flooding in houses, public spaces or gardens (sewers backing up or surcharging through manholes where the system cannot cope)
- surface water flooding of public spaces (where additional surface water cannot enter the drainage network as it is already at capacity).
- Increased storm overflow spills with likely knock-on pollution impacts.

Appendix B: Increased Government and regulatory expectations on flooding resilience

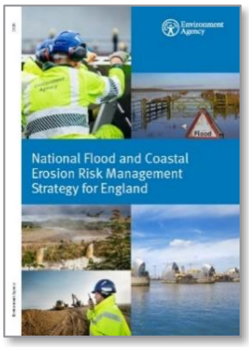
The last few years have seen a growing political will forming. The EFRA select committee recommended in 2016 that water companies should take on land drainage and river management functions from local authorities. It acknowledged, “*water bills would increase to cover the new responsibilities, but local levies would be removed to make the proposal broadly cost-neutral for consumers”.*

The Government has increasingly called for a coherent plan for the management of flooding risks. The 2020 Flooding policy statement confirms the need to manage flows of water through catchments more effectively. Communities should be better protected from flooding at the same time as providing wider benefits for water resource management and the environment.

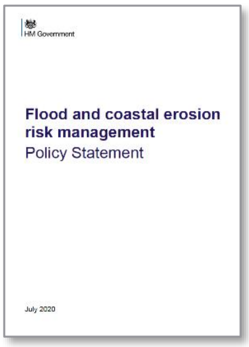
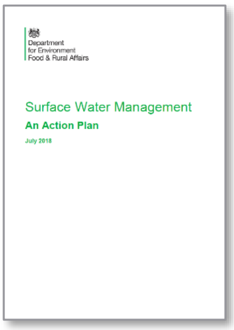
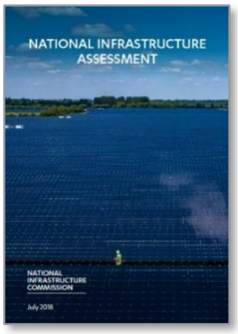
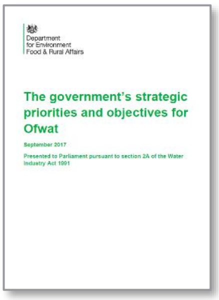
The Government’s 25 Year Environment Plan (published in 2018) sets out a commitment to reduce the risk of flooding through the increased use of SuDS and natural flood management solutions – working with nature to protect communities from flooding, slowing rivers and creating and sustaining more wetlands to reduce flood risk and offer valuable habitats.”[13] The plan specifically states that surface water flooding poses a significant and increasing risk, which can lead to sewer flooding and environmental pollution, and that Lead Local Flood Authorities, water and sewerage companies, highways authorities and other risk management authorities should better work together to manage it:

“Sustainable drainage systems (SuDS), … reduce the risk of surface water flooding. People and wildlife enjoy improved surroundings in urban areas, and water quality is better. SuDS can also help communities adapt to climate change. Water and sewerage companies can also help to improve surface water management. The Government’s strategic priorities and objectives for Ofwat, the water industry regulator, set out how we expect companies to be challenged to develop a mix of solutions to meet current and future water management needs. This includes improved partnership working with local authorities to manage flood risk and adoption and maintenance of SuDS.”

The table below gives a summary of the key external policy statements relevant the increasing need to utilise SuDS and blue-green infrastructure:

Document	Linked statements	
National Flood Risk Management Strategy (NFRMS) (Sep-20)	One of the three core ambitions is ‘Climate Resilient Places’, including a Strategic Objective to encourage nature-based solutions and a measure to work with partners to develop adaptive pathway approaches to plan for future flooding and climate hazards.	

[13]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf

Document	Linked statements	
Defra Flood Risk Management Policy Statement (Jul-20)	Aligned with the policy area to 'Manage the flow of water more effectively', specifically to promote actions which can help prevent and better manage the potential impacts of surface water flooding.	
Defra Surface Water Action Plan (Jul-18)	Includes a key theme of 'Joined up planning for surface water management' and stresses the need for those responsible for managing surface water (including water companies) to work together to tackle risks effectively. Water companies' Drainage and Wastewater Management Plans (DWMPs) are noted as one of the most important plans to manage surface water.	
National Infrastructure Assessment (Jul-18)	A theme of 'Reducing the risks of Drought and Flooding'. Recommendations include: A national standard for flood resilience 0.5% per annum by 2050, increasing to 0.1% for dense urban areas. Nationwide catchment-based plans to combine green and grey infrastructure Water companies and local authorities should work together on joint plans including investment requirements.	
Defra Strategic Policy Statement to Ofwat (Sep-17)	Defra expects that Ofwat should "encourage companies in the use of natural capital and have appropriate regard for the wider costs and benefits to the economy, society and the environment."	

Appendix C: Future flooding pressures faced

A growing problem

Flooding is the most frequent form of natural hazard in the UK[14]. There is also an increasing number of houses being built on flood plains. This means that when floods do occur, they are more likely to directly affect the population. Flood risks and their interaction with growth and development are described in the new National Flood Risk Management Strategy[15].

Extended periods of extreme winter rainfall are now seven times more likely because of human induced climate change. For every degree of global warming, the earth's atmosphere can hold about 6% more moisture. This increases the energy available to be fed into thunderstorms. The circulation of weather systems is also affected, with warmer air that has risen in the tropics descending in more northerly latitudes. For northern Europe, this will result in wetter winters.

We experienced these challenges first-hand during 2019/20. The summer of 2019 was the second wettest since 1910 leading to saturated ground conditions as we entered the wetter autumn period. Rainfall during October led to flooding across the Midlands up to the border with Wales. The River Wye saw record levels and it was reported that at the end of October the entire stretch of the River Severn was covered by flood warnings throughout our Shropshire, Worcester and Gloucester counties. During November and December the rainfall continued leading to the River Avon topping its banks and flooding agricultural land throughout Gloucestershire and Worcester. In other parts of our region we experienced the wettest autumn on record, with Nottinghamshire especially impacted. As we entered 2020, a stronger than normal jet stream which was tracking further south than normal resulted in a succession of Atlantic storm systems to hit the UK. Named storms Ciara, Denis and Jorge brought record breaking rainfall to the country with most of our regions seeing more than 250% the monthly average. On the whole the Met Office reported that February 2020 was the fifth wettest since 1862. The storms hit our region in quick succession leading to both the Rivers Wye and Severn being at their highest ever recorded levels and further flooding across the Midlands.

Since the 1950s, annual precipitation has increased in northern Europe and the number of consecutive days of rain is increasing. The UN's Intergovernmental Panel on Climate Change expect that this trend will continue. Its fifth assessment report has predicted with high confidence that northern Europe will see a rise in extreme rainfall in the decades ahead[16]. Total rainfall from extremely wet days has increased by about 17% [need reference]. This has meant that the frequency of flash floods has increased at a higher rate than river floods since 1980.

The number of devastating floods that trigger insurance payouts has more than doubled in Europe since 1980. Munich Re – the world's largest reinsurance company – show that there were 30 major flood disasters requiring large scape insurance payouts in Europe last year – up from just 12 in 1980[17]. This trend is set to accelerate as warming temperatures drive up atmospheric moisture levels.

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[14] Neelson, A. *(*2017*).* Flood disasters more than double across Europe in 35 years*. The Guardian Retrieved from* https://www.theguardian.com/environment/2017/jan/19/flood-disasters-more-than-double-across-europe-in-35-years

[15]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/920944/023_15482_Environment_agency_digitalAW_Strategy.pdf

[16] https://www.ipcc.ch/assessment-report/ar5/

[17] https://www.theguardian.com/business/2017/jan/04/insurers-paid-out-50bn-natural-disaster-claims-2016

The impact of future pressures on surface water flows entering our catchments

The external pressures that will drive increasing future sewer flooding risk if we do not intervene are:

- **Climate change** (increasing the amount and intensity of surface water that can enter our network)
- **Increasing urban creep** (increasing impermeable surfaces in a catchment effectively increasing the size of the area that is drained into our network)
- **Population / property growth** (increasing the amount of foul water entering our network and surface water where it is drained to a combined sewer)

In 2011, Ofwat commissioned Mott Macdonald to write "Future Impacts on Sewer Systems in England and Wales"[18]. Based on a study of 97 sewerage catchment models covering 16% of the population of England and Wales; it calculated a median increase in sewer flooding volumes and incidents in the 2040's of 51%. Such an increase in flood volumes will affect more customers, more frequently, and with a greater severity.

Driver	% increase in sewer flooding volumes and incidents (median catchment model)
Population growth	5%
Property creep	12%
Climate Change	27%
Combined	**51%**

We are undertaking this type of analysis at a catchment level for our DWMP planning. Catchment models which include the amount of surface water entering the catchment during a storm are used to identify baseline performance and sewer flooding risk. This allows us to understand both the location and volume of sewer flooding events for given storm probabilities.

Using the surface water information shown above, we can show that, during a five-year 60-minute rainfall event, around 128 litres per second of surface water enters into our networks for every hectare that eventually drains into our combined sewers – enough to fill an Olympic swimming pool in less than five hours. Changes in rainfall intensity as a result of climate change, or an increase in runoff due to an increase in impermeable areas (for example from front gardens being paved over to provide off-street car parking) will exacerbate this value. An UKWIR study undertaken in 2017[19] concluded that increased flood volumes are likely to be at least double the climate change driven rainfall increase. This is due to headroom within the sewerage network being finite and so once spare sewer capacity is used up, there is nowhere for excess flows to go, other than result in flooding or increased storm overflow spills. There will also be corresponding impact on surface water flood risk as a sewerage system at full capacity can no longer accept surface water inflow, resulting in in increased above ground flood risk.

[18] "Future Impacts on Sewer Systems in England and Wales" Ofwat, 2011

[19] "Rainfall Intensity for Sewer Design – Technical guide" 15/CL/10/16-1, UKWIR, 2015

Whilst the relationship between rainfall and flooding will vary depending on individual catchment characteristics, we are seeing this common theme being borne out in the DWMP modelling we are doing as part of the Baseline Risk And Vulnerability Assessment (BRAVA) work to inform the December 2020 DWMP National Picture.

Perturbing the models with 2050 inputs allows us to understand the impact on future sewer flooding performance. The increase for the 23 catchments is shown in the table (right). It shows that future sewer flooding volumes will likely increase by an average of 67% - reinforcing the earlier Ofwat forecast.

Traditional sewerage-based solutions are likely to struggle to mitigate the double impact of increased rainfall intensities affecting both sewer flood risk and surface water flood risk. Therefore, a holistic approach to manage surface water at source is needed. SuDS based solutions are well placed to manage that impact and will offer wider benefits to other flood risk partners and the wider community / environment.

Sewerage catchment	2050 Sewer flood volume increase*
Ilkeston	146.0%
Derby	117.6%
Minworth	101.9%
Matlock Lea	86.8%
Coleshill	84.3%
Rushmoor	83.8%
Worcester	70.2%
Loughborough	66.0%
Stoke Bardolph	64.6%
Wanlip	63.4%
Roundhill	62.4%
Strongford	61.8%
Coalport	60.0%
Barnhurst	57.9%
Mansfield	57.0%
Finham	56.6%
Netheridge	55.1%
Goscote	52.9%
Monkmoor	49.8%
Hayden	45.1%
Longbridge	43.6%
Claymills	35.3%
Kidderminster	26.6%
Average	**67.3%**

*Flood volume increase from the combined impact of climate change, urban creep, growth and new development as well as a consideration for water usage, efficiency and occupancy rate trends.

Appendix D: Identifying wider benefits of blue-green infrastructure

Designing blue-green infrastructure to deliver more than just surface water management does not need to be difficult or costly, but it does require early consideration at the planning stage, creativity, consultation and partnership. When attempted, blue-green interventions can deliver benefits for the whole community in terms of biodiversity, climate regulation, regeneration, learning, health, recreation and play. The RSPB state that organisations that link the requirement for sustainable drainage infrastructure and objectives of wider social and environmental policy have shown that it is a cost-effective way of delivering sustainable, resilient communities in urban areas[20].

Surface water drainage (additional to combined sewers)

Surface water management relates to how water is drained before it enters major watercourses. Rain falling on permeable surfaces will typically return to groundwater via infiltration. However, impermeable areas or (or permeable areas where the infiltration rate is exceeded will see water flowing over ground to watercourses or via constructed drainage networks. Our combined sewer network forms part of this conveyance.

Surface water flooding can be defined as flooding from sewers, drains, small watercourses, ditches and groundwater that occurs during heavy rainfall. It includes:

- Pluvial flooding: flooding as a result of high intensity rainfall when water is ponding or flowing over the ground surface (surface runoff) before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity.
- Sewer flooding: flooding which occurs when the capacity of underground systems is exceeded, resulting in flooding inside and outside of buildings. Normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters.
- Flooding from small open-channel and culverted urban watercourses which receive most of their flow from inside the urban area.
- Overland flows from the urban/rural fringe entering the built-up area, including overland flows from groundwater springs.

In prolonged, exceptionally heavy downpours, which are becoming more frequent, the ground can become saturated and the drains and sewers which carry away surface water may not be able to cope, leading to surface water flooding. Although this is more likely in low-lying areas, and to premises at the foot of slopes, it can happen to many other properties that are not specifically designated as being at risk of flooding on the Environment Agency's flood risk maps.

Surface water flooding may be triggered or made worse in urban areas where the ground consists of mostly hard surfaces such as concrete or tarmac, so the rainwater flows straight off rather than soaks away into the ground. It is estimated that around 2 million properties are at risk of surface water flooding in the UK – rising to 3.2 million by 2050.

Increasing the permeability of urban spaces reduces the pressure on engineered drainage systems or potential of surface flows to collect in areas where it will case cause damage. Blue-green Interventions

[20] https://ww2.rspb.org.uk/Images/SuDS_report_final_tcm9-338064.pdf

as part of a wider integrated surface water management strategy can also provide localised storage. This will help to attenuate flows lowering flood pollution risks to water bodies. This, in turn, reduces the risk of economic damage and inconvenience.

Traditional piped drainage networks convey water far more quickly than natural processes. Rivers respond quickly to rainfall exacerbating downstream flooding. Flooding also occurs where housing and other urban development such as the paving of gardens and the building of extensions (often referred to as 'urban creep') increases the volume and speed of runoff. Slowing the hydraulic efficiency of surface water flows and flattening storm hydrographs, will mitigate the risk of most flooding drivers – not just sewer flooding.

Flooding risk reduction will impact on the economic wellbeing of individuals and communities. The costs from repair or recovery after flooding include:

- Repairing damage to buildings and other property due to inundation and contamination by floodwater.
- Repairs to infrastructure damaged by the floods
- Temporary accommodation for the victims of flooding.
- The wider community costs of disruption to employers, people unable to attend their workplace or the recovery time to resume normal business activities.

Water resources

By slowing down catchment hydrology and improving water quality, SuDS can help to recharge groundwater supplies potentially contribute to the mitigation of sustainable abstraction risks increasing security of supply and reducing impact on the environment. Effective management of surface water also opens the potential for distributed water resources / greywater usage. This then has knock on impacts on potable water consumption.

Increased use of blue-green infrastructure in catchments can increase infiltration to groundwater. This can help maintain natural hydrology, increase availability of water for abstraction or reduce treatment costs. Benefits will be greatest where groundwater is over-abstracted, is in an area of moderate or serious water stress or during very dry/drought periods.

Use of blue-green infrastructure at a more local scale can also generate water reuse opportunities which in turn reduce the pressure on more regional water supply challenges. Capturing surface water runoff locally and using it for toilet flushing or landscaping reduces the amount of potable (mains) water required. This will have knock on benefits to the consumers through lower bills and reduce pressure on our own abstraction, treatment and distribution costs.

Ecology and pollution and biodiversity

Sustainable drainage and blue-green infrastructure will reduce flows entering combined sewers. This will correspondingly reduce escapes of sewage both in terms of flooding (which, when close to watercourses can have a pollution impact) and combined sewer overflow discharges. This, in turn, has the potential to improve (or avoid deterioration of) the quality of the receiving water body. This is strongly aligned to the current policy direction of travel as demonstrated by the new Storm Overflows Taskforce which has the goal of eliminating harm from storm overflows[21].

Surface water runoff is often polluted with silt, oil and other contaminants which, when discharged to rivers, can harm wildlife and contaminate drinking water sources. Most blue-green infrastructure interventions generate water quality improvements by reducing sediment and contaminants from runoff. This is typically through either settlement or biological breakdown of pollutants[22]. Piped drainage also prevents natural percolation of rainfall into groundwater resources that support summer river flows. Lower summer flows can lead to the concentration of nitrates and phosphates in rivers and wetlands, causing an increase in algal blooms, harming wildlife and reducing amenity value.

Improvements in receiving water quality will result in a number of benefits. The most obvious is on the EAs assessments of WFD waterbody status. Others include aesthetic benefits (reduction in visible pollution such as an oily water surface), health (e.g. reduced risk of infection from bathing/watersports) and improvements in river system ecology and biodiversity. Improvements in water quality may help offset the ecological impact of climate change on river ecology, where rising temperatures are expected to adversely affect sensitive species such as invertebrates[23].

Most blue-green interventions have the potential to make a significant contribution to the terrestrial and waterborne biodiversity of an area (e.g. green roofs, ponds, swales, wetlands, trees). This biodiversity and ecology value underpins some of the other related benefits, such as health and wellbeing. They have the potential to bring urban wetlands and other wildlife-friendly green spaces into our towns and cities. Working at catchment scale provides opportunities to generate additional benefits, as connected features can act as linking habitats, stepping stones or as part of a corridor, allowing wildlife to move through urban areas and into rural areas.

Energy and carbon

Embedded carbon emissions from the production and construction of blue-green interventions are generally agreed to be lower than traditional grey infrastructure. This is due to the difference in construction materials and the carbon sequestration benefits of newly planted trees and other vegetation.

Once constructed, ongoing operational carbon is often lower as the maintenance, energy and carbon cost for sustainable drainage features is lower than the associated pumping costs of network storage interventions. By intercepting and infiltrating surface water flows and reducing flows into the surface water and combined networks, energy and carbon costs are avoided at sewage pumping stations further down the network, as well as potentially at inlet and inter-stage pumping stations within the receiving sewage treatment works.

Treatment requirements are also reduced, with a lower volume of stormwater requiring treatment. Wastewater treatment process inefficiencies can be avoided by dealing with a lower volume of sewage that has been diluted with stormwater. Often, biological treatment processes are most efficient (and so use less energy, need less chemical dosing etc) if they can be supplied with a more stable inflow of sewage (in terms of flow and load).

[21] https://www.gov.uk/government/news/taskforce-sets-goal-to-end-pollution-from-storm-overflows
[22] https://www.susdrain.org/delivering-suds/using-suds/benefits-of-suds/water-quality-management.html
[23] https://www.sciencedaily.com/releases/2019/06/190603102545.htm

The net carbon impacts of the proposed solutions are outlined in Annex 06: Net Zero Carbon, but based upon the average across all scenarios this project becomes climate positive after 20 years with an annual carbon saving of 21 tonnes of carbon emissions every year.

Climate adaptation

Blue-green infrastructure will help us adapt to rising temperatures and increasingly extreme and unpredictable weather events. For example, research suggests the number of people at risk of urban flooding in England could increase to 3.2 million by 2050 because of climate change and population growth. The national environment white paper clearly indicates the strategic role green infrastructure must play in combating the effects of climate change such as flooding and heat waves.

Sustainable drainage solutions provide obvious opportunities for adaptation including flood attenuation, groundwater recharge, wetland creation and local climate regulation through evaporative cooling. In the urban high streets of the future, where average temperatures may increase by up to 6°C, trees, groups of trees and SuDS wetlands could be an essential part of the street scene. Implementing blue-green infrastructure now to deliver these adaptation benefits for the future represents high quality joined up planning.

Climate change will also affect the distribution of wildlife, habitats and the health of ecosystems which in turn will have an impact on human well-being. The RSPB has stated that blue-green infrastructure provision will help reduce habitat fragmentation, allow migration of species and support ecosystem resilience through targeted wetland creation and management.

Amenity, health and well-being

We have commissioned a study from Create Streets. They are specialists in planning and designing urban spaces that are: beautiful, sustainable, prosperous, economically and socially successful and correlated with good wellbeing and public health outcomes. They have undertaken a detailed review of academic, policy and case study information to inform us how the presence of blue-green infrastructure and the way in which it is designed and created can have material well-being benefits over and above the direct flood protection provided.

"Solutions to reduce the impacts of… extreme weather conditions for cities must be holistic, based on systems thinking, for both the people, the economy and the planet. This approach to urban design is often called 'biomorphic urbanism'[24]. When cities are formed and designed around life, they are 'bio-centric', they create shared natural assets for all forms of life that enhance the human experience of cities."

Well-being improvements derived from green spaces do not necessarily need to be delivered at a grand civic scale. Research suggests that people obtain more positive impacts on their well-being from smaller, more frequent and accessible greenery such as the spaces and streets between buildings[25] For example, street trees have a positive impact on well-being by providing greenery to the street as well as solar shading[26]. Urban managed green space has an important impact on the propensity to

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[24] Kindel, P. J. (2019) Biomorphic Urbanism: A Guide for Sustainable Cities. Available at: https://medium.com/@SOM/biomorphic-urbanism-a-guide-for-sustainable-cities-4a1da72ad656
[25] BoysSmith,N.,Venerandi,A.,&Toms,K.(2018).'Beyondlocation'.LandJournal,12-14.
[26] Winch, R. Hartley,S. Lane, J. (2020) *The Ignition project: Nature-based solutions to the climate emergency.*

exercise. In one study, those living within a mile of green space were 38% more likely to engage in physical exercise than those living further away[27].

Research has shown that spending time in places with increased biodiversity decreases chances of developing inflammatory-based illnesses such as asthma, cardiovascular disease, some cancers, potentially some neurodegenerative diseases, type 2 diabetes, inflammatory-associated depression, and some forms of obesity[28]. Research has also found that more biodiverse spaces increase mental well-being[29].

Placemaking and urban regeneration

Appropriately designed blue-green infrastructure in urban settings can help to stimulate economic recovery and support climate change adaptation objectives.

By reducing the volume and flows of surface water runoff entering into the drainage/sewerage system, sustainable drainage can help to create more ‘headroom’ or capacity in the drainage network of a catchment. This can unlock land that would otherwise be unavailable for development.

In Copenhagen, the masterplan included “parks and playgrounds that can be flooded during heavy rainfall but in dry weather serve as recreational spaces for the citizens”. This means flood mitigation and prevention interventions will also “support the overall goal of increasing the liveability of the city of Copenhagen”[30].

Similarly, in Sheffield, part of a former ring road has been transformed into a green routeway. Flood resilience measures have combined the traditional benefits of rain gardens, swales, street trees and greenery with the additional benefits of active travel as provided by the pedestrian spaces for walking, improvement in public realm, public transport routes and cycle ways[31].

Green spaces and streets encourage people to slow down, linger and interact with each other. In residential areas, this increases social interaction and enable stronger communities to form[32]. Uniform and regular street tree planting have also been found to “calm the traffic naturally and ‘define’ the space[33]. Parks and managed green spaces provide a local distinctiveness that can “help to build a stronger sense of 'ownership' and civic pride” associated with positive well-being[34]. Greenery near buildings can also impact on levels of expected crime, fear of crime or violence[35]. This has been

[27] Cohen D.A., McKenzie T.L., Sehgal A., Williamson S., Golinelli D. and Lurie N. (2007). *Contribution of public parks to physical activity.* American journal of public health, Vol. 97 (3), pp. 509-514.

[28] Haahtela, T. , Holgate, S. Pawankar, R, Akdis, S., Benjaponpita, S., Caraballo, L. Demain, J. Portnoy, J. Hertzen, L. (2013) The biodiversity hypothesis and allergic disease: world allergy organization position statement. World Allergy Organization Journal. Vol. 6 (3).

[29] Sandifera,P.A.,Sutton-Grierb,A.E.,Ward,B.P.(2015) Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. Ecosystem Services (12) pp1-15

[30] Ramboll. (2020) *Cloudburst mitigation will prevent cities from drowning.* Available at: https://ramboll.com/media/articles/water/cloudburst-mitigation-will-prevent-cities-from-drowning

[31] Green Cities (2019) Available at: https://uk.thegreencity.eu/best_practices/grey-to-green-sheffield-phase-1/

[32] UKGBC (2020) *Nature-based solutions to the climate emergency.* Available at: https://www.ukgbc.org/wp-content/uploads/2020/08/Nature-based-solutions-to-the-climate-emergency.pdf

[33] Boys Smith, N. (2016). *Heart in the Right Street.*

[34] Everard, M., Moggridge, H.L. (2012) *Rediscovering the value of urban rivers.* Urban Ecosystems, Vol.15. pp. 293–314.

[35] Iovene, M. , Boys Smith, N. , Seresinhe, C, I. (2019) *Of Streets and Squares.*

attributed to the calming effect of greenery and the greater outdoor use of spaces. A study by in Baltimore found a 1.2% decrease in crime levels for every 1% increase in tree canopy[36].

The way in which interventions are designed and implemented can also have a material impact on resident ownership of their communities. In Hammersmith and Fulham, residents were involved from the beginning of the project and thorough delivery[37]. They informed the designs based on how they used the existing spaces, problems they experienced, and improvements they would like to see. Throughout the process 427 residents were involved. After the project was finished, engagement continued through food growing and gardening clubs, training for locals on sustainability and using the enriched locality for community events.

Environmental jobs and skills

Delivering blue-green infrastructure involves three key components: design, construction and maintenance, all of which require specific competencies and skills.

Design: Through our current sewerage network strategy, we have started to upskill our strategic and asset-specific design functions. This is seen through the delivery of our AMP5 and 6 case study interventions. Where necessary, this involved specific technical input, which in the future could be delivered in-house.

Construction: Construction of blue-green infrastructure features are not necessarily more complex to construct than traditional 'grey' alternatives – typical processes include construction and landscaping operations such as excavation, filling, grading, topsoiling, seeding and planting. However, ensuring the workforce is experienced in the asset type is crucial. Two external case studies caution that using contractors with no previous experience of sustainable drainage installation can lead to reduced functionality and cause costly future maintenance and/or repair.

Maintenance: Maintenance of blue-green infrastructure is vital in order to deliver the anticipated benefits such as flood risk management, amenity value and biodiversity. Typical tasks required to maintain sustainable drainage are set out in the table below. These activities are likely to require an increase in roles such as Land Management or Wetland Officers. These activities could be undertaken by our workforce, through delegation to special interest partners or potentially through community engagement. Without the ongoing maintenance of blue-green infrastructure, we run the risk of benefits eroding over time, costly future repairs and even flooding communities. Acquiring an understanding of effective maintenance regimes early helps us to prepare our workforce for the future rollout of the strategy in AMP8 – such as through the training, upskilling and partnerships we form.

[36] Troy A., Grove J.M. and O'Neil-Dunne J. (2012). T*he relationship between tree canopy and crime rates across an urban–rural gradient in the greater Baltimore region.* Landscape and urban planning, Vol. 106 (3) pp. 262-270.

[37] Groundwork (2020) *LIFE+ Climate-Proofing Social Housing Landscapes Social Return On Investment (SROI) Report* https://issuu.com/groundworklondon/docs/c2_sroi_report

Activity	Indicative frequency	Typical tasks
Routine/regular maintenance	Monthly	Regular management (including mowing and litter picking) Inspection of inlets, outlets and control structures.
Occasional maintenance	Annually (dependent on the design)	Silt control around components Vegetation management around components Suction sweeping of permeable paving Silt removal from catch pits, soakaways and cellular storage.
Remedial maintenance	As required (tasks to repair problems due to damage or vandalism)	Inlet/outlet repair Erosion repairs Reinstatement of edgings Reinstatement following pollution Removal of silt build up.

Blue-green infrastructure can have positive community engagement benefits. This can include positive impacts for the economic well-being of people. The work completed in Hammersmith and Fulham provided new jobs and apprenticeship programmes for young and local people[38].

[38] 11 new jobs were created by the project; eight people were trained as sustainability champions ; 46 council contractors and managers were trained; and 22 young people were employed as 'green team trainees'. They received a Level 1 horticulture qualification and were supported to find employment on completion of the programme. There were also eight training workshops held for the local council and maintenance team.

Appendix E: Identifying the location for our catchment trial

We have followed a thorough process to identify a suitable location to undertake an effective catchment wide trial on how to best manage surface water with blue-green infrastructure – this has identified Mansfield. It is an appropriate size to test how to best refocus delivery of our sewerage network obligations in the face of large future pressures. Mansfield will also be particularly well placed to benefit from the wider societal and community positives generated from blue-green infrastructure such as improving amenity and stimulating urban regeneration.

Criteria for selecting a suitable catchment

We are proposing the UK's first catchment-scale trial to unlock how best to deliver flood-resilient community benefits at scale and pace. When it comes to understanding how catchments would benefit from this approach, we believe that maximum benefit will be achieved in catchments with the following attributes:

- **Vulnerability to current and future surface water pressures**. We need to focus on a location where future risks are anticipated (including surface water flooding, sewer flooding, and storm overflows).
- **Specific opportunities to leverage wider societal benefits**. Delivering in more deprived areas provides us with the greatest opportunity for both Green Recovery levelling up (vulnerable customers are often less well able to respond to flooding) and net community benefit (such as through access to managed green spaces).
- **Opportunities for delivery and learning**. Such as presence of combined sewers (providing scope for separation) and space available to construct nature-based solutions.

Once the flood-resilient communities concept has been demonstrated at a catchment level and shown to be cost beneficial, these benefits should be realisable across the breadth of our region. **Our key priority it to deliver a robust and representative trial which will unlock benefits across many catchments**, rather than guarantee the greatest amount of benefit at the first attempt. Consequently, we also considered the following additional factors:

Additional success factors

A catchment of appropriate size and make-up	• To make sure the results of the trial are meaningful to our wider region
Alignment with known current performance risks	• Investment also delivers shorter-term net benefit such as flooding reductions.
Near term plans for significant investment in the existing infrastructure	• To align future maintenance and growth needs, maximising the efficiency of any investment.
Potential for the investment being a stimulus for economic growth and development	• To focus where solving flooding could unlock wider development plans.
Collective appetite from key stakeholders and partners	• To deliver of a common set of blue-green infrastructure interventions.

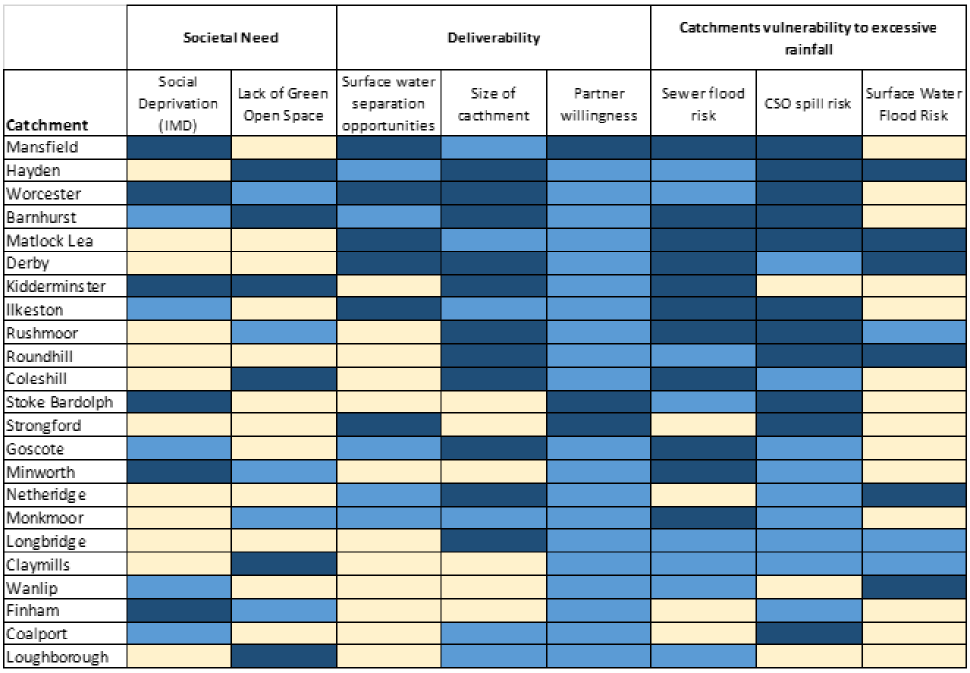
Catchment selection process

We have approximately 3,200 surface water sewers which currently discharge into the combined sewerage network. Over 2,100 of these are in just 23 of our 960 sewerage catchments. Disconnecting flows at all these locations could remove up to 159 m^3/second of rainwater from our network. On top of this, runoff from highway or publicly paved areas is estimated to produce a further 450m^3/s of surface water runoff across these 23 catchments. **We have focused our catchment selection analysis on these 23 priority locations.**

The criteria we used to select our trial catchment.

Category	Dataset(s)	Comment
Societal Need	OS Green Open Space	Selecting catchments which currently have less than average green open space will mean the natural capital we deliver will be more valued.
	Indices of Multiple Deprivation	We want to the strategy to deliver real amenity and social change to local communities.
Deliverability	Partners Willingness	Having a willing partner on board will help enable delivery.
	Surface Water Separation Opportunities	Ensuring we pick a catchment with plenty of opportunities as there will be a natural drop-out rate once we explore detailed feasibility of specific locations.
Catchments vulnerability to excessive rainfall	Current and future sewer flood risk	Drainage and Wastewater Management Planning Baseline and Vulnerability Assessment modelling evidences both what our pressures are today as well as up to 2050 from climate change, urban creep and new development.
	Current and future storm overflow spills	
	Surface water flood risk mapping (uFMfSW)	Beyond our usual remit of sewer flooding, looking at better surface water management in general has crossover benefit to our system as well our customers who may flood from other sources.

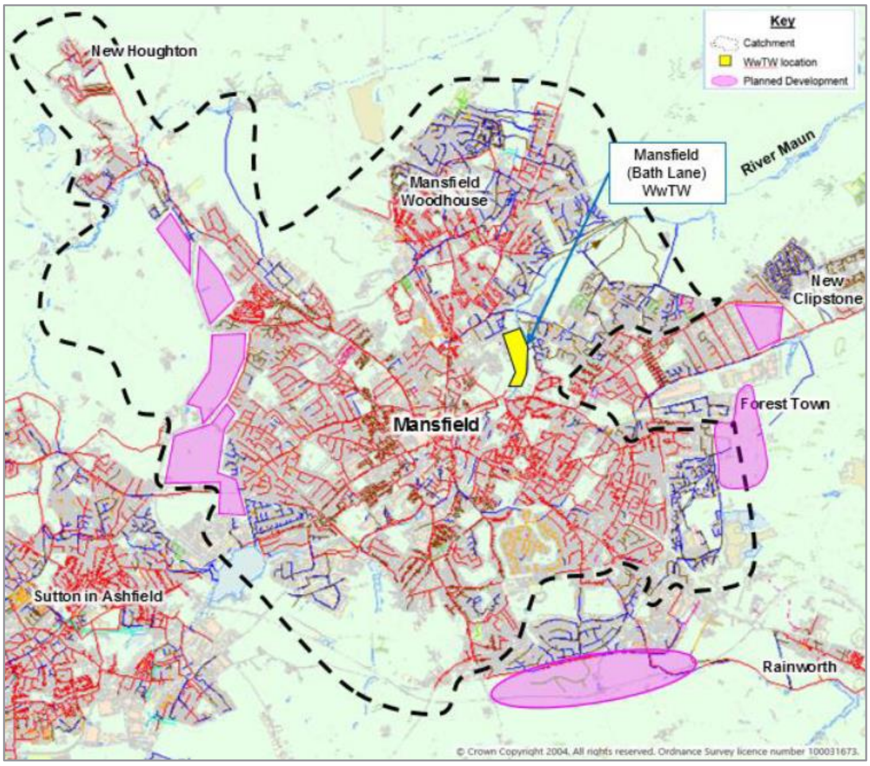
In the table below, we have used robust datasets to assess our candidate catchments against a representative set of criteria. This includes using findings from our DWMP BRAVA modelling to determine future vulnerabilities and potential blue-green infrastructure opportunities. Each catchment is identified as very favourable (dark blue) or favourable (light blue) relative to the other catchments. The remaining cream category suggests a typical level of performance / risk.



Our selected catchment: Mansfield

Supported by the above analysis, we have selected our Mansfield sewerage catchment for the trial (i.e. the area that currently drains to the Mansfield - Bath Lane sewage treatment works).

Overview of the Mansfield WwTW catchment



Mansfield Bath Lane sewage works serves a population of 89,000. Given the relatively small receiving water it discharges into, it includes enhanced treatment processes (an activated sludge plant with energy intensive tertiary processes) and must comply to relatively tight consents (BOD 10mg/l, Ammonia 3mg/l Phosphorus 1mg/l).

The Mansfield catchment asset base contains a typical assemblage of combined (red), foul (brown) and surface water (blue) sewers. This largely reflect the way in which the town has grown with a core combined system and peripheral separated housing estates. The Bath Lane STW is just north east of the centre. This means that some parts of the catchment rely on pumping to transfer to the works. Several surface water transfer sewers are present. In the east a syphon is used to transfer from the Oaktree estate to a balancing pond before discharging into Vicar's Water. To the north surface water is discharged direct to the Maun. To the North West, a transfer sewer is used to discharge into the Meden at Pleasley. Finally, the Kingsmill reservoir to the south west of the centre is also used to drain some sections of the Ladybrook estate. Sutton in Ashfield STW also used to discharge to the reservoir however, this has now been transferred downstream.

The Mansfield catchment is an appropriate size to challenge our current thinking yet remains broadly representative of many of our wider catchments. This means the knowledge we will gain will be transferable across our region and more widely.

We have also started to engage with key stakeholders and partners within the catchment in order to nurture a collective appetite for this project – essential for unlocking wider benefits and delivering holistic blue-green interventions. This is set out further in section 3.

Appendix F: ARUP report developing and quantifying the net benefit of blue-green infrastructure scenarios for the Mansfield sewerage catchment

[Redacted]

Appendix G: Sensitivity analysis: Managing major drivers of uncertainty

The table below sets out how we have managed the major drivers of uncertainty inherent within the business case so that it can deliver against its objectives, retain flexibility and protect the interests of customers.

Driver of uncertainty	Business case approach	Potential detriment to customers	Mitigation in place
Baseline and 2050 modelling approach	Used best available DWMP BRAVA catchment models. 2050 runs use uplifts in line with current scientific knowledge and available forecasts. Storage target based on increased network escapes and CSO spills which are considered to be discrete.	More activity may be delivered than required for the identified time period.	Where materially different storage target is subsequently identified, the delivery accountability mechanism can be used to commensurately reduce the scale of the programme delivered. Conversely accepting that future pressures will continue to rise, delivering additional benefit early is low regret.
Counterfactual – Choice and effectiveness	Standardised shaft tank and pump away interventions scaled for each sub-catchment have been developed.	Reduced counterfactual costs could reduce the relative cost effectiveness and benefit of blue-green intervention scenarios.	STUCA unit cost are assured, regularly updated and have been shown to be efficient. Project on-costs have been consistently applied to both counterfactual and blue-green interventions. Where materially different counterfactual interventions are subsequently identified, the delivery accountability mechanism could be used to commensurately reduce the scale and unit cost of the programme delivered.
Counterfactual – Unit cost (from STUCA)	We have used our current capital programme estimation approach to derive costs		
Blue-green infrastructure – Choice and effectiveness	ARUP analysis sampled the Mansfield catchment to identify opportunities by typology, identified storage equivalent benefit by intervention and set assumptions on uptake (success factor).	Storage equivalent benefits may not be delivered as identified.	Developed four delivery scenarios, each with three intervention assemblages. Target programme size and output derived to reflect the information provided. This reduces reliance on individual blue-green infrastructure assumptions.
Blue-green infrastructure – Unit costs	ARUP unit costs derived based on their experience of developing and delivering blue-green infrastructure in the UK and abroad.	If unit costs are too high, programme costs would be inflated.	Target programme expenditure (£85m) bakes in a further cost efficiency for most of the scenario / intervention assemblages. The delivery accountability mechanism will also return any out performance to customers.
Blue-green infrastructure – Timeframe	Set out a challenging programme timetable in line with the need to learn how to better deliver at scale and pace.	Amount of interventions delivered in AMP7 may be less than targeted.	Delivery accountability mechanism ensures that future revenues reflect only the activity that is delivered based on a unit rate that should deliver net benefit to customers.
Blue-green infrastructure – Quantification of wider benefits	We have quantified the wider benefits for nine types of benefit. Two of these have then been discounted to remove an potential double counting.	Interventions may create less net benefit than assumed.	Programme expenditure and target has been scaled to give increased confidence that interventions will be cost effective or marginal before wider benefits are considered. Therefore, likelihood of not delivering net benefit remains low even if wider benefits are reduced.