SSC37
Our Asset Management approach to best-value investment planning through 2025-2030 and beyond

Contents

Introduction

An overview of our asset management approach at PR24

This appendix serves to outline the multi-faceted approach we have taken in establishing what we feel is an investment programme that prioritises our continued ability to provide clean, high-quality and reliable water supplies to our customers now and in the future.

We recognise the importance of effectively maintaining our existing assets, balanced with a clear understanding of the need to ensure resilience through a flexible and diverse asset base. In a constantly changing environment, we know that this resilience in our operations enhances our ability to respond to unexpected events and maintain our service to our customers. We have developed our approach in line with core Asset Management principles, building on recommendations through Ofwat's Asset Management Maturity Assessment in 2020/21 and cross-sector collaboration through the Ofwat facilitated Operational Resilience working group, developing increased focus in critical areas of our Asset Management system. These include enhancing our capability in monitoring our asset health and condition monitoring, improving our top down and bottom up risk capture processes across different asset classes and, critically, ensuring that we have a system and framework in place that allows us to quantify the wider value of our assets and their resilience in our decision making.

These step changes have allowed us to better consider a 'systems thinking' approach in our capture, collation and use of risk data as a robust baseline in our process. In turn, this has provided rigour in our ability to link our AMP8 plans with the long term. And we set out through this appendix those links to our Long Term Delivery Strategy pathways that have been strengthened with new tools, models and embedded processes. The long-term alignment and validation of our investment needs and associated solutions in this way has enabled us to identify both our base maintenance and enhancement needs and ensures that we capture the full range of timescales over which we need to invest to provide clean, high-quality and reliable water supplies to our customers now and in the future. And, as we set out in this appendix, we are cognisant of the need to plan our essential investment around long term asset resilience in context of the need for inter-generational fairness for our customers, and have developed our plans on this basis.

And it is customer preference and priority engagement that has been at the forefront of our planning in establishing our investment proposals. We have dedicated significant resource through AMP7 to refresh our investment optimisation capability, with the introduction of a new enterprise solution in Copperleaf H20, to analyse a wide range of investment options, appraising their costs against our customers' priorities in relation to our performance targets. Through this process, we have developed a plan that will deliver the service our customers expect and pay for. And critically, we are focused in ensuring a sustained Asset Management approach through AMP8 that supports efficient and timely delivery.

- **Over the period 2025-2030 we will invest £150 million net capital expenditure to maintain our assets for the long term**. This includes investment in our infrastructure and non-infrastructure assets to; deliver our stretching leakage reduction ambition, improve our storage resilience in critical supply zones with the building of two new reservoirs, reduce risks to raw water quality; maintain our boreholes, pumping, treatment and control system assets; and improve operational efficiency.
- **And, we will invest £84million net in our infrastructure assets to**; rehabilitate 254 km of mains across both of our regions, undertake mains diversions, deliver strategic valve and pipe bridge maintenance and improve pressures with customer communication pipe replacements.
- **We will also invest a total of £140 million net capital expenditure to enhance our assets**. We will deliver a combination of regulatory driven and risk-based enhancements covering five key work programmes; water quality, resilience, supply side enhancements, demand side enhancements and the environment. We will continue to invest to meet our regulatory requirements including those defined by our Water Resource Management Plan (WRMP), and the Water Industry National Environment Programme (WINEP), with notable schemes relating to a new transfer main at Grafham in the Cambridge region, together with a significant uplift in our demand side investment through our Universal metering, enhanced leakage detection and water efficiency programmes. We also include a number of water quality improvement schemes supported by the DWI as recognised needs in AMP8, including enhanced nitrate and manganese treatment in addition to our cyber security commitments through the Network and Information Systems regulations. We have also worked to develop a key part of our Net Zero strategy as investment in renewables at sites across our network. Finally, in addition to the significant base programme investment supporting increased resilience of our production and network assets, we include enhancement solutions across both areas to ensure we are protecting customers in the long term from the impacts of climate change and growth driven events that can have catastrophic consequences to our continued ability to provide high quality, reliable supplies to our customers in any scenario. These include new boreholes, mains and associated infrastructure.

Since the Ofwat Asset Management Maturity Assessment that took place in 2021/2022, we have made a series of significant steps forward in our asset management maturity. These improvements have covered everything from data quality improvements to re-designing our asset management team structure and deploying new tools & technologies. This is part of a longer-term plan to better establish good asset management practices within our organisation. Importantly though, we prioritised maturity improvements that have enabled us to deliver the best possible business plan for our customers and stakeholders. These improvements have included:

- Conducting a thorough quantification and assessment of hazards & risks consistently across our entire portfolio
- Implementation of an updated value framework within a portfolio optimisation tool (Copperleaf's H2O product)
- Development of a new model for predicting mains bursts based on machine learning principles
- Development of a new model for determining levels of potable storage within our supply zone

Using these new capabilities, we have developed our most detailed business plan from a bottom-up perspective, with a focus on the use of richer data and information we have about our assets to better understand their health and performance. Section 1.1 below provides further detail on specific aspects of these improvements made through AMP7 that have allowed us to, more than ever, understand the balance between our asset health and our service. And our stretching asset health linked Performance Commitments, such as mains bursts and unplanned outages, reflect our confidence in the capital plans we have developed best striking that balance for our customers.

We have also taken a top-down approach using predictive models and forecasting future scenarios aligned within Ofwat's Common Reference Scenarios. The process we have followed is shown in **Figure 1**, below. Our approach has incorporated four distinct areas of development, from risk and asset modelling through to the optimisation of a plan that best represents the needs of our customers.

And it is within this context that we have set out our methodology in detail throughout this appendix, with each section aligned with these four areas for clear understanding of the approach and resulting outputs at each stage as shown below. We have had this process independently assured by a 3rd party and are confident that this has helped us develop a best value plan.

The remainder of this appendix will describe the process in more detail, giving a clear insight into how we developed our business plan, before concluding in section 5 with a breakdown of the costs across our base maintenance and enhancement programmes.
For the Wholesale Water price controls, the scope of these outputs includes:

- Non-infrastructure base maintenance
- Infrastructure renewals
- Enhancement Capex and Opex
- Management and General (including business systems, fleet, IT maintenance and facilities investment)

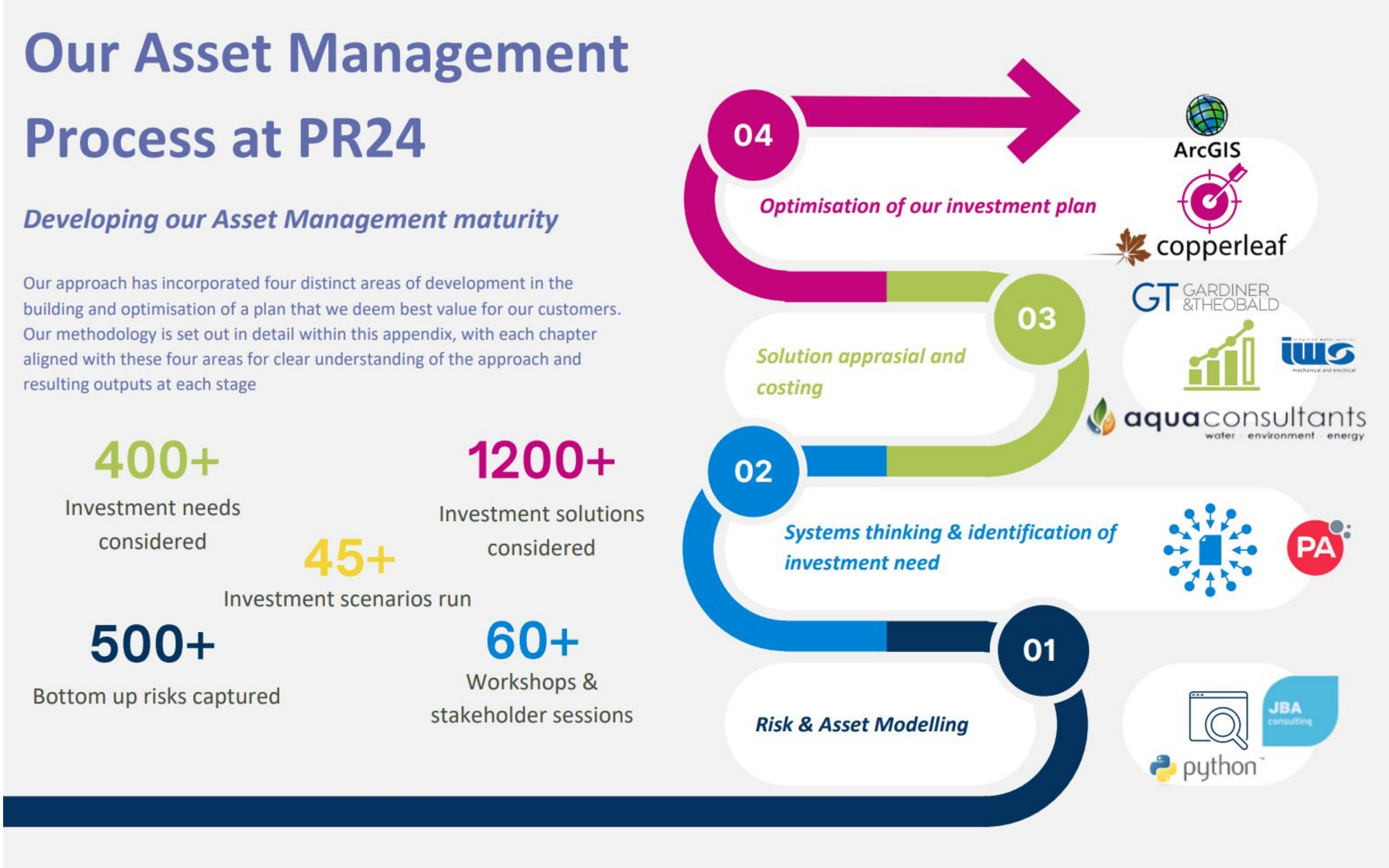


Figure 1 – our Asset Management process at PR24

A timeline of engagements that helped us develop our plan

We consulted with stakeholders regularly, and throughout the planning process. These stakeholders included lots of our own people (from asset operators to asset owners and the leadership team), as well as our Board and our customers. These engagements happened through several different channels, shown in **Table 1**, below.

Table 1 – engagement forums used through the development of our asset management plans for PR24, their purpose, the attendees, and the frequency.

Channel	Purpose	Frequency
1:1 risk reviews	Risks were captured and quantified with individual business owners.	2-3x per owner
Zonal study workshops	One workshop per supply zone to carry out a source to tap review.	1x per supply zone
Investment challenge sessions	Quarterly review of risks, needs, solutions, costs and plans	Quarterly
PR24 programme boards	Progress of overall PR24 programme and the asset management plan	Monthly
Leadership team meetings	Updates provided monthly on the Totex plan to a sub-Board	Monthly
Board meetings	Updates provided monthly on the Totex plan to Board	Monthly
For a full review of our customer engagement, and how it has informed our plan, please see section 3.2.3 and also the appendix **'SSC07 Customer engagement strategy and key insights.'** Our asset management plans were presented to customers multiple times during their development. We offered different options for our plans, which focused on different outcomes and pathways towards our 2050 vision. This allowed us to receive specific feedback from customers at a scheme level, which was fed back into our planning process.		

Figure 2 – a timeline of engagements that took place during the development of our asset management plans for PR24. We engaged early and often, with a wider variety of stakeholders to develop our plans

How we've responded to Ofwat's Asset Management Maturity Assessment

Table 2 – our AMMA recommendations, the improvements we made, and the impact this has had on our PR24 submission and AMP8 business plan. These recommendations have been taken from our company summary.

Ofwat AMMA recommendation	How we are addressing the recommendation
#1 – Develop a clear framework to demonstrate how current processes fit within an asset management system. Include wider consideration of uncertainty within plans, beyond WRMP and water treatment interventions.	• Our approach to developing the AMP8 business plan, is one that will be integrated within our Asset Management System for AMP8 delivery. • The methods (tools, processes, systems, data) that we have used to build our business plan are now key parts of our AM System (for an example see Section 1.6.1 on our IRE model and how this is used in delivery). • Embraced the Long-Term Delivery Strategy principles and added uncertainty analysis to our planning processes and tools. • See Section 1.5 for an example of how we have done this to model zonal storage and infrastructure resilience requirements to inform our plan, and section 1.6.1 for uncertainty analysis within our infra deterioration model using climate change data and Machine Learning to enhance our accuracy in outputs. • Cost uncertainty around our plan is considered in section 3 of the appendix, managed through a phased approach to building increasing solution and cost detail in addition to benchmarking our costed base and enhancement programmes. • We also address inherent uncertainty in our investment optimisation process, through our use of scenario modelling and valuation set sensitivity testing, for example, through the use of triangulated Willingness to Pay value sets, to test the relative impact of each upon our plan. More detail is provided on this in section 4.
#2 – Develop its evidence on how risk data is applied in decision-making to ensure consistency, across different asset types. Improve quantification of risk across all areas.	• Adopted a single approach to the quantification and visualisation of risk and value throughout the decision-making process (see Section 1.2). This was based on an industry-accepted 6-capitals framework with our bespoke monetary values sets. • Quantified risk and value from the outset of the process (beginning with a simplistic 5x5 assessment, growing into a full cost-benefit appraisal). • Demonstrated use of elicited risk and modelled data in zonal master planning workshops to embed our holistic systems thinking approach, outlined in section 2.1 to 2.3. • Reported and reviewed outputs from the risk and value framework to the senior leadership team at multiple workshops – **Figure 2**).
#3 – Enhance capability to monitor asset health information and trends, particularly for assets with high consequences of failure, to inform its maintenance and investment planning. Consider a quantitative approach to consistently incorporate the wider value of asset health and resilience to its decision-making framework.	• Included an enhancement case to improve network monitoring so that we can collect important data about the health of our assets (see our Smart Water System Trial business case, in **section 13** of our enhancement appendix, **SS36 – Evidencing our enhancement expenditure in 2025-2030)**. • Section 1.1 outlines our maturing asset health framework, and how asset health is monitored and governed to support understanding of risk on a sustainable and live basis. • Our new and updated models for PR24 have assessed our operational resilience to climate change, demand changes, abstraction reductions and technological changes. New parameters for these models have been added where there is a material impact (e.g. soil moisture content in our IRE model).

#4 – Develop a formalised risk escalation process that can be used consistently across the organisation including escalation to board. Improve evidence of board and senior management engagement in planning.	• Developed dashboards to present risk and value outputs to the board and senior management team. These present risks scores and risk summaries that can be quickly analysed (see Section 1.3 and 1.4). • Utilised our geospatial system to present map-views of the investment plan and constituent risk information to the board, and senior management teams. • Risk tolerances were set across the asset types and performance commitments. Risks were promoted to the senior management team above this threshold.
#5 – Consider further development of its approaches to identify and address gaps in asset management capability and resources for its employees.	• Our asset management team has grown substantially since the AMMA and our people have filled previous gaps in asset management capability. • Our people have trained in the use of new models, methods and process for investment planning and business case authorship. • We have implemented good practice asset management capabilities throughout the business, not just within the asset management team. Our people are using the new risk and value framework to build individual investment plans and business cases. Section 6 provides further information on our Asset Management roadmap, building on maturity developed through AMP7 to further enhance our capability in

Section 6 of this appendix provides further detail around additional reviews we have carried out both internally and externally in supporting the PR24 plan development and also, importantly, in the setting of our roadmap to increasing maturity through AMP8 and beyond. These include;

- supporting the Ofwat AMMA review and findings in 2021 as discussed in **table 2** above
- a dedicated review by PA Consulting of our Asset Management capability early in AMP7 in early 2022
- leading Asset Management bodies such as the Institute of Asset Management and ISO55001
- membership of asset management focused forums with other water companies, regulatory bodies and technical working groups to understand synergies and best practice

Figure 3 below illustrates where our specific areas of development, aligned with the AMMA assessment categories, have been established in context of our ongoing Asset Management maturity.

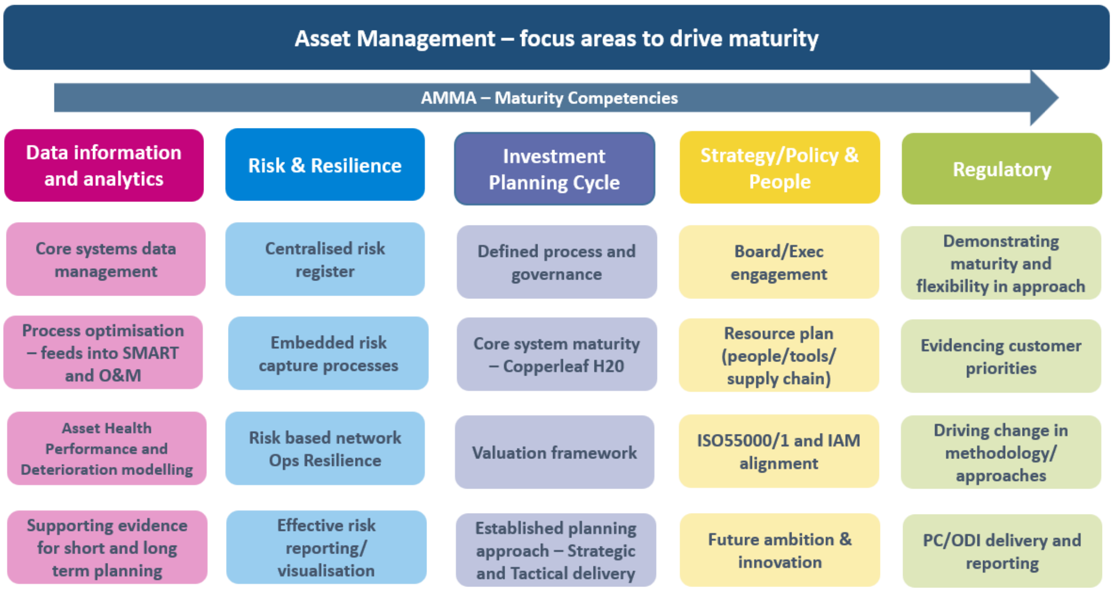


Figure 3 – our Asset Management maturity focus areas through PR24 and beyond

Linking our asset management approach for AMP8 with the long-term (LTDS)

For this price review, we have recognised the importance of linking our AMP8 plans with the long-term. The new requirement to submit a 25-year Long-term Delivery Strategy (LTDS) alongside our 5-year business plan for 2025-2030 came at a good time for us as we sought to improve our asset management maturity. Many of the new approaches, tools, and models that are discussed in this document were built to serve both. For example, we deep dive in section 1.6.1 to show;

- how our new model for predicting bursts spans the full horizon of the LTDS, building in new variables driven by the Common Reference Scenarios (notably climate change in this case), which have determined our 5-year infrastructure renewals expenditure linked to the desired AMP8 Performance Commitment Level (PCL).

And, through section 1.5, we show;

- how we set out to develop a model that could assess the resilience of our supply zones to climate change, demand, operating environment, and reservoir level. The model calculates a robust supply-demand position (hours of storage available) based on a wide range of operating scenarios (hydraulic constraints, available sources etc.) and conditions.

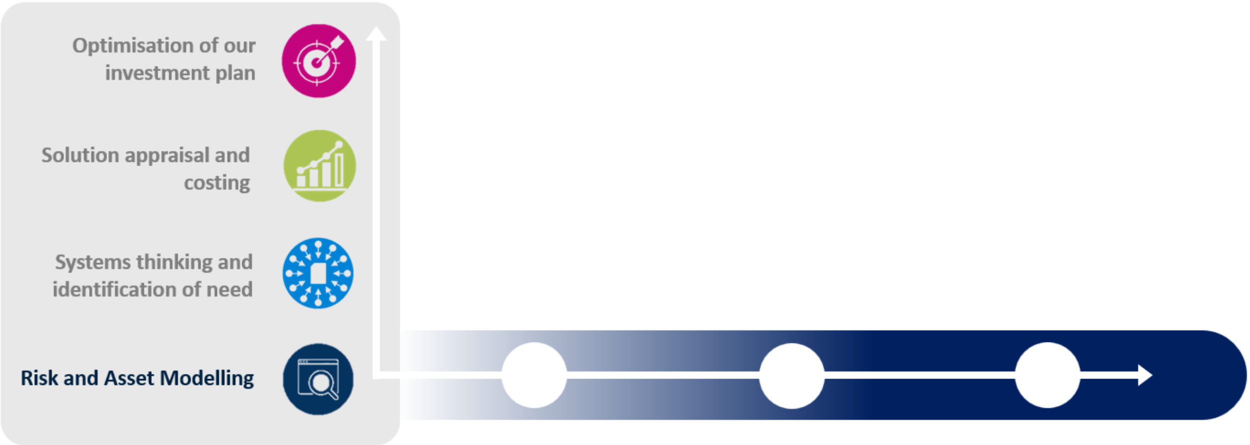
This type of modelling and analysis has created an inextricable link between our asset management plans, business plan and the LTDS. Whilst there are areas we can still improve, we are pleased with the coverage of models and data-driven approaches to decision-making across all horizons.

This appendix will focus specifically on the 5-year asset management plans for the period 2025-2030. However, we have signposts to the LTDS throughout the document, which will be contained in summary boxes as shown below. For more information on how the tools, techniques and systems used to develop our 2025-2030 plans were used to develop our 25-year LTDS in terms of operational resilience, please refer to **section 5.4** of our appendix **'SSC02 South Staffordshire Water – long term delivery strategy.'**

LTDS summary box

Summary boxes like this will be used in this document to provide a brief overview of how our process for building the 2025-2030 links with the LTDS. In many cases, the same tools, techniques, systems, models and approaches have been used, just with a different time horizon being selected. As a result we are confident that we have a strong link between our asset management plans and our LTDS. We have a plan in place to continue improving our maturity and ability to bridge the short and long-term. More information on this can be found in Section 6 of this document – our asset management continuous improvement roadmap.

1. Risk and asset modelling



As part of our normal planning processes we continually monitor and manage risks across our asset portfolio. As an example of this, during AMP7, we implemented an upgraded version of IBM Maximo works asset management system, and took the opportunity to develop an application within the system to capture and manage risk. Further, we developed an asset capture application and associated process for contractors and delivery teams to utilise in ensuring accurate we receive an accurate update to our asset register upon completion of a project. And we worked to create a refined asset hierarchy and asset 'blueprint,' working with our production and networks teams to refresh our asset register in Maximo to reflect those critical assets we know that we need to prioritise in terms of asset health and performance monitoring.

Risk Review

Following our review of our existing asset management capability (see **table 2** in our introduction and also section 6.1 for details on our asset management system review outputs), and to support our PR24 process, we undertook a one-off activity to refresh our entire risk database. This incorporated every asset class, to ensure a thorough and up-to-date view of the potential investment required to achieve our 2030 and 2050 outcomes.

The asset classes covered during our risk review were:

- Surface Water Reservoirs (Blithfield & Chelmarsh)
- Raw Water Transfer Mains
- Water Treatment Works (Seedy Mill & Hampton Loade)
- Groundwater Source Stations
- Service Reservoirs
- Trunk Mains (including interconnectors)
- Distribution Mains
- Wider Network Assets (flow meters, consumption meters, strategic valves, control valves etc.)
- Facilities
- Fleet
- Business Systems
- Operational Technology
- Physical Security
- Cyber Security

All risks were captured and quantified against a consistent framework, referred to as our Six Capitals risk and value Framework. See Section 1.2 for more information. Where possible, we tried to use data and models to identify these risks. For areas of expected higher risk (hypothesised based on current performance in AMP7, and future outcomes), we even developed new models. The methods and models we used as part of our PR24 risk refresh included:

Expert Review

- ✓ All Asset Classes

Our people interact with our assets every day and are well trained in identifying failures and spotting potential future risks. They capture condition and performance data, promote investment through our project lifecycle, and see new assets through installation to operation. Expert review and elicitation of risk is an important part of the process we have undertaken, especially in areas where we do not yet have high quality data to use in a model. Therefore, all asset classes covered in the scope of this review had some form of expert input by our asset owners. This was either in the form of an elicitation workshop to capture risks, or as a risk review following the completion of a data analytics or modelling activity. More information can be found in sections 1.3 and 1.4.

Hazard Reviews

- ✓ Surface Water Reservoirs (Blithfield & Chelmarsh)
- ✓ Raw Water Transfer Mains
- ✓ Water Treatment Works (Seedy Mill & Hampton Loade)
- ✓ Groundwater Source Stations
- ✓ Service Reservoirs

In January 2022, we established a Central Review Team (CRT) to complete hazard reviews at all our Production sites and reservoirs. This was a highly structured activity that captured hazards and quantified the risk of these against our Risk & Value Framework. The output was a holistic set of hazards, and a risk assessment for each that was scored on a 5x5 matrix (i.e. each hazard had a risk score that ranged from 1 to 25). Our Six Capitals risk and value framework allowed us to compare outputs across all the asset classes in scope of this review, as well as with the other assets that had a similar risk assessment completed. This process also later supported us in the promotion of risks and identification of potential schemes. More information can be found in section 1.4.

Supply zone resilience model

- ✓ Water Treatment Works (Seedy Mill & Hampton Loade)
- ✓ Groundwater Source Stations
- ✓ Service Reservoirs
- ✓ Trunk Mains (including interconnectors)

For PR24 and future planning activities, we created a resilience model for every one of our Water Supply Zones. These models assess the level of emergency water storage we have in each zone based on hourly demand profiles, growth in the zone and operating levels of the reservoir (driven by condition and design) within the zone. We also modelled different operational scenarios where certain assets (groundwater sites, valves) were taken out of the system. This helped us to identify single points of failure, as well as sensitivity of the supply zone to different inputs. Using this model in combination with our hazard review outputs, and overlaying with our policy development for emergency storage (see section 1.5 **figure 13**) allowed us to take a truly whole-system approach to this risk review as we were able to link the two together. More information on this approach and how it informed our core AMP8 and longer term pathway for our LTDS planning, can be found in Section 1.5.

LTDS summary box – resilience modelling for 2050 outcomes

In developing our new models for supply zone resilience and infrastructure deterioration (see next section), we have carefully considered the requirement to plan for 2030 (AMP8) and 2050 (beyond AMP8). Both models have been created to cater for both, and embed long-term planning into our tools.

The supply zone resilience model allows us to vary all inputs to 2050. This includes changing demand assumptions to factor in growth, adjusting hourly demand profiles to reflect the changing behaviours in a warmer climate, and the year in which the analysis is taking place (every year from present day to 2050). These are aligned with the Ofwat Common Reference Scenarios. This model has been central to identifying resilience investment requirements for AMP8-AMP12 and developing our LTDS in this area. This is like our new infrastructure deterioration model, where we have tested a range of parameters that align with the Ofwat scenario for Climate Change. Allowing us to predict when, and under what circumstances, we would need to go beyond the normal renewal rate of 0.4% per annum to achieve our 2050 ambition.

Infrastructure deterioration model

- ✓ Distribution Mains

Our infrastructure deterioration model is a well-established method for identifying the current and future risk profile of our small diameter distribution mains. For the past three price reviews, it has been based on a linear regression model, assuming that age, condition and pipe material are the primary risk drivers. On review of this model compared to past performance, and after seeking advice from independent 3rd parties, we have rebuilt this model for PR24 using a different method. Deterioration of our distribution mains are sensitive to more parameters than the industry has accounted for in their linear models. These additional parameters include weather, ground moisture, soil composition, and others. A more complex model is required to account for these parameters as well as the traditional age, condition and material ones. To accommodate a wider range of inputs, and make use of more advanced analytical methods, we have developed a new infrastructure deterioration model that used machine learning to predict future risk. For PR24, we completed model runs using both the old and new models, which has given us a thorough understanding of the risk we carry on our distribution mains. More information can be found in section 1.6.1.

Non-infrastructure deterioration model

- ✓ Water Treatment Works (Seedy Mill & Hampton Loade)
- ✓ Groundwater Source Stations

Our non-infrastructure model projects the refurbishment and replacement cycles for our Production assets (Water Treatment Works and Source Stations). The projection runs to 2050 and allows us to identify any periods where there are potentially lumpy expenditure requirements, so that we can plan accordingly. Each asset class has an associated deterioration curve based on a range of input parameters specific to the asset. The model currently includes Capex costs only and applies a fix-on-fail strategy to all assets. For our PR24 plans, we have refreshed the dataset within the existing model and undertaken an activity to review the outputs against the hazard reviews completed for each site. More information can be found in section 1.6.3.

1.1 Maturity in our asset health framework

We were clear at the outset of AMP7 that in addition to refreshing our risk database as outlined above, we wanted to drive improvements in our asset health framework as we understand that the measurement and ongoing monitoring of asset health is a vitally important factor in providing resilient services, both now and in the future. We reference in our Strategic Asset Management Plan (SAMP) a definition of asset health as ;

‘How the physical assets that we operate perform and will perform in the future to ensure that we deliver a reliable and safe supply of drinking water to our customers.’

We are clear in that asset health is a much richer concept than simply asset condition in that it needs to consider not only the physical state of the asset, but also the performance, role and importance of the asset in ensuring that service performance targets and customer expectations can be met. Our measures and indicators support us in focusing operational decision making on the total expenditure solutions that are in the best interest of our customers. We follow utility industry good practice as outlined in the United Kingdom Water Industry Research (UKWIR) research paper "Serviceability Methodologies" that, originally developed by Ofgem for the UK electricity and gas transmission and distribution companies.

Our framework methodology was developed based on a set of principles, tools and practices to provide a self-assessment approach to asset health indicators across the asset base. This allows us to integrate our planning objectives as part of investment planning with the indicators we use for operational performance, monitoring and company assurance.

And it is with this focus that we sought to fully understand where potential risks and opportunities lay in context of our existing maturity within our framework. We have established capability in;

- Consistently used service measure frameworks across recent AMP periods, linked to investment optimisation systems and decision making, and used to demonstrate that we understand how our capability to deliver service is changing over time and with its impact on cost to the business

- Our use of risk analysis based on service or value frameworks to assess whether service risk is consistent with planned levels forecast in our business plan

- Our asset health indicators being used as supporting indicators to provide early warning of emerging problems. For example, CRI is our key measure of service in relation to water quality but is affected by the performance of a range of different assets

- The use of asset health data in operational decision making

- Our strong links between asset health and resilience. As part of addressing future strategic challenges we had developed a resilience lens at PR19 to enable us to understand and quantify parameters that impact our resilience. The lens includes measures for asset health. The lens enable us to measure maturity and target areas where we/our customers consider an improvement is required. Our appendix, **SSC05 Integrated resilience framework,** provides further detail on how this has been updated at PR24.

And we used the findings of a dedicated review by PA Consulting of our Asset Management capability early in AMP7, with a specific focus on our processes around investment decision-making. These findings, summarised in **figure 4** below, highlighted a number of opportunities for us to build on our existing asset health framework throughout AMP7 and were utilised in our PR24 planning process, including;

- Greater emphasis on holistic zonal and system wide reviews in context of asset health, the study identifies the root cause of different aspects of poor performance. The outputs are evidential, auditable and qualitative, allowing for a targeted investment approach, providing the greatest benefit at the lowest cost, driving value for money for our customers. See our significant step change in investment need identification at PR24 that incorporates zonal thinking in section 2.1.

- pursuing innovative techniques around information and data around asset health such as smart systems, sensors and analytics. We signpost here to our Smart Water system trial in our enhancement case appendix, '**SSC36 Evidencing our enhancement expenditure in 2025-2030', section 5.3.**

- In the case of complex non-infrastructure assets, better understanding of asset lifecycle and maintenance impacts could enable more efficient asset operation. See section 1.6.3 for advances we have made in this area.

Figure 4 – an example of risk and asset health SWOT analysis identified through PA Consulting investment planning review in 2021 (full outputs in section 6.1)

We provide a summary below of other areas of development related to ensuring our picture of asset health remains current, relevant and sustainable in linking through to best value investment and planning for long term resilience.

- Introduction of a new, consistent value framework, as part of the implementation of Copperleaf H20, with a richer set of service measures used to appraise investment benefit
- Copperleaf scenario planning also supports reporting on asset performance, including risk, levels of service, value achievement, and financial outcomes. Tracks changes to the investment plans, risks, and benefits including audit reporting – see section 4 for further detail
- Improvements to our asset data capture functionality, through upgrades to our Maximo system
- Innovative mains condition data capture techniques – see section 5.1.2.1 for further detail
- Enhanced visualisation capability to better present asset health and risk data to key stakeholders, for example through our Power BI dashboarding and its interface with Copperleaf H20 inputs and outputs

1.2 Our value framework

For PR24, we developed and implemented a new risk and value framework that covered the breadth of the Six Capitals. This is fast becoming an industry-recognised approach to assessing risk and value, which we will continue to improve upon throughout AMP8. All stages of our business planning process have been aligned to this framework, allowing us to compare the relative benefits of risks, needs, schemes, and projects. An overview of the measures in our framework is shown in **Figure 5.**

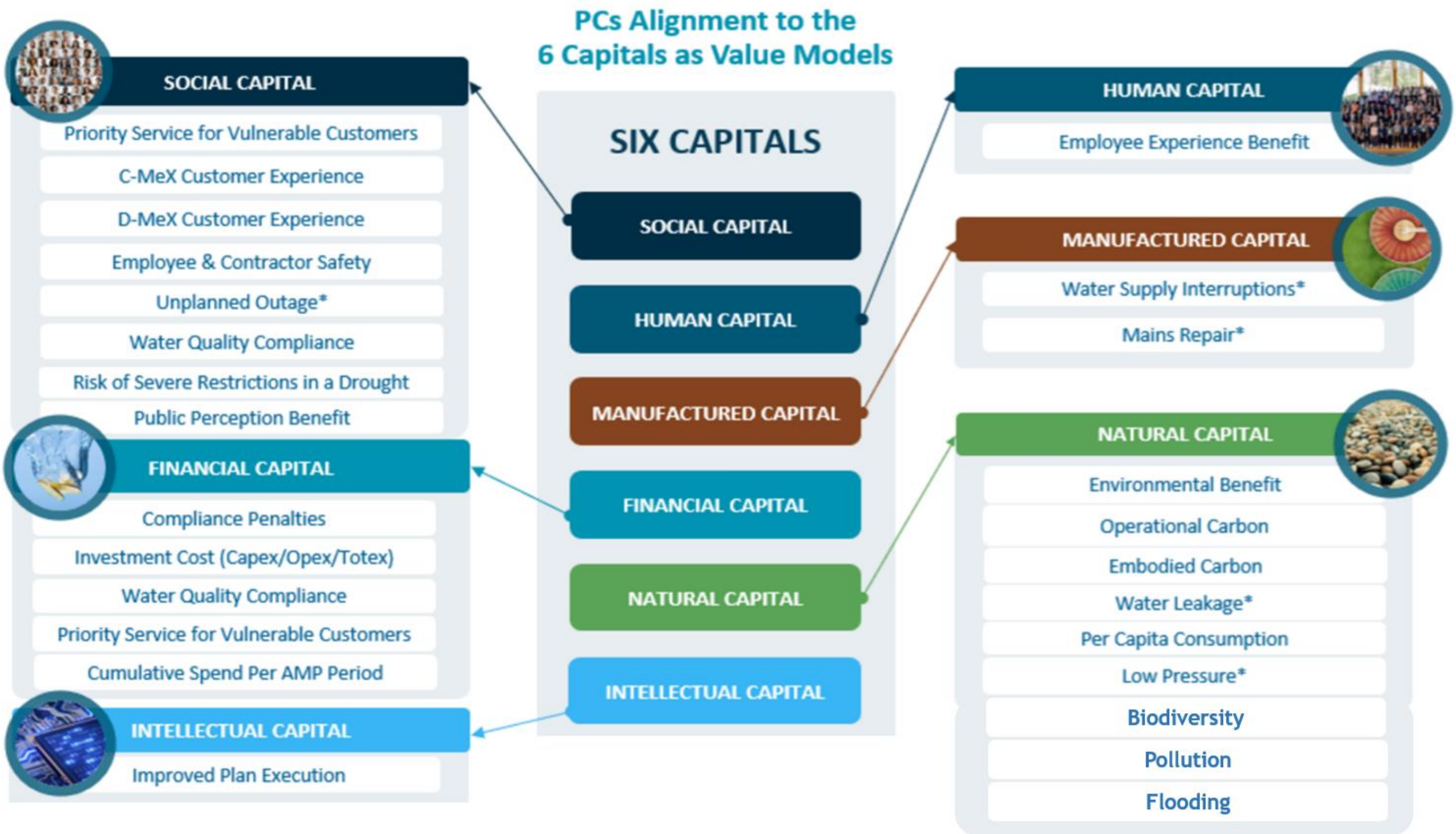


Figure 5 – our Risk & Value Framework for PR24 and beyond, aligned with the Six Capitals and Ofwat's PC's

Utilising this framework has allowed us to justify the value each investment would offer us, and our stakeholders. The outputs were used to inform customer engagement sessions and describe the choices that can be made within the portfolio, particularly outside of the statutory planning frameworks. Section 3.2.3.1 provides a deep dive into the development of the framework.

There are some important things we want you to know about this framework and how we've used it:

- **Risk Quantification** – from the outset of the process, we applied the framework to all risks that were identified. This totalled more than 500 risks (for comparison, our preferred plan for AMP8 has less than 100 risks). Against the measures shown in **Figure 5**, risks were scored on likelihood and consequence against a traditional 5x5 set of risk categories. An example of these can be seen in Section 1.3.
- **Option Assessment (Multi-Criteria Analysis – MCA)** – once risks that fell within our risk tolerance were removed (to be review and monitored on an ongoing basis through AMP8), and the remaining risks were developed into full schemes with a long list of options, a multi-criteria analysis took place for each option. Importantly, we set and defined our risk tolerance thresholds utilising asset criticality, our asset health framework outputs **(see section 1.1),** known asset failure consequence and regulatory obligations. This MCA used similar Six Capital

categories to assess each long-list option for the promoted schemes. Outputs from this were used to filter the long-list into a short-list. See section 3.2.1 for further detail on this approach and how costing was applied to both long and shortlisted options through our two stage costing process with Aqua consulting and other suppliers.

- **Value Appraisal** (Cost-Benefit Assessment – CBA) – for promoted schemes, with a short-list of options following our MCA, a full CBA was undertaken. This CBA uses the same set of measures as shown in **Figure 5**, with each measure (value model) having a defined set of questionnaires for the user to complete. Asset Management remained as independent in this process as possible, supporting investment owners and ensuring consistency in assessment of value across the portfolio. Further information can be found in Section 4 around our cost benefit approach, along with a deep dive into our related investment optimisation process.
- **Variables** – once schemes and options have completed questionnaires, the risk is monetised by multiplying by a financial variable. For PR24, we have multiple sets of financial variables dependent on the portfolio scenario we wish to test. One set of financial variables covers our private costs associated with each measure (for example, a burst costs us £1,570 to fix). Another set cover our customer Willingness to Pay (WtP) costs, reflecting, without the use of any weighting, the value customers place on the measures within each value model across the Six Capitals. The final set of financial variables we used also includes societal value. Section 3.2.3.3 details these value sets, along with the discount rates applied relative to these costs in our Copperleaf H20 system.
- **Financial Model** – after costs are added to the options for each scheme, we can report the financial outputs for the schemes, and the portfolio. This includes reporting metrics such as the Net Present Value (NPV) and Benefit-Cost Ratio (BCR). We carry out all our CBAs over a 40-year time horizon, including re-investment cycles, changes in Opex and appropriate discount factors in line with industry guidance such as the HM Treasury Green Book. Guidance from this book was also used in the development of our longlist approach, the structuring of our enhancement business cases and in applying
- **Optimisation** – as the above four bullet points were completed the whole short-list of options and schemes, the optimisation process we followed allowed us to test customer preferences against different versions of the AMP8 plan and report the outputs back to them. We were able to demonstrate the value and payback of their choices between key measures (such as maintaining burst performance vs improving the environment). The optimisation process helped us identify our best value plan, as well as our preferred plan for the 2025-2030 period.
- **Visualisation and Decision-Making** – whilst we have made significant steps forward in using data and information to build our business plan, an element of interaction between the results from this quantitative assessment and our people, remains essential. Use of a consistent risk and value framework has enabled us to present choices in a consistent manner. Two example dashboards are shown in **Figure 6** that were used with our people.

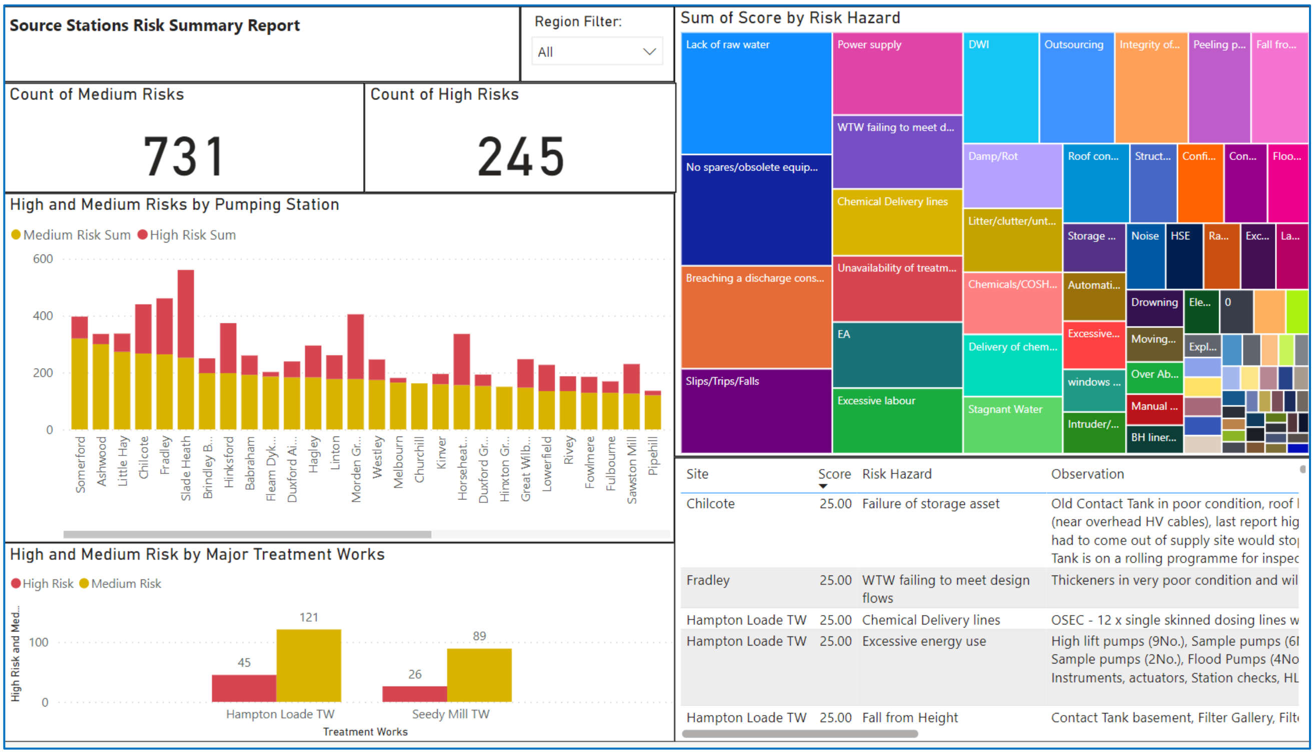
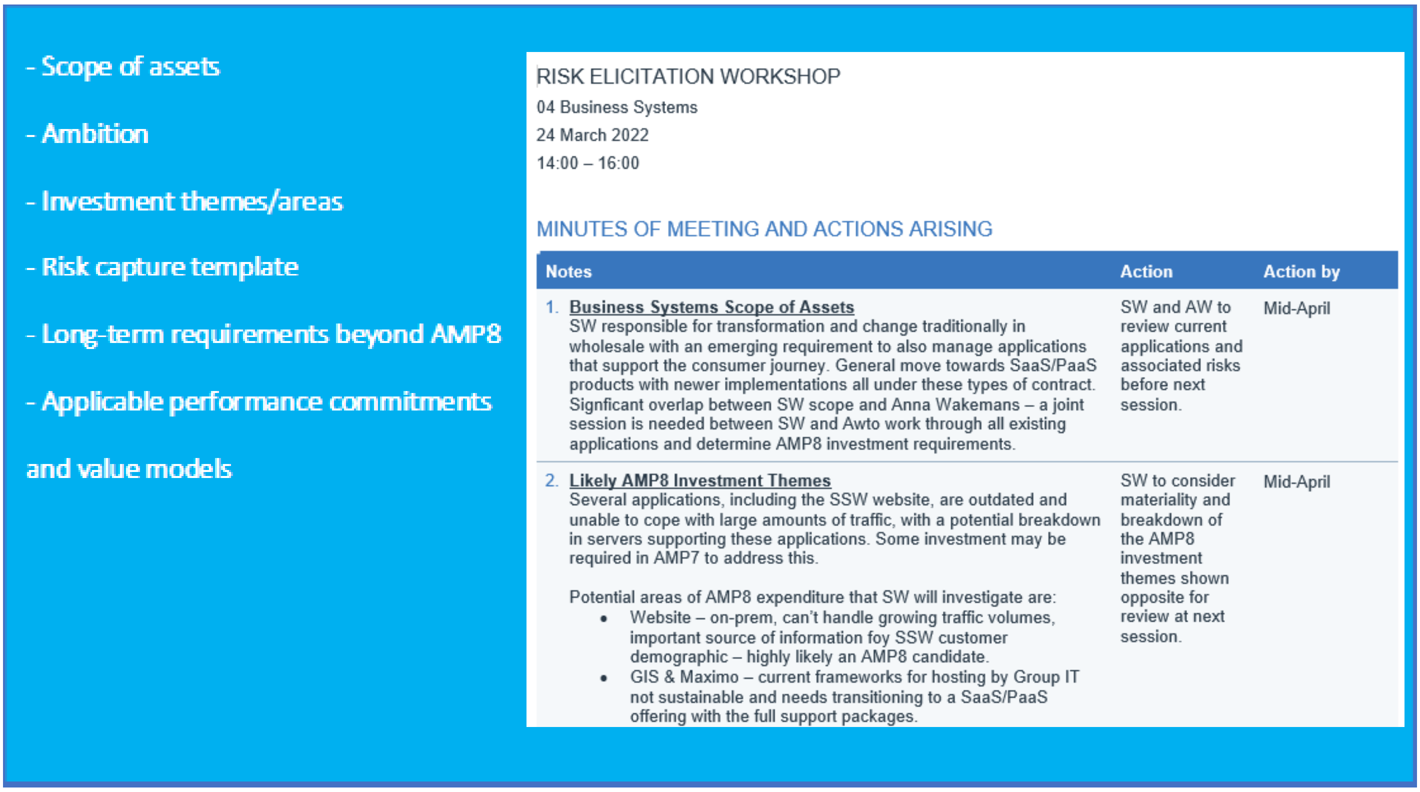


Figure 6 – example of dashboarding used to present outputs from our Risk & Value framework for our people to review

1.3 Expert review

To develop our risk portfolio and subsequent base and enhancement plans, we first began with individual risk elicitation sessions with the asset owners across our business. We are proud of the experience our people have gained over multiple decades managing and running the assets that deliver drinking water to our customers. These risk elicitation sessions were highly structured around our Six Capitals risk and value Framework, discussed in section 1.2. An example agenda for the initial risk elicitation sessions is given in **Figure 7**, below.

All assets were covered in these initial review sessions and the key purpose was to ensure our people were involved from the outset in the development of our business plan. We were also able to use these sessions to brief asset owners on the framework we were subsequently using to assess risk and value, and optimise our PR24 business plan. Following the initial kick-off sessions, the asset owners took an action away to review risk registers and current asset performance to identify the risks for the period 2025-2030. In several parts of our business, this involved the use of deterioration models and statistical analysis. All risks were captured in a common template with applicable value models scored by the asset owner, then reviewed by Asset Management.



RISK ELICITATION WORKSHOP
04 Business Systems
24 March 2022
14:00 – 16:00

MINUTES OF MEETING AND ACTIONS ARISING

Notes	Action	Action by
1. **Business Systems Scope of Assets** SW responsible for transformation and change traditionally in wholesale with an emerging requirement to also manage applications that support the consumer journey. General move towards SaaS/PaaS products with newer implementations all under these types of contract. Signficant overlap between SW scope and Anna Wakemans – a joint session is needed between SW and Awto work through all existing applications and determine AMP8 investment requirements.	SW and AW to review current applications and associated risks before next session.	Mid-April
2. **Likely AMP8 Investment Themes** Several applications, including the SSW website, are outdated and unable to cope with large amounts of traffic, with a potential breakdown in servers supporting these applications. Some investment may be required in AMP7 to address this. Potential areas of AMP8 expenditure that SW will investigate are: • Website – on-prem, can't handle growing traffic volumes, important source of information foy SSW customer demographic – highly likely an AMP8 candidate. • GIS & Maximo – current frameworks for hosting by Group IT not sustainable and needs transitioning to a SaaS/PaaS offering with the full support packages.	SW to consider materiality and breakdown of the AMP8 investment themes shown opposite for review at next session.	Mid-April

Figure 7 – the agenda we followed for our very first risk elicitation workshops that kicked off our planning process.

We chose a 5x5 risk matrix approach for the initial elicitation as it allowed us to gain a rapid understanding of the likely size and shape of our business plan risk portfolio. It is also a risk methodology still familiar to the sector, and one which can be aligned to our latest approach for monetising risk. The Asset Management team governed the process, ensuring consistent assumptions were applied and the scoring criteria were followed correctly. Each value model within our Six Capitals risk and value framework (**Figure 5**) was assigned a criteria for each 1-5 score. The calculation used was as follows:

$$Risk\ Score = Probability\ of\ Failure\ \times Likelihood\ of\ Consequence \times Scale\ of\ Consequence$$

Where:

Probability of Failure is expressed as a number and based on observed and/or predicted failures

Likelihood of Consequence is a 1-5 score assessing the likelihood an asset failure leads to an event with a consequence

Scale of Consequence is a 1-5 score assessing the magnitude of the impact form the event

An example risk scoring output from these early expert elicitation sessions is shown in **Figure 8.** These were essential in allowing us to begin to align our risk scoring in context of the Six Capitals value framework – shown in the red box on **figure 8**. Further, they applied logic around whether the risk in question was a short or longer term requirement, and in this way became an initial source of information to support the build of our LTDS core and adaptive pathway thinking.

South Staffs Water PR24 risk elicitation - Boreholes (SST)		Risk ID	NINF-BOR-001	
		Title	Ashwood 1	
		Description	**Notes:** Nitrate and chlorthal. Current mitigation by blending. Turbidity. Pipe inflow needs checking. **Site configuration:** duty/standby with Ashwood 1,2,3,4 **Importance:** Highly important to supply system, outages would result. Survey required.	
		Risk Capture	*Score*	*Evidence*
Frequency of Failure (observed or predicted number of failures)		2025 (now)	1.000	Borehole reported to be in bad conditioin in all areas including, WQ, Structural Quality, Headworks, Pipe Inflow, Cleaning and Catchment Risks. however performance is currently acceptable (3) with no signficant issues yet observed. We have therefore assumed frequency of failure is 1 in 2025.
		2035 (future)		
Financial Capital	WQ Compliance	L	3	Taken middle grading of performance due to Nitrate and Chlorthal WQ issues. Mitigations in place by blending. Likelihood of failure middle grading as 25 years since last survey.
		C	4	
	Cost of Failure	L	4	Taken worst grading of performance (across WQ and supply and structural quality) and assumed this is the likelihood some additional monitoring/intervention may be required as 25 years since last survey. Reflects likelihood we may need to incur additonal cost at the borehole.
		C	3	
	Financial, Legal and Reputational Risk	L		
		C		
Manufactured Capital	Supply Interruptions	L	4	Identified the configuration of the boreholes on the site to infer a likelihood of observing a supply interruption. A duty/standby with both unable to meet licensed output gives a grading of a 4. Pipe Inflow issues and high DYAA.
		C	3	
	Mains Repair	L		
		C		

Figure 8 – an example risk output from our initial expert risk elicitation session. This was completed for all assets.

We were able to collate all risks into a single dashboard for initial validation with our leadership team. Our Power BI dashboard visualisation was a critical part of our ability to provide sense checks at every stage of our plan build.

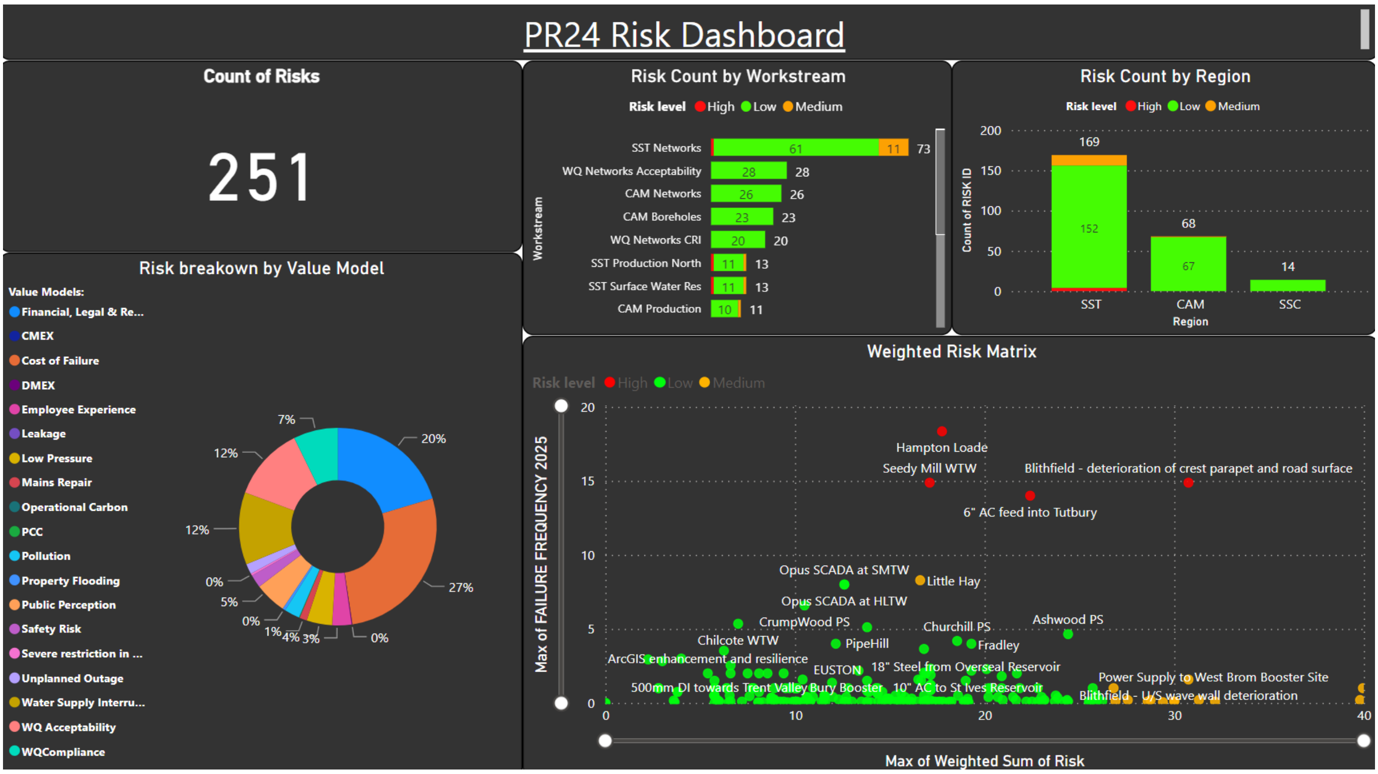


Figure 9 – our initial risk dashboard documenting all risks raised by the business for the period 2025-2030.

More than ever, with this facility, we were able to present data to allow effective discussion, analysis and review at key milestone stages (see **table 1 and figure 2** on page 1 for these touchpoints), and to all different stakeholders across the business. This supported substantiation from the wider business as regards risk, need and solution identification, as well as checks on value/benefit assumptions made and estimated costs. And we ensured this layer of justification and corroboration from stakeholders was a recurring theme through our zonal master planning outputs in section 2, our solution and costing phases in section 3 and finally, our investment optimisation scenario modelling in section 4.

Reaching this level of risk review early into our business planning process for 2025-2030 allowed us to rapidly identify what investment would likely be required to achieve our ambition for AMP8 and beyond. This was a substantial improvement in our Asset management capability that addressed one of our company specific AMMA findings. However, we recognised that we needed to do substantially more to justify, evidence and prove the risks and supporting information. The subsequent parts in this section detail how we did this.

1.4 Site-specific hazard reviews

To develop and refine the risks for our non-infrastructure assets, we mobilised a Central Risk Team (CRT) to carry out Hazard Reviews (HazRev) at all sites. The CRT appointed a lead risk assessor for each region, who was responsible for completing a HazRev at all our above-ground, non-infrastructure sites.

The HazRevs were comprehensive and included current Regulation 28 and Drinking Water Safety Plans (DWSP) and an assessment of risk against several categories ranging from abstraction to health & safety, and power supply. A current, and future risk score was assigned as well as a residual risk score which account for current mitigations that are in place. For each risk item in the HazRev, a potential mitigation was identified. This mitigation could have been a capital maintenance scheme, operational intervention or upgrade. In alignment with our Six Capitals risk and value framework, scores were assigned on a 5x5 matrix, allowing us to update risk scores in our central risk repository. A snapshot of the summary page from one HazRev can be seen in **Figure 10**.

Site:
Date: 01/06/2022

Risk	Risk Hazard	Observation	Score	Future Risk Scor	Future controls
5	No spares/obsolete equipment (Reactive rather than proactive maintenance)	Single BH pump setup with a spare BH dedicated pump (unknown operability), no spare drive	12	15	(1) Create a new spares stock system to manage spares (2) Establish practice for storing spare BH pumps and operability
7	Outsourcing	IWS (Pumps) - Mitsubishi (VSD) - HSB (Reserve Vessel), Ground Control (Grounds maint.) Station checks. Planned Maint/Cal, training, Reactive Maint. Business watch (intruder alarm), HACH (Turbidity Monitors),	12	16	(1) Consider brining forward next PPT (2) Consider the purchase of a spare drive
9	Over Abstraction	Telemetry Alarm -PLC controlled - Pump cut outs (deepest advisable pumping water level), Station Checks - BH pump has VSD- Abstraction flow meter at wrong end (Hinxton), Water Resources monitor, EA abstraction audits. Due to licence conditions with peak being 4 times average there is significant risk of over	16	16	(1) Consider brining forward next PPT (2) Control room to improve pump planning (3) OT to enable smart alarms to highlight risk over abstraction / assist Water Resources
46	Slips/Trips/Falls	Very poor outside lighting, some uneven paths, uneven grounds (rabbit holes), trackway in poor condition, pathways can be icy in the winter, grass can get long (if not kept on top of)	16	16	(1) Upgrade site lighting with LED and timer outside switch (2) Install a GRIT bin at site (3) Improve trackway
72	Intruder/Vandalism/Theft	No history of intruders at site. Buildings covered by alarm. NO CCTV at site, gate locked. No SR door and chamber is SR	12	16	(1) Replace door to SR door (2) Install a external CCTV at site
74	Lack of raw water	Abstraction through onsite BH (single BH, single pump) Headworks for the BH in chamber. Have a spare dedicated BH pump (unknown condition), There is a BH chamber sump pump	12	12	(1) Consider headworks improvement for BH (2) Establish practice for storing spare BH pumps and operability
81	Power supply	Loss of comms Telemetry alarm + Warning notice UKPN - suffers higher levels of brown/black outs inline with Duxford/Sawston areas	16	16	(1) Site wide UPS (2) Install a plug in point for a generator

Figure 10 – the process our CRT followed to complete a HazRev at all non-infrastructure sites. A full spreadsheet can be found in Annex 7.1.1 to this appendix

Once all HazRevs had been completed, the risk portfolio and scores previously shown in section 1.3 were updated. New value models and applicable Performance Commitments were added, and frequencies were updated. Another session was then held with our senior leadership team to present the latest view of risk. A specific dashboard was created summarising the CRTs HazRev outputs, shown in **Figure 11**.

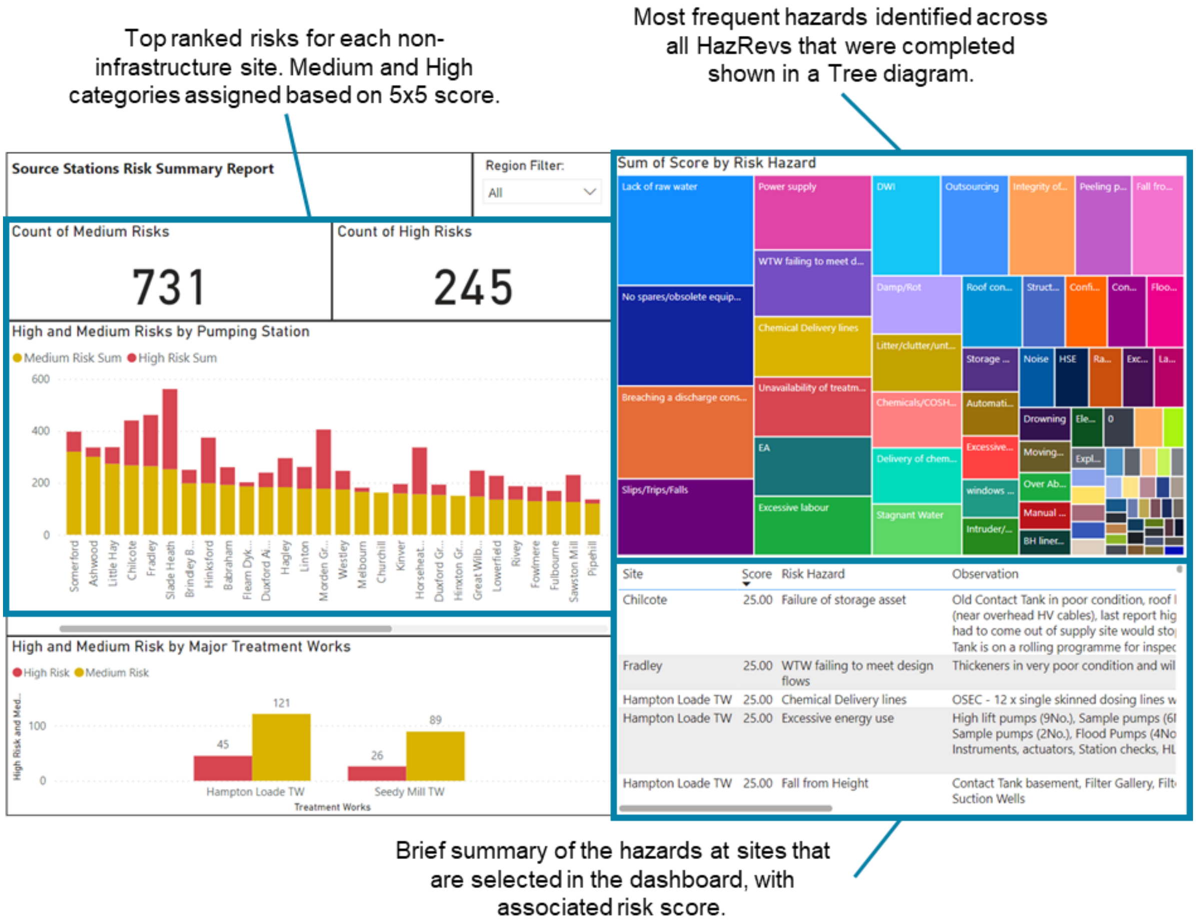


Figure 11 – dashboard summary of the HazRev outputs, used with the leadership team early in the planning process.

1.4.1 Summary of our initial risk data refresh for PR24

Assimilating the refreshed risk data through the processes outlined through this section allowed us to establish a comprehensive and validated set of baseline risks, scored against our common value framework, and in terms of timing requirement. This bottom up approach allowed us to accurately assess our initial position in terms of base maintenance requirements, provide early insights into delivery requirements and secure ownership of the plan by the business. It also allowed us to review different risk capture methodologies existing in some areas of the business and ensure that where a level of maturity was evident, that we were able to accurately capture and collate the outputs into our common framework to ensure consistency and relevancy.

Importantly, in addition to the operational risk capture, we also sought to understand risks developed through a top down lens, categorised into company ambition and aspirational targets. The former were centred around specific areas of focus such as our resilience ambition (supported by our Resilience Framework and associated Resilience Lens developed at PR19), together with optimum future operations scenario planning, and Smart network centred activity. We overlaid this with aspirational views around carbon, leakage, the environment, digital and metering – driven by growth related risks occurring over a longer future. Again, this served to reinforce our initial views on the shape of our LTDS pathways, and allowed us to begin analysis of risks across multiple price reviews in a collaborative and traceable fashion. **Figure 12,** below, provides a summary of this approach.

Critically, the outputs from our risk reviews fed through into our holistic zonal master planning process discussed in section 2, along with modelled outputs from our new supply zone resilience model (section 1.5) and from our upgraded infrastructure and non-infrastructure modelling capability, covered in section 1.6.

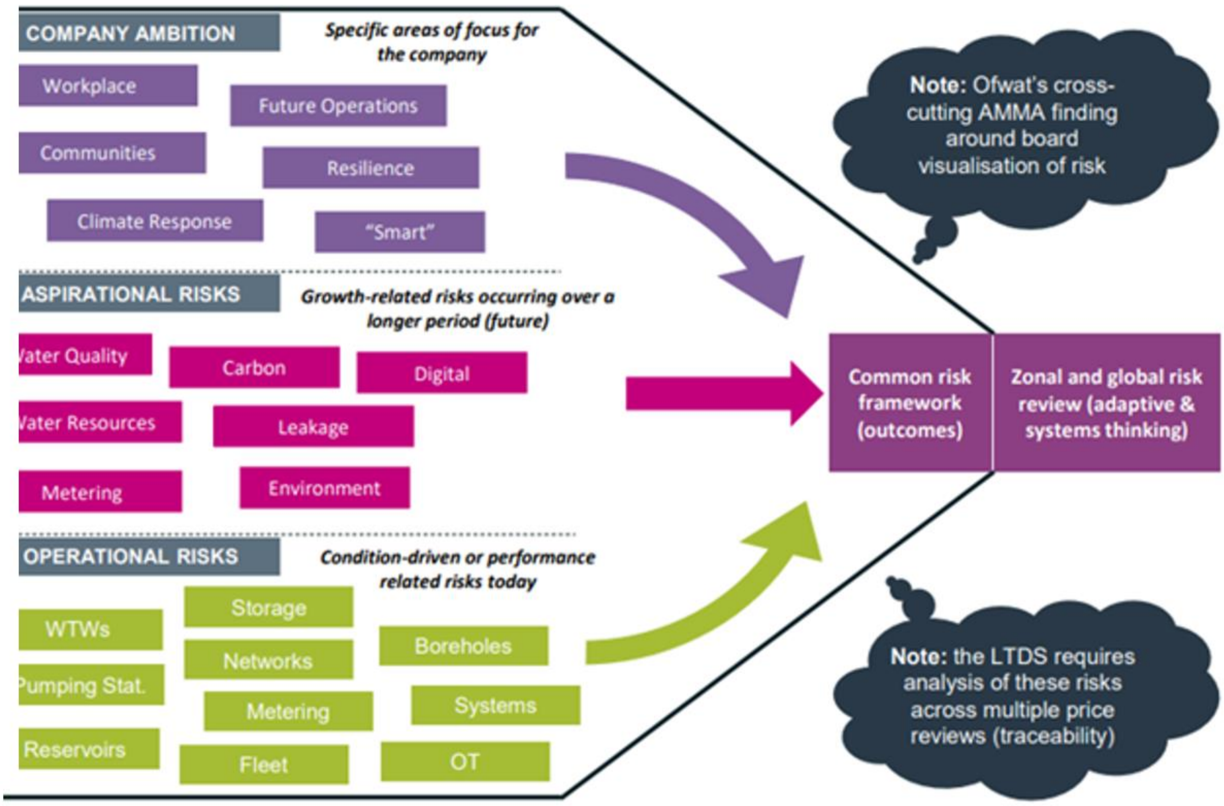


Figure 12 – summary of our risk database refresh exercise, feeding into our zonal master planning process in section 2

1.5 Supply zone resilience model

For PR24, we looked across our existing maturity in the understanding of our short and longer term operational resilience, basing the review upon the flexibility, adaptability and diversity of our asset base to respond to external shocks and stresses. This objective was aligned with the periodic review of our **AMP7 Resilience Action Plan (see Appendix SSC07 Integrated Resilience Framework for our PR24** updates on this) and also drew upon collaborative and constructive sector wide discussions facilitated by the Ofwat Operational Resilience working group.

A key strategic outcome considered critical to our business plan and LTDS was to plan and build a new resilience model for all supply zones in our network. We sought to have a model that could assess the resilience of our supply zones to climate change, demand, operating environment, and reservoir level. The model calculates a robust supply-demand position (hours of storage available) based on a wide range of operating scenarios (hydraulic constraints, available sources etc.) and conditions. **Figure 13** describes these inputs and logic to support policy development driving our decision-making around investment proposals in the short and long term.

Optimising our zonal supply:demand balance – ensuring we make the most of our water resource and secure it for areas that need it most in the face of climate uncertainty.

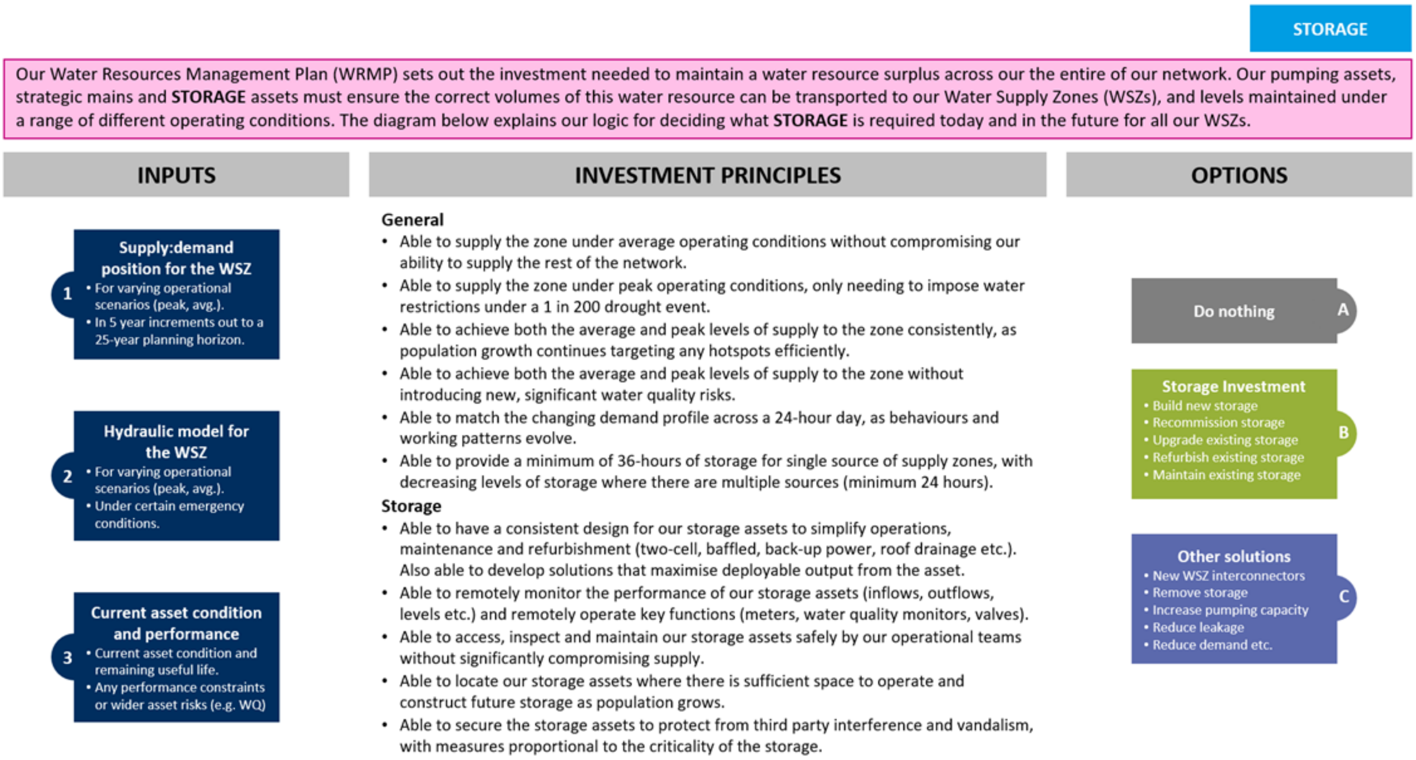


Figure 13 – inputs and logic underpinning out storage resilience modelling

Working with JBA Consulting, the review considered demand levels during 2023 and looked at the effect of projected demands in the future. The output for each supply zone always included the emergency storage times based on all supply reducing to zero. There were a series of operational scenarios defined for each supply zone from a least likely set of circumstances to a most likely set. An example set of scenarios are shown in **Figure 14.**

Scenarios	Description
1	All imports on zero to establish emergency storage.
2	West Bromwich Booster in. All other imports out of supply. No use of exports.
3	Little Hay and Bourne Vale sources in (combined volume of 9.5Ml/d over 24-hour period). All other imports out of supply. No use of exports.
4	Valve 1 and Grange Farm VS exports in maximum use (50Ml/d combined). Seedy mill in pumping 60Ml/d. Scenario simulates Barr Beacon supporting the Sedgley, Walsall, West Brom, Wednesbury supply zones due to loss of Hampton Loade WTW into Sedgley.
5	West Bromwich Booster in. All other imports out of supply. Hopwas infusion exporting on a flat 4Ml/d and Outwoods infusion exporting on a flat 12Ml/d.

Figure 14 – operating scenarios defined and modelled for the Barr Beacon supply zone.

Figure 15 provides an example of the outputs for the Barr Beacon region in the Staffordshire area. It begins by outlining various scenarios. Below these scenario descriptions, a table displays the corresponding storage times for different demand levels (Average/Peak) and measure types (Maximum, Minimum & Average) associated with each scenario. Measure type refers to the starting level of the reservoirs in the zone based on useable volume (which can be linked through to condition of the structure and any water quality constraints).

Scen.	Average day demand			Peak day demand		
	Max. (hr)	Min. (hr)	Avg. (hr)	Max. (hr)	Min. (hr)	Avg. (hr)
1	15	13	14	10	6	8
2	N/A	N/A	N/A	19	8	12
3	22	16	19	11	7	9
4	23	16	19	11	7	10
5	33	30	33	14	6	10

Figure 15 – outputs from the supply zone resilience model in the Barr Beacon supply zone, showing storage times for different demand levels

The outputs were then translated into an interactive dashboard using ArcGIS. The dashboard was created and published through ArcGIS Online and later embedded within ArcGIS StoryMaps. This integration provided a user-friendly platform for exploring the results from different demand/supply scenarios, making data interpretations simpler for us, and allowing us to see which regions were most at risk. Review and visualisation of uncertainty analysis through the use of varying demand and operating scenario in this way is a step change in our resilience planning, even more so in context of a whole systems view perspective.

Figure 16 showcases the storage dashboard with a map displaying the various regions in both Staffordshire and Cambridge areas. Each region on the map is visually represented with a numeric value, reflecting the storage time (in hours) of the respective reservoirs within that specific area. The regions are also colour-coded based on their storage times: red indicates storage times less than 12 hours, amber signifies storage times less than 24 hours, and green represents storage times of 24 hours or more. This is in line with our storage policy and LTDS, where we are seeking to fall in line with an industry average level of storage.

The map has interactive features, allowing us to click on any region to access detailed information specifically related to that area. This was useful for exploring the results and comparing to the outputs from earlier risk elicitation activities. The left-hand side of the dashboard allows users to filter the map according to the Administrative Area (Staffordshire or Cambridge), Time Period (Present Time, 2032, 2042 and 2050), Demand (Average or Peak), Scenario (1-7), and the Measure Type/Reservoir Level (Maximum, Minimum and Average). These filters enabled easy data exploration and analysis, ensuring we were able to access the specific information we needed to make informed decisions effectively.

On the right-hand side of the dashboard, a comprehensive list of different regions is presented, organised according to the applied filters. Each entry in the list includes the region's name, a descriptive account of the corresponding scenario, and the number of hours of emergency storage available in that region. The list allows quick access to the vital information about each region's emergency storage capacity, and is also RAG colour coded, providing us a clear representation for storage levels.

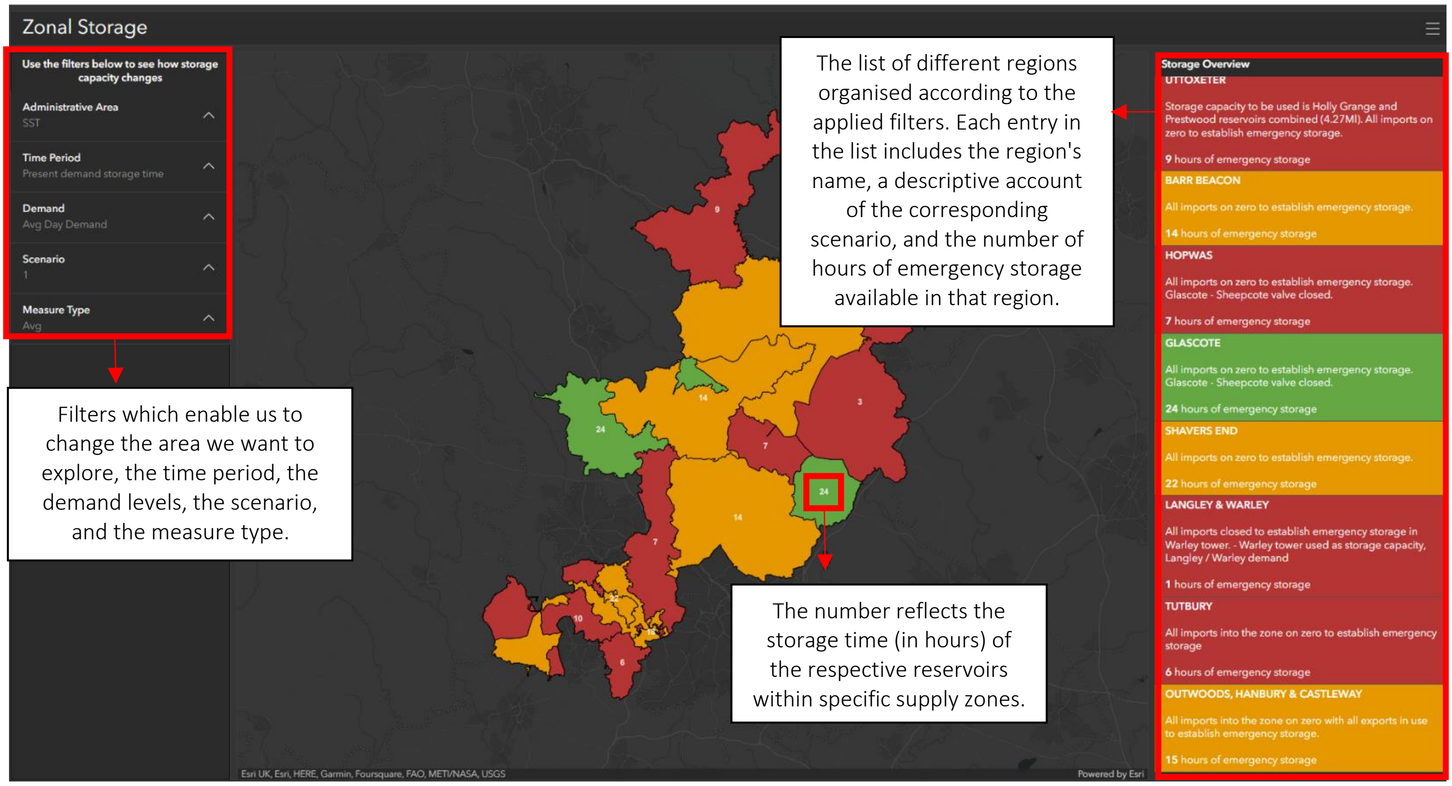


Figure 16 – interactive ArcGIS map summarising the outputs from our supply zone resilience model

More detailed analysis allowed us to produce a box and whisker plot for each of our supply zones, across both of our operating regions, **figure 17** below shows one for our South Staffordshire region. This takes all storage times, under all scenarios, for the full 25-year period to look at the distribution of likely storage times. Supply zones that have a range of storage times lower than the 24-hour ambition are ones that we have targeted first, as part of our low or no regrets assessment (see policy development in **figure 13**, above).

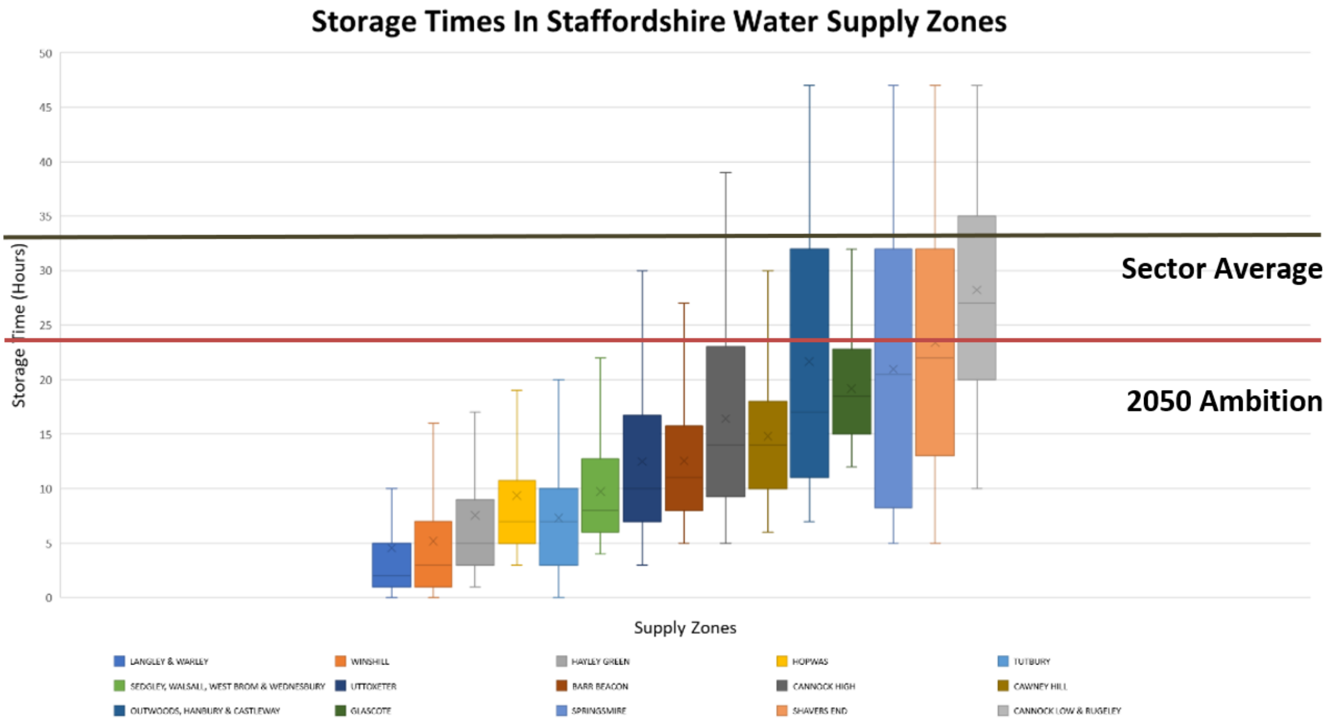


Figure 17 – South Staffordshire outputs from our storage supply zone resilience model

As these models represent a whole-systems view, they have been used extensively throughout our planning process to match investment back to the needs of our supply zones. Sections 2.1 and 2.2, provide extensive detail as to how the outputs from our resilience modelling have been incorporated into our zonal master planning approach at PR24. Particular emphasis is given in terms of how they have informed our system thinking workshops that work to consolidate the rich data and analysis around risk and modelling into a consistent platform for informed appraisal by our SME's, across our Production, Water Quality, Networks, Operational Technology, Water Strategy and Delivery teams across both of our regions.

1.5.1 Resilience case study – Langley zone in our South Staffordshire region

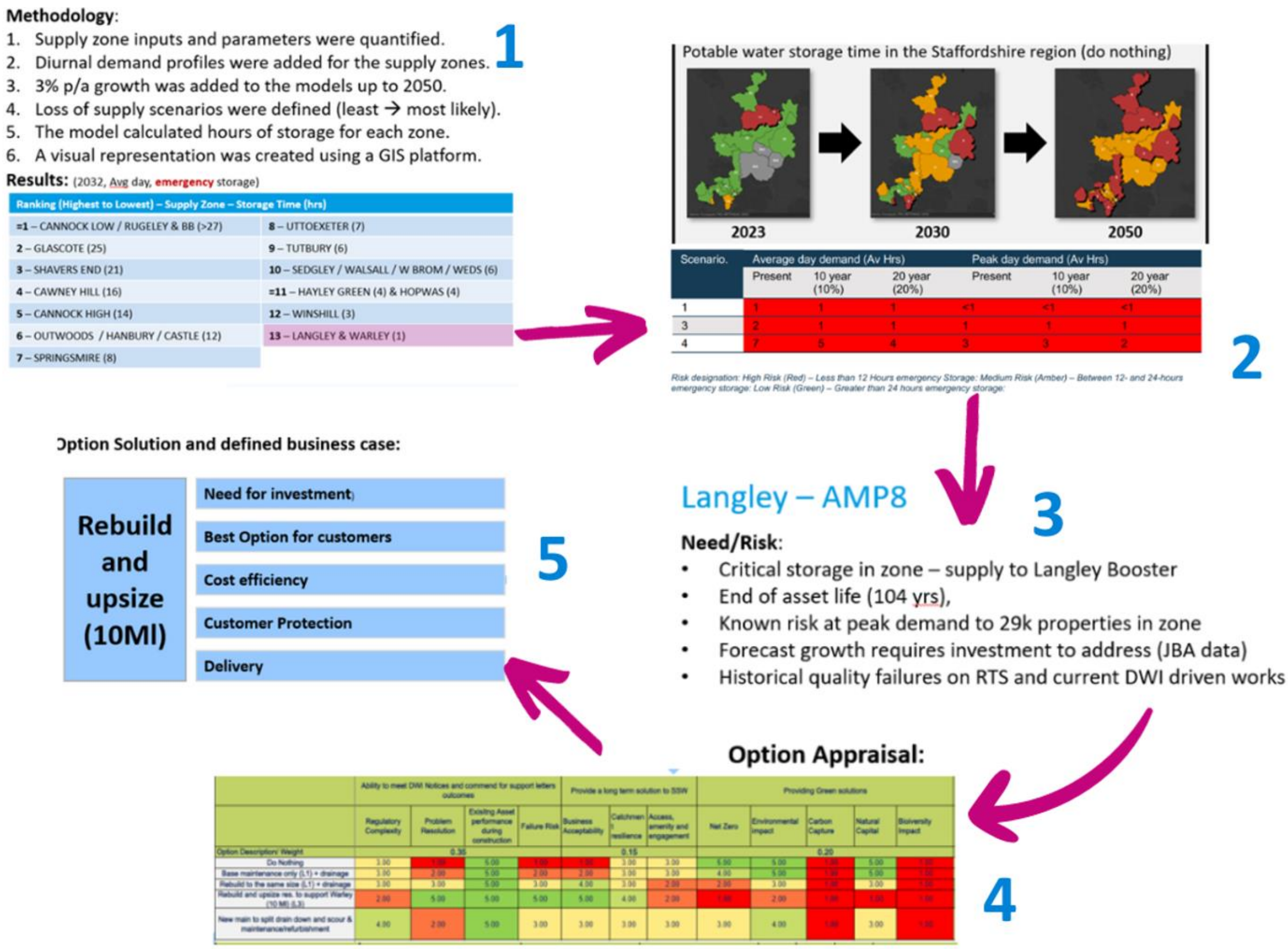


Figure 18 – Langley zone case study evidencing the use of our resilience model to drive priority investment decisions

Further information around this case can be found in **section 5.1** of our enhancement case appendix, **'SSC36 Evidencing our enhancement expenditure in 2025-2030.**

We discuss in section 2.3 how we identified our core pathway expenditure around resilience through the simple decision-making hierarchy as outlined in **Figure 31**, such as that described in the case study for Langley above. Within this section, we also set out a case study on the Cambridge zone resilience modelling outputs, and the conclusions drawn to support investment decision making in AMP8 and as part of our longer term thinking in our LTDS core pathway.

Our full LTDS appendix, **'SSC02 South Staffordshire Water – long term delivery strategy'** provides a comprehensive breakdown of our range of operational resilience modelling across both production and network resilience (that is, those which are not covered by existing statutory planning frameworks or legal duties).

1.6 Deterioration models

We have made a number of improvements to our existing deterioration models since PR19, and following a peer review carried out by Jacobs on our existing infrastructure deterioration capability. This section provides an in depth review of our advances in this area and the increased accuracy in their outputs. Importantly, maturity in output forecasts was then able to be used in conjunction with those of our refreshed risk and new resilience modelling to form part of our master planning approach, covered in section 2.

Figure 19, below, illustrates the steps we went on, and areas we challenged ourselves in across our journey of improvement. It evidences material we used to engage our teams at each stage of this process, from a thorough re-evaluation of our existing capability through to innovative testing of Machine Learning capability in our refreshed model.

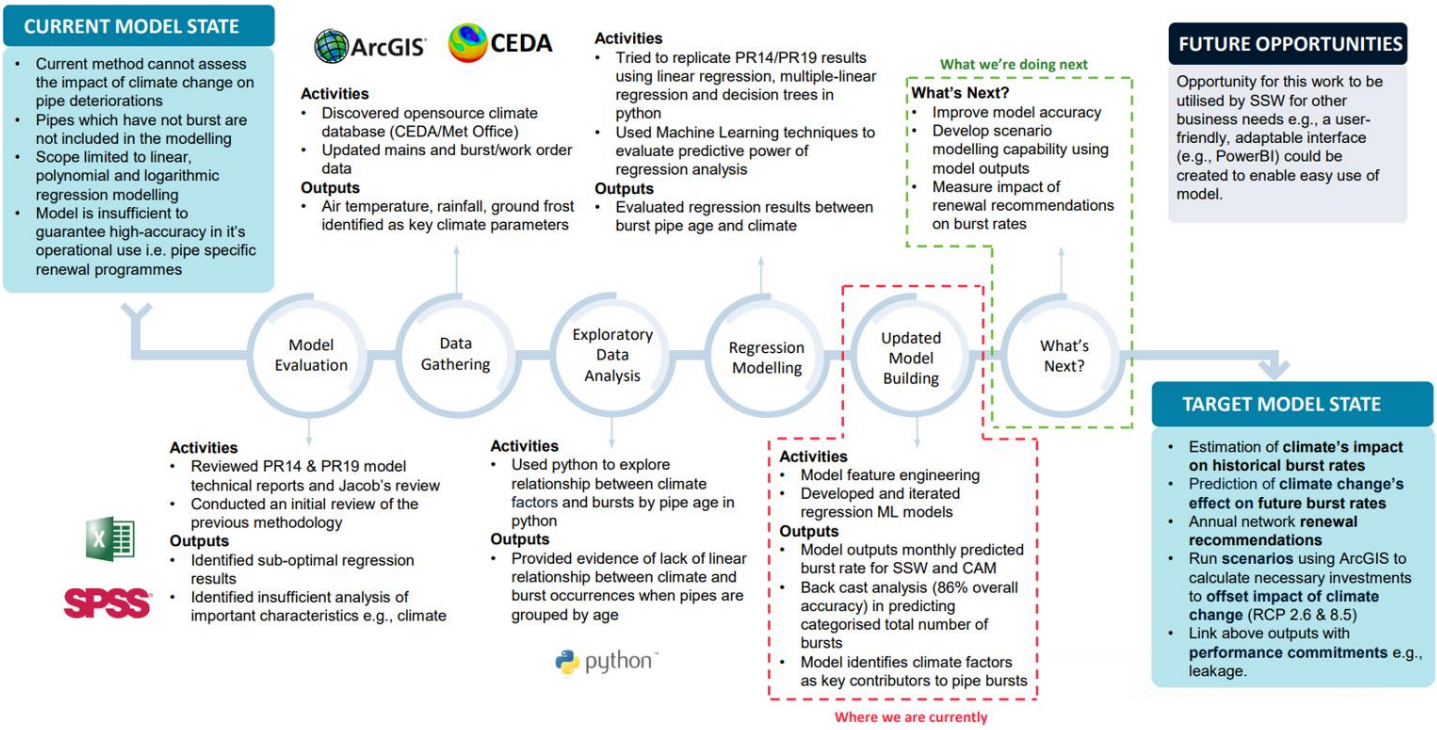


Figure 19 – A summary of the steps we took to develop a step change in our infrastructure deterioration modelling

For the last price review we used our tried and tested linear regression model to forecast deterioration of our small diameter distribution mains based on pipe age. This was a model that had been used multiple times to assess deterioration and was updated with new failure data each price review, before generating new deterioration curves and, determining likely burst performance. The inputs to this linear regression model are shown in **Table 3**.

Input	Source	Purpose
Burst Work Orders	Works Management System	This data allows for the quantification of bursts on along a section of pipe.
Pipe Age	Company GIS	This data allows for an understanding of what age a section of pipe was at the points in which bursts occurred, which allows us to understand failure trends over time.
Pipe Diameter	Company GIS	This data allows for the network to be grouped up into sections called cohorts. This attribute along with others are used to create optimal cohorts that provide the best relationships for modelling.

Pipe Material	Company GIS	This data allows for the network to be grouped up into sections called cohorts. This attribute along with others are used to create optimal cohorts that provide the best relationships for modelling.
Soil Corrosivity	Company GIS	This data allows for the network to be grouped up into sections called cohorts. This attribute along with others are used to create optimal cohorts that provide the best relationships for modelling. This attribute is more often used with sections of pipe that can be subject to corrosion, such as Cast Iron
Soil Fracture Potential	Company GIS	This data allows for the network to be grouped up into sections called cohorts. This attribute along with others are used to create optimal cohorts that provide the best relationships for modelling. This attribute is more often used with sections of pipe that can be subject to corrosion, such as PVC.

Table 3 – inputs to our previous linear regression model to forecast small diameter distribution main performance against age

For PR24, we started our planning process by re-running this model to quickly identify the forecasted performance for AMP8 based on performance and renewal rates in AMP7. The Do-Nothing results are shown in **Figure 20** with key points annotated on the graph.

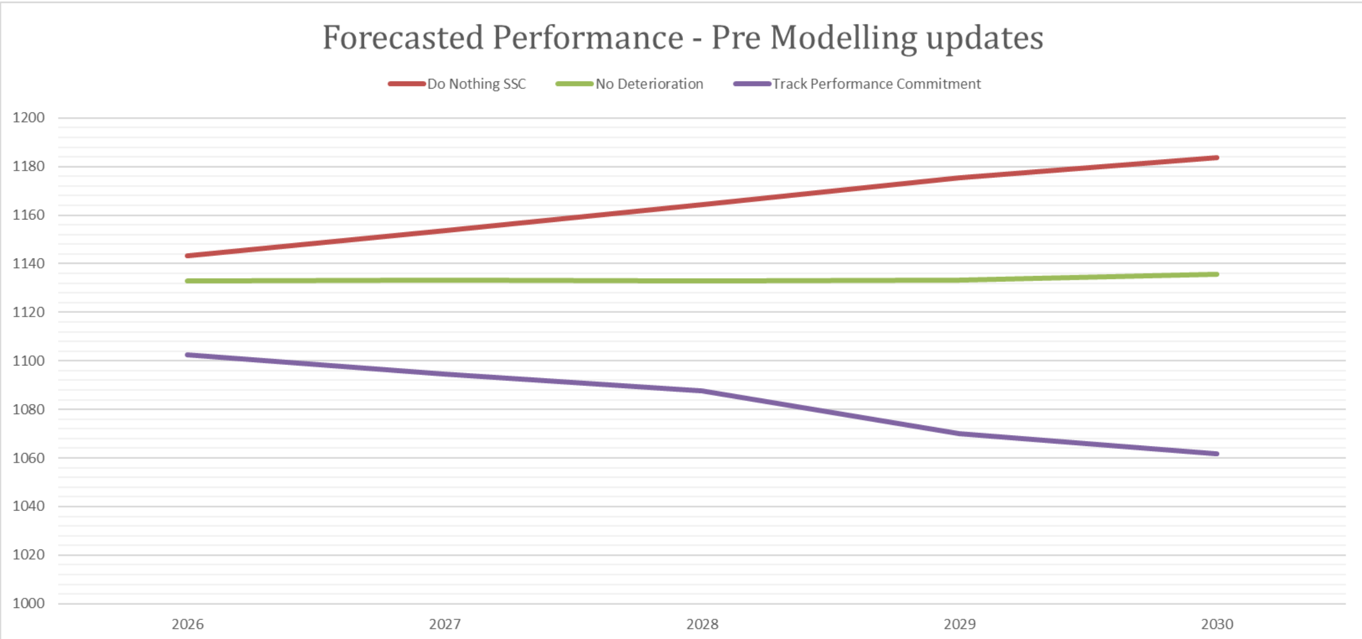


Figure 20 – our modelled burst, "Do-Nothing" scenario for the 2025-2030 period using an updated version of the model that was used for our PR14 and PR19 submissions.

We provided our senior leadership team with an early view of likely renewal requirements based on:

- **Refreshed data** using last 10 years of burst work orders, and the most up to date asset register from our GIS to account for renewal schemes that have been completed since the last price review.
- **Established scenarios based on our 25-year burst ambition** to consider what level of renewal is required to manage deterioration and meet these future outcomes.
- **Accounted for leakage driven renewals** (from WRMP investments) as well as potential reduction from whole system calming to establish a delta that our base capex renewal programme will fill.

After our linear regression model had been run to generate this initial view, we took time to review the accuracy of the model outputs and previous recommendations from our independent assurer at PR19. Deterioration of our small diameter mains has become a more complex modelling problem in the last decade, with external parameters hypothesised to impact deterioration more than age and pipe material. As such, for PR24 we set out on an improvement pathway to incorporate the effects of climate change into the model.

Infrastructure renewals is a large part of our Totex plan each price review, and since 2011 we are one of the Top 3 by mains renewal rates and burst performance, as shown in **Table 4**. We are proud of our performance in this area, and are ability to maintain the risk profile of these assets, whilst achieving performance targets efficiently. Starting the journey of improving our infrastructure deterioration model is seen as an important part of maintaining our position in the sector.

Company	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	Average
AFW	0.89%	0.84%	0.85%	0.74%	0.70%	0.60%	0.43%	0.31%	0.18%	0.13%	0.08%	0.07%	**0.48%**
ANH	0.43%	0.26%	0.28%	0.22%	0.06%	0.09%	0.23%	0.26%	0.08%	0.04%	0.08%	0.12%	**0.18%**
BRL	0.98%	1.08%	0.73%	0.82%	0.07%	0.22%	0.24%	0.24%	0.47%	0.25%	0.13%	0.12%	**0.45%**
BWH	0.48%	0.43%	0.46%	0.39%	0.39%								**0.43%**
DVW	0.53%	0.58%	0.48%	0.23%	0.63%	0.23%	0.27%						**0.42%**
HDD								0.63%	0.43%	0.15%	0.09%	0.29%	**0.32%**
NES	0.62%	0.57%	0.36%	0.34%	0.28%	0.29%	0.32%	0.41%	0.30%	0.09%	0.15%	0.10%	**0.32%**
NWT	0.12%	0.14%	0.12%	0.09%	0.03%	0.04%	0.05%	0.03%	0.03%	0.02%	0.03%	0.09%	**0.07%**
PRT	0.71%	0.56%	0.74%	0.44%	0.33%	0.63%	0.66%	0.65%	0.45%	0.25%	0.49%	0.33%	**0.52%**
SES	0.42%	0.36%	0.63%	1.26%	0.64%	0.33%	0.45%	0.29%	0.47%	0.10%	0.23%	0.46%	**0.47%**
SEW	0.45%	0.43%	0.27%	0.29%	0.15%	0.07%	0.08%	0.26%	0.24%	0.17%	0.03%	0.08%	**0.21%**
SRN	0.59%	0.52%	0.20%	0.09%	0.02%	0.17%	0.23%	0.08%	0.11%	0.05%	0.03%	0.03%	**0.18%**
SSC	0.87%	0.90%	0.80%	0.50%	0.42%	0.48%	0.67%	0.46%	0.31%	0.38%	0.28%	0.24%	**0.53%**
SVE								0.50%	0.59%	0.09%	0.15%	0.19%	**0.31%**
SVT	0.80%	0.64%	0.58%	0.48%	0.41%	0.35%	0.26%						**0.50%**
SWB	0.81%	0.17%	0.22%	0.22%	0.12%	0.13%	0.11%	0.08%	0.09%	0.08%	0.10%	0.05%	**0.18%**
SWT	0.87%	0.12%	0.18%	0.19%	0.06%								**0.29%**
TMS	0.71%	0.30%	0.07%	0.05%	0.20%	0.12%	0.40%	0.48%	0.48%	0.09%	0.16%	0.19%	**0.27%**
WSH	0.70%	0.63%	0.47%	0.24%	0.26%	0.41%	0.35%	0.16%	0.21%	0.14%	0.07%	0.08%	**0.31%**
WSX	0.78%	0.70%	0.78%	0.48%	0.41%	0.40%	0.49%	0.39%	0.22%	0.22%	0.24%	0.21%	**0.44%**
YKY	0.46%	0.38%	0.28%	0.02%	0.11%	0.15%	0.13%	0.09%	0.06%	0.10%	0.03%	0.08%	**0.16%**
Year average	**0.64%**	**0.51%**	**0.45%**	**0.37%**	**0.28%**	**0.28%**	**0.32%**	**0.31%**	**0.28%**	**0.14%**	**0.14%**	**0.16%**	**0.33%**
AMP average	**0.49%**				**0.29%**					**0.15%**			

Table 4 – our mains bursts performance and renewal rate compared to the sector since 2011 (based on APRs)

1.6.1 Developing maturity in our infrastructure deterioration modelling for PR24

To better understand the impacts of future climates on our infrastructure assets we undertook the work of incorporating future climate predictions into our modelling processes by initially taking a step back at our current process and other modelling capabilities were available to us. Initial findings from this review showed that a shift to machine learning processes would offer improved modelling accuracy as well as enabling us to meet OFWAT's requirements for looking at investments over the long term.

The machine learning principles in the new model allow us to analyse the multi-variant problem of mains deterioration. The inputs for this model are shown in **Table 5**. Comparing **Tables 3 and 5**, shows that the number of inputs has increased, with new parameters such as air temperature, and network configuration now included alongside the traditional parameters of pipe age and material. Historic burst performance is still included; however we now include pipes that have not previously burst in the analysis (where the previous model did not). Moving to this type of modelling approach was also recommended by our independent assurers at PR19. **Figure 21** provides an overview of development areas through PR24, covered in depth throughout the remainder of this section.

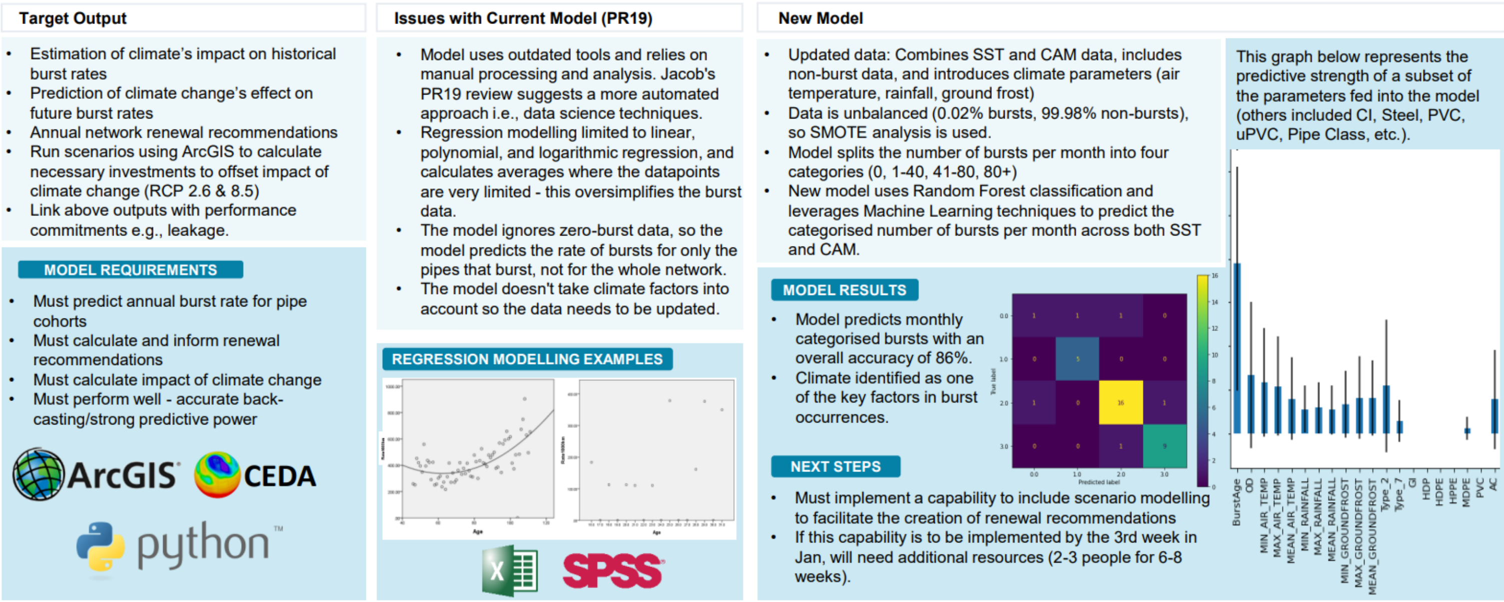


Figure 21 – a deep dive on our how our new model leverages Machine Learning techniques to improve modelled burst predictions

Input	Source	Purpose
Burst Work Orders	Works Management System	This data allows for the quantification of bursts on along a section of pipe.
Pipe Age	Company GIS	This data allows for an understanding of what age a section of pipe was at the points in which bursts occurred which allows us to understand failure trends over time.
Pipe Diameter	Company GIS	This data allows for the network to be grouped up into sections called cohorts. This attribute along with others are used to create optimal cohorts that provide the best relationships.
Pipe Material	Company GIS	This data allows for the network to be grouped up into sections called cohorts. This attribute along with others are used to create optimal cohorts that provide the best relationships.
Soil Corrosivity	Company GIS	This data allows for the network to be grouped up into sections called cohorts. This attribute along with others are used to create optimal cohorts that provide the best relationships.
Soil Fracture Potential	Company GIS	This data allows for the network to be grouped up into sections called cohorts. This attribute along with others are used to create optimal cohorts that provide the best relationships.
Pressure rating	Company GIS	The pressure rating (sometimes called Class) of a pipe material often indicates the strength of the pipe as pipes with a higher pressure rating tend to have a greater wall thickness.
Renewal Length	Company GIS	The amount of renewal that takes place on part of the network can have both a positive and negative bearing on the failure rates of the remaining sections of network within an distinct area of the network (For example an Supply Zone)
Supply Zone	Company GIS	This parameter allows for the regional network to be grouped into smaller geographical area's for overlaying climate related data.

Minimum Air Temperature	Met Office	The Minimum Air temperature is a useful parameter for understanding how the network reacts to temperature changes within the model.
Maximum Air Temperature	Met Office	The Maximum Air temperature is a useful parameter for understanding how the network reacts to temperature changes within the model.
Average Air Temperature	Met Office	The Average Air temperature is a useful parameter for understanding how the network reacts to temperature changes within the model.
Minimum Rainfall	Met Office	Minimum Rainfall is a useful parameter as a proxy for understanding the potential level of saturation within the soils that surround the pipes.
Maximum Rainfall	Met Office	Maximum Rainfall is a useful parameter as a proxy for understanding the potential level of saturation within the soils that surround the pipes.
Average Rainfall	Met Office	Average Rainfall is a useful parameter as a proxy for understanding the potential level of saturation within the soils that surround the pipes.

Table 5 – inputs to our new machine learning model for predicting burst performance across our small-diameter mains network

In order to train our model on how climate affects our pipe network, we needed to find out which climate parameters were most likely to affect failure rates. This data was obtained from the Met Office archives within their HadUK-Grid Datasets.

HadUK-Grid is a collection of gridded climate variables derived from the network of UK land surface observations. The data have been interpolated from meteorological station data onto a uniform grid to provide complete and consistent coverage across the UK. The data sets cover the UK up to 1km x 1km resolution and a range of other resolutions to allow for comparison to data from climate projections and across a country, administrative regions and river basins. The dataset spans the period from 1836 to present, but the start time is dependent on climate variable and temporal resolution. The grids are produced for daily, monthly, seasonal and annual timescales, as well as long term averages for a set of climatological reference periods. Variables include air temperature (maximum, minimum and mean), precipitation, sunshine, mean sea level pressure, wind speed, relative humidity, vapour pressure, days of snow lying, and days of ground frost.

The advantage of the HadUK-Grid datasets are that they span back for many decades that encompasses the same timeframe that we have asset failure data for. The data itself comes in many different formats. In order to provide the best relationships between weather parameters and our network we used NetCDF format, **figure 22**, which is a multidimensional raster format. This allowed us to integrate the historic met office data into our company GIS and accurately overlay our network of pipes. By splitting our network up into geographical area like supply zones we can measure small climate variances within our regions and these can be picked up by the model.

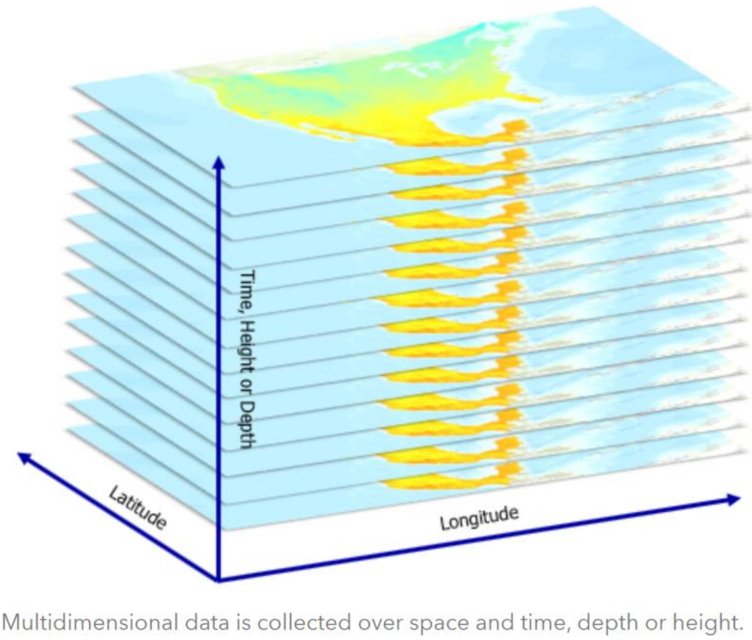


Figure 22 – an illustrative example of a netCDF multidimensional raster.

Once we had collected climate data by Supply Zone for our failure data time envelope we could begin our initial assessment of which parameters were most important in determining failure rates of the pipes in our network. The analysis showed that Air Temperature and Rainfall were the strongest parameters and should be incorporated into the final model. A full view of the model features that were incorporated into the final model are shown below in **figure 23**.

By moving to a model that looks at spatial relationships between pipes and climate we needed to structure our data slightly differently to how we have done with previous models. As the climate data was based on distinct geographical areas the network needed to be geo-chunked into the same area's that we had climate data for. As such, the new model has been trained to consider the characteristics of the network components within each supply zones alongside climate predictions in order to determine an expected number of failures in a given year.

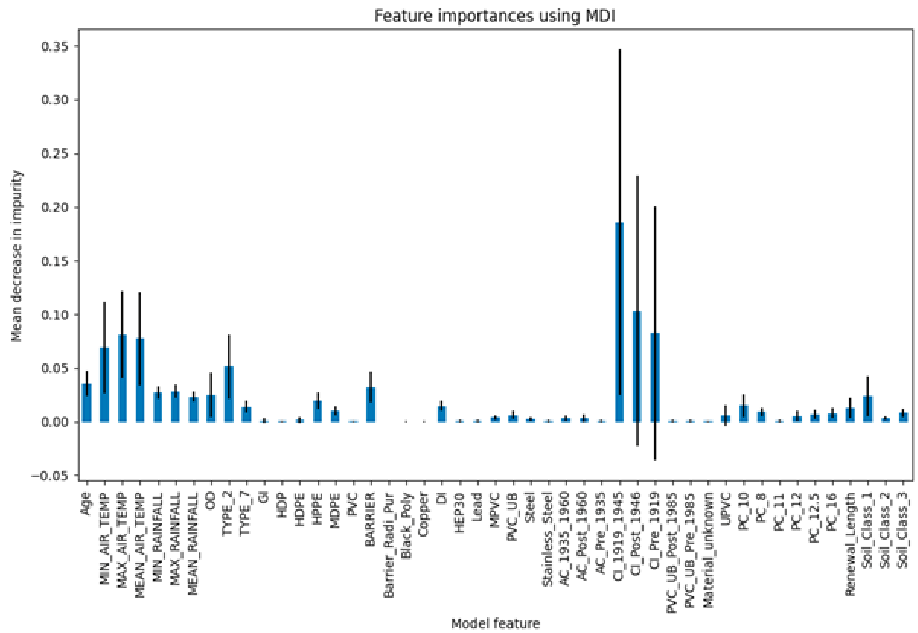


Figure 23 – model features (variables) and their importance in the model for determining failure rates

In order to determine the accuracy of the new model historic data was split into two parts, the model was trained using a large proportion of the data and then tested using the remaining data points. The model was asked to predict what has happened in the past using data it has never seen before. As we have accurate historic failure data we have an accurate benchmark to compare against the modelled results. The model was found to have an R2 value of 0.61. **Figure 24** shows the results of these tests.

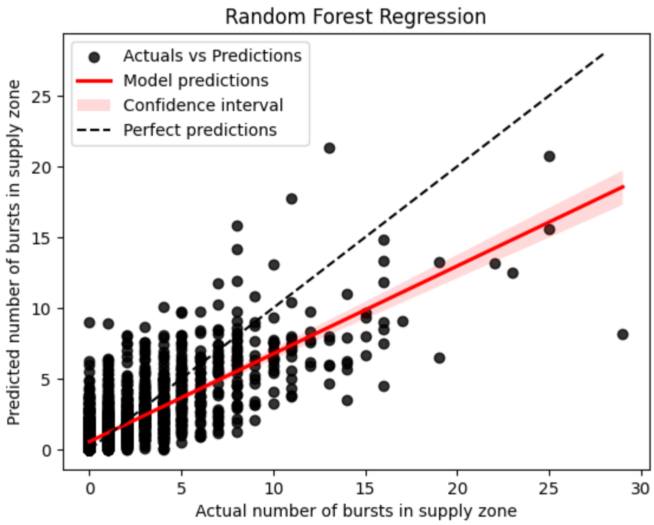


Figure 24 – model features (variables) and their importance in the model for determining failure rates

No model is perfect in its predictions but the results show a significant increase in the accuracy of predicting burst numbers for both regions when compared with previous models. A breakdown of the positive aspects and areas of challenge for further model development is shown in **Table 6**,below.

	Linear Regression	Machine Learning
Positive	• A tried and tested approach in the sector with comparable datasets and outputs that can help with confidence. • Simple model that can quickly be re-run with new datasets, with very little time required to produce a new set of outputs. • Simple to understand and communicate to stakeholders who may not be well-versed in statistical analysis. • In line with approaches used for non-infrastructure assets within our company, allowing for cross-comparison. • Can be configured within most off-the-shelf products for investment planning and decision-making 9rather than needing a complex statistics platform).	• All small diameter distribution mains are included within the model, irrespective of whether there is burst history. • Multiple, time-variant parameters are analysed within the model (age, weather, network configuration, material etc.). • All mains are modelled together, rather than in separate cohorts to ensure no bias towards certain mains. • In line with PR19 independent assurers' recommendation on leveraging machine learning principles. • High degree of accuracy in prediction despite needing time to train and learn burst patterns in a new weather climate.

Challenges	• Pipes which have not burst are filtered out of modelling – leading to an average "likelihood to burst" factor being applied most deterioration analysis. • The only variable within the model is pipe age. All other inputs are static and do not vary over time. • Pipe cohorts were modelled individually and grouped in the post-processing stage rather than being modelled together. • Other time-varying parameters are not included in the linear model. • Network configuration (location, connectivity) of the pipes is not included. • Low accuracy of prediction compared to recent performance (due to the changing environment around bursts – requiring a new model).	• Requires time to 'train' the model with new datasets that capture information against all the input parameters needed. • More complex to explain to stakeholders than simple linear models. • For PR24, it is the first time using the technique so there are no past results to compare to and potential uncertainties with how the model behaves (hence both models have been used). • Time to re-run the model with a new set of inputs takes longer as there is more data to prepare and input. • For PR24, not fully integrated with our chosen decision support tool and investment planning system.

Table 6 – the positive aspects and areas of challenge surrounding our modelling capability

Model outputs provide an annual view on future burst mains based on differing levels of renewals so that we can begin to see what level of renewals will need to be completed in the next AMP as well as future AMP's. Similarly to previous model outputs we first run a scenario that has no renewal activity within it with further scenario runs incrementally increasing the level of renewal we do. This allows us to understand the benefit of each scenario when compared with doing no renewal. As expected, we see an increase in annual burst numbers when we run a scenario with no renewals and start to see improvements in burst performance when we introduce renewal strategies to the model.

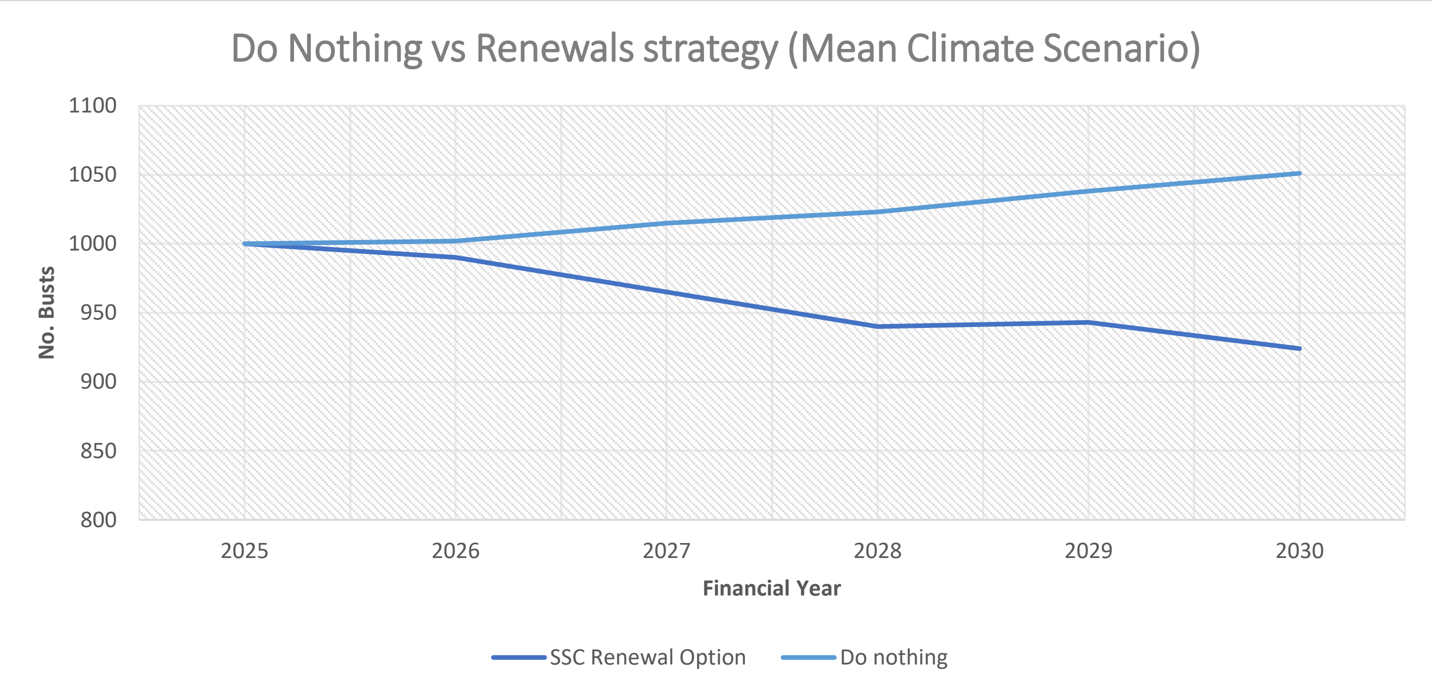


Figure 24 – comparison of Do Nothing and 50km annual renewal strategy.

We have set a performance commitment that provides us with a targeted reduction in bursts each year. The proposed target will push us to reduce annual burst numbers by around 11 per year. Using the model we were able to run a scenario that output the annual renewal lengths required to achieve this.

1.6.2 Costing of the infrastructure renewals budget

To appraise the budget costs for the renewal lengths output from the model various stakeholders were consulted across the business and information on schemes delivered over previous years was gathered. The cost of replacing a water pipe can vary depending on an number of things, for example, the type of road that the pipe sits within can influence costs associated with traffic management and reinstatement costs. Using historic outturn costs allowed us to quantify an average renewal rate per meter for schemes in each region. These run rates have been used to determine the renewal budgets for AMP8.

We intend to improve costing for renewal schemes in future years by creating a unit cost database that takes into consideration the influential factors that affect the cost of a renewal scheme. This will provide more accurate costings of the schemes that are optimised throughout the modelling process, as such being able to pick up on sensitivities in the analysis when schemes are selected in built up urban area's or on trunk road networks.

1.6.2.1 Scheme selection during AMP8

During AMP8, we will need to select the schemes that form the proposed budget for AMP8. Schemes selection is based on a number of data ranging from burst failure history to leakage levels within the DMA. We use a combination of systems such as ArcGIS to geo-chunk the pipe network into deliverable size schemes and Copperleaf H20 to capture all of the proposed risk and value for schemes so that we can produce an optimal replacement program that supports delivery of reducing impacts on customers and the environment.

The geo-chunking process is based on the make-up of the pipe network and focuses on groupings of pipe that have similar characteristics such as material, install time frame and surrounding soil type. Pipes are then grouped by geographic characteristics like which DMA they exist within which then takes into consideration pipe connectivity.

All connected pipes that fall within a scheme are copied across from the company GIS into the Copperleaf system, where schemes can be ranked and prioritised based on the risk areas like:

- mains with high leakage;
- mains which burst often;
- mains that when they burst have a large impact to customers such as long duration supply interruptions, road closures, property flooding and damage to third party infrastructure;
- mains that are under capacity causing poor pressures;
- mains that are over capacity causing potential water quality issues.;

Within Copperleaf, we are able to generate an optimal programme of renewal schemes based on delivering against our mains repairs performance commitment and leakage ambition by applying constraints that a programme must meet. Customer priorities are built into the Six Capitals value framework (section 1.2) that Copperleaf uses to quantify value against schemes. Outputs from recent Willingness to pay studies have been incorporated into the value sets so that monetary values that express customer preferences can be considered within cost benefit analysis.

This process is run multiple times through the year with the latest data to ensure that emerging risk areas are anticipated and reflected in future programmes of work.

As well as forecasted failure rates of assets, historical failures are taken into account. Schemes are targeted based on cluster analysis to identify hotspot trends within data. An example of this can be seen in **Figures 26** and **27** below. We would expect to target schemes within those DMA's that have the higher rates of failure when compared to other zones on the region.

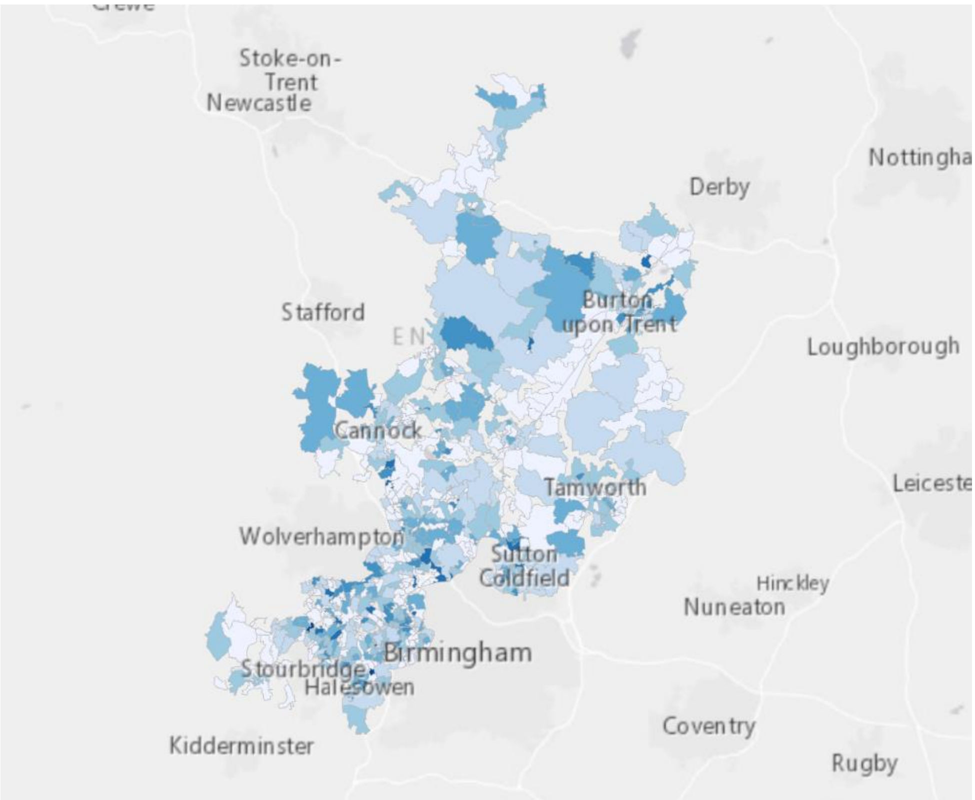


Figure 26 – SST DMA zones showing hotspot analysis of burst over the last 5 years. Darker areas have higher concentrations of burst per meter

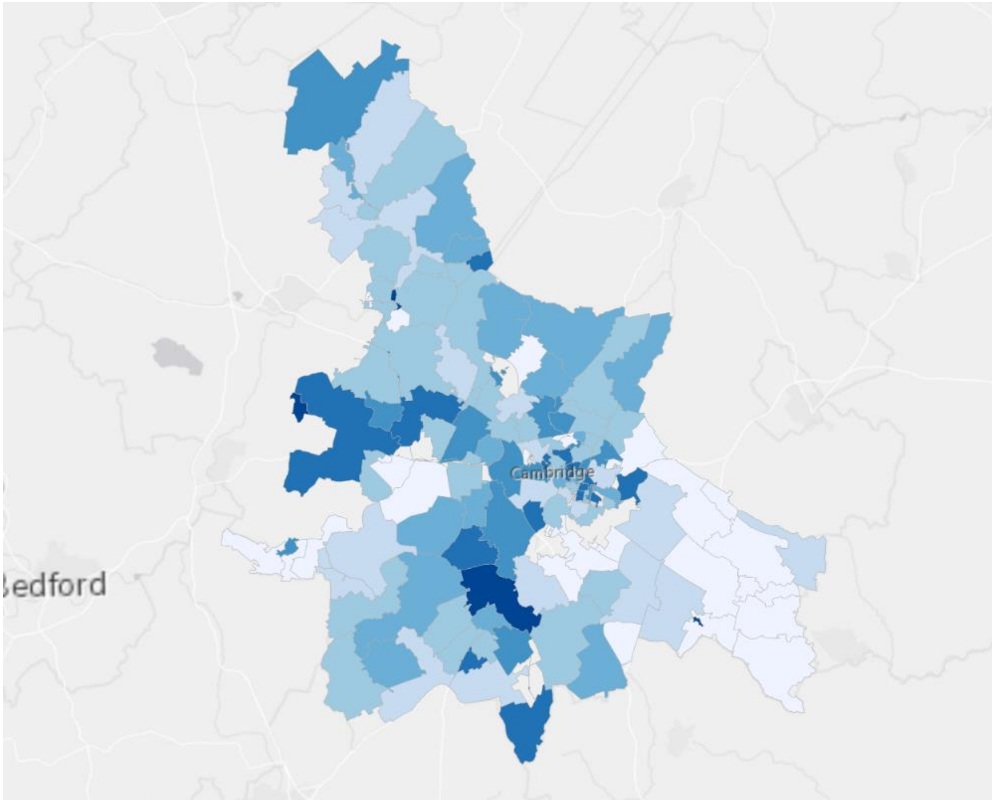


Figure 27 – CAM DMA zones showing hotspot analysis of burst over the last 5 years. Darker areas have higher concentrations of burst per meter

LTDS summary box – infrastructure modelling to 2050

Both our linear regression model and machine learning model for deterioration modelling of our small-diameter distribution mains forecast performance to 2050. They also consider varying renewal scenarios and by PR29, will be fully integrated within our system for investment planning (Copperleaf H2O). Our new machine learning model has capability that allows us to test the Ofwat Common Reference Scenarios. Air temperature and rainfall level have shown to be the most significant drivers of deterioration within our new model, however we need to continue training the model before we can ascertain what expenditure is required to mitigate this additional deterioration. Further detail can be found in the operational resilience **section 5.4** of our appendix, '**SSC02 South Staffordshire Water – long term delivery strategy.'**

1.6.3 Non-infrastructure modelling at PR24

In addition to the resilience modelling across our production and network assets described in section 1.5, we also look to utilise our hydraulic models in supporting understanding of our non-infrastructure criticality.

Asset failures were simulated to assess the impact to our service, firstly being simulated one at a time to determine the impact of a single point of failure, then, multiple failures simulated within each zone to determine the potential impact of cumulative failures. Failures were simulated by systematically 'switching off' assets within the hydraulic modelling software – so our source stations, booster stations and service reservoirs and towers. For source stations and booster stations, we simulated asset failures under an average demand, peak hour scenario to reflect the worst case scenario risks we have to manage on the most frequent of occasions - a daily basis. Therefore, by simulating failure under a higher demand scenario, we were able to assess potential impacts to customers that we have not already quantified. After simulating each asset failure (single or multiple), we documented the impact on service level to customers in terms of low pressures and no waters. We then added existing mitigation measures to the model, for example, opening valves between zones or operating transfer boosters.

In our assessment of maturity, we recognise the industry wide problem of linking non-infra asset health indicators directly to customer service, and like others, consider the challenge around establishing a single few measures that can cover the health of the full range of assets. Our approach around establishing asset health has thus seen more emphasis placed internally on risk indicators focused around WQ. To improve this we have developed a more granular bottom up asset specific risk register (**as discussed in** section 1.3) building upon DWSP's and previous non-infra risk elicitation and surveys with a view to develop an integrated hierarchy of data. Further, notable modelled data around our pumping asset health encompasses vibration analysis, thermographic data and energy based pump efficiency programmes that feed into prioritized investment cases.

1.6.3.1 Non-infrastructure deterioration model

NON-INFRASTRUCTURE MODEL (REPAIR)

• Capital maintenance focused models • Used to predict long-term maintenance • Combined with site risk registers to form plan • Uses Weibull models to define repair rates • Models based on either data or judgement	SUMMARY
• Models with data input require failure data • Some models require engineering judgement • Other parameters…cost per intervention	INPUTS
• 40 yr capital maintenance forecasts • 40 yr operational expenditure forecasts • 40 yr repair rates aligned with IO OPMs • Potential for criticality, mean time to repair type measures etc.	OUTPUTS

In refreshing the data set used within our existing non-infrastructure model, we also took the opportunity to carry out a review with PA Consulting in terms of areas of potential improvement. With improved datasets (see section 1.6.3.2 below), we refreshed and looked to include longer life assets where possible. We also sought to establish clear ownership of the model and associated processes to ensure its ongoing sustainability.

Further, we engaged PAM Analytics to provide an additional layer of quality assessment around our existing data sets, reviewing the static and dynamic datasets captured in our asset registry and through maintenance activity. We investigated the use of survival analysis to generate bespoke deterioration curves for asset classes, predicated on mean time to failure using a given maintenance frequency.

Outputs were overlaid with risk elicitation exercises (sections 1.3 and 1.4), to support validation of critical investment requirements, and fed into the zonal resilience master planning process (section 2.1).

1.6.3.2 Non-infrastructure asset data

A major upgrade in AMP7 of our works asset management system, Maximo, has given the capacity to capture and interrogate identified asset health datasets to complement risk elicitation and stakeholder views. With immediate impacts delivered around system changes and process implementation, our ability to manipulate asset performance data and view/create easily accessible dashboards to monitor trends has enhanced our ability to turn data into informed decision making. This is important in contest of our modelling capability highlighted above. Linking asset health measures through from live telemetry systems into Maximo is also being developed. This will support the Smart/Live Networks drive in improving asset health understanding from real time data – we expect much greater transparency to come through around failure modes from this information, feeding into our predictive analytical models and supporting proactive interventions to benefit customers.

1.7 Statutory obligations

A large proportion of our investment needs are driven by regulatory factors – investments we are required to make to meet our statutory obligations. The main regulatory bodies affecting our non-infrastructure and infrastructure assets are Ofwat, the Drinking Water Inspectorate, the Environment Agency (EA) and the Health and Safety Executive. Our investment needs relating to our statutory obligations were put forward by the relevant owners across the business throughout the planning process.

- WRMP, WINEP, DWSP and other statutory planning frameworks follow bespoke methodologies for risk analysis, scheme identification, option development and plan optimisation.
- All statutory schemes in these frameworks are also assessed in parallel using our common risk and value framework to ensure the whole portfolio can be optimised & managed within our investment planning system.
- Where possible, processes such as benefits assessment and costing have been aligned, but for some of these planning frameworks there are differing submission dates and required methods (for example, WINEP).

1.8 Innovation workshops

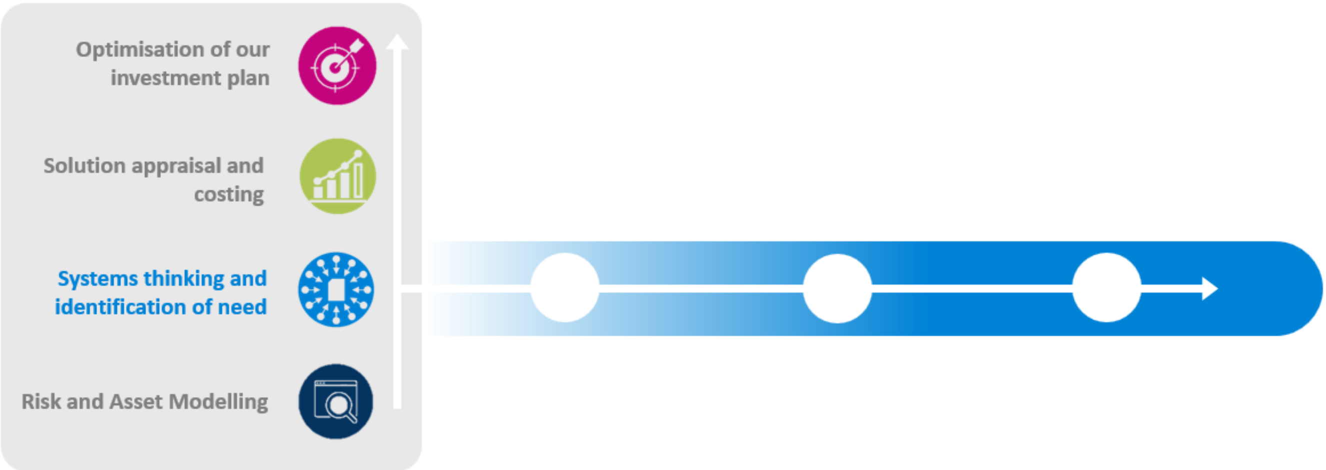
As well as our asset-focused assessment of risk, we also reviewed our 2050 ambition and some of the innovative things we could do to reach these outcomes.

Several sessions were held with the SLT to review ideas proposed by different people. These were aligned with elements of our ambition and prioritised for development based on the potential value to customers, and effort to develop.

Covering a breadth of key areas including responsible water resource, management, customer service, efficient operations and environmental and social governance.

Outputs from these sessions were categorised into proposals supporting our near term ambition in AMP8 and those that were centred around our ability to optimally meet future strategic challenges and served to promote and establish our thinking around core and adaptive planning pathways specific to our LTDS.

2. Systems thinking – identification of needs and initial solutions



2.1 Zonal resilience master planning for resilience in AMP8 and beyond

We have developed and enhanced our ability at PR24 in ensuring the transition from our bottom up risk elicitation (defined through section 1 risk and asset modelling) to investment need and scheme identification has been developed through a zonal master planning approach.

As a core principle of this approach, we set out to create an innovative environment through structured workshops (see section 2.2 below) where asset experts can rethink the way the infrastructure is operated and propose sustainable, long-term investment solutions.

Consolidating the risk inputs that had been captured, collated and scored across the entire business, Asset Management facilitated 'systems thinking' sessions bringing together a wide range of expertise from Production, Water Resources, Water Quality, Networks, Asset Management and our Capital Investment Delivery teams. These sessions were integral in ensuring captured risk was viewed holistically by these key stakeholders, with an understanding of the interdependent nature of our asset base across both infra and non-infrastructure criticality assessments.

Crucially, these workshops were informed by both the outputs of the expert risk analysis detailed in sections 1.3 and 1.4, and also by the supply zone resilience and asset deterioriation modelling outlined in sections 1.5 and 1.6. This approach allowed consideration of more than 500 risks, generating around 1200 investment solutions options, within context of existing operational strategies and future state objectives (for example in terms of our storage level policy ambition as outlined in **figure 13 in** section 1.5).

Decision making around potential options to meet current and future resilience ambition was supported in the use of assessing potential options agasint our Six Capitals value framework (see section 1.2) to understand the value against our proposed AMP8 Performance Commitments to our customers and in our strategic business objectives. And, we developed decision trees (evidenced in section 2.3) that contained within them a refined set of questions that served to establish those low or no regret options in context of our short and longer term resilience ambition.

We set out in this section these separate components of the master planning process, and how they have fit together to produce our best value, least cost base and enhancement programmes for the period 2025-2030, and also how the process has driven the identification of key investment within the core and adaptive pathway plans for resilience within this period and up to 2050 as part of our LTDS.

The development of this planning approach was done with a core principle of ensuring a sustainable and consistent platform linked to a well understood value framework. We felt this ideology was critical to the maturity of our Asset Management system, and would serve to provide a baseline moving past PR24 and into AMP8 with continuity in our capcity to refresh and review as needed.

Our master planning is also intrinsically linked to our established Resilience Action Plan targets, refreshed for the period 2025-2030, as detailed in our appendix 'SSC05 Integrated resilience framework'.

Zonal Resilience Master planning summary – innovative thinking in our approach to the escalation of risk to investment need…

From Source to Tap, we stepped through the network as it is operated, reviewing risks and challenging ourselves to:

- Identify the root cause, including any links to other risks
- Develop zonal solutions that address the root cause
- Consider future uncertainties (growth, demand, climate etc.)
- Propose investment that is adaptive (can respond to change)
- Link risks and proposed solutions to long-term outcomes (LTDS)
- Identify investment dependencies, efficiencies and impacts

– Stop missing opportunities to invest efficiently & effectively

– Promote long-term network requirements, linked to our Long Term Delivery Strategy

– Continue delivering a great service to customer today and tomorrow

The full zonal resilience master planning process is set out below in figure 28

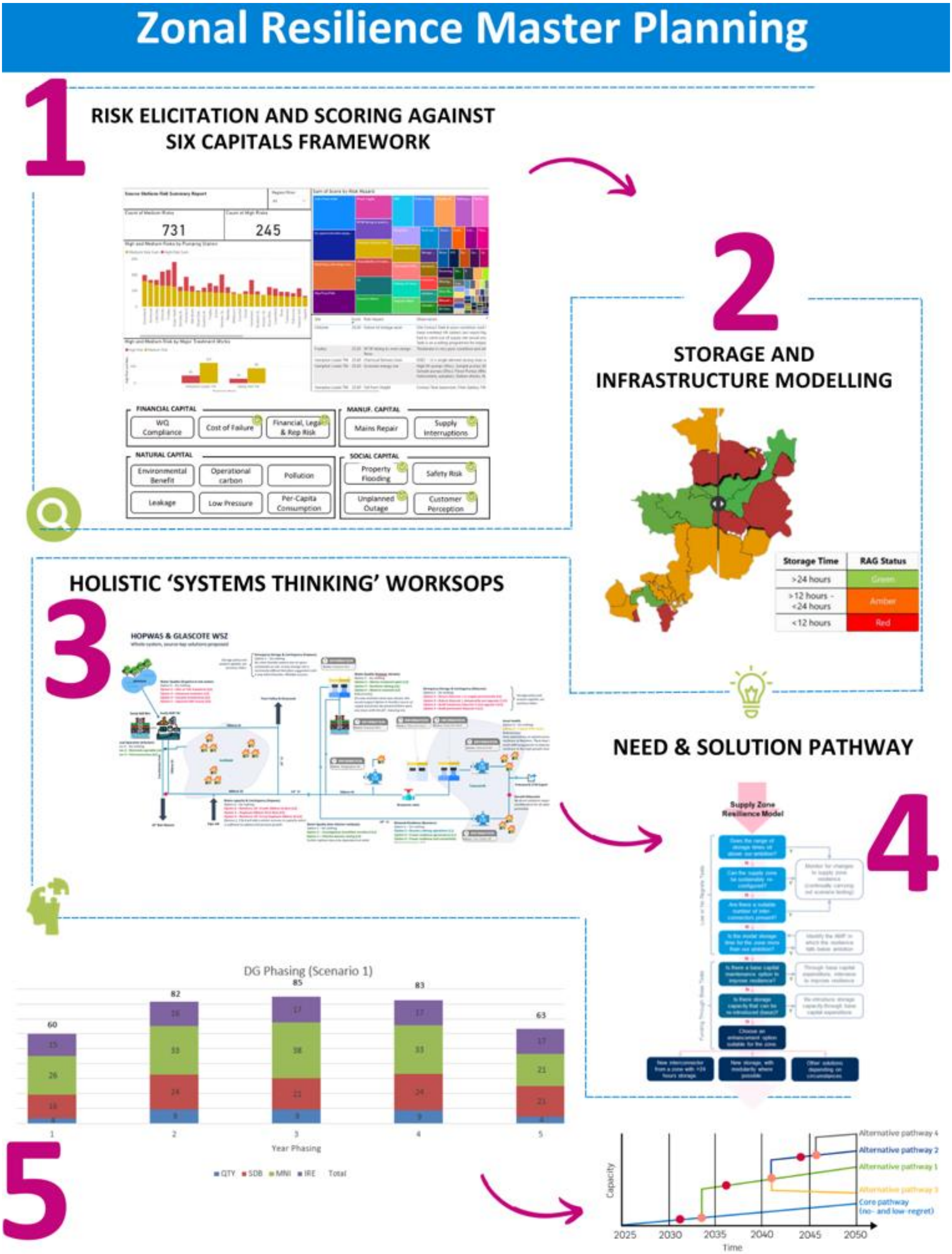


FIGURE 28 - AMP 8 PLAN OPTIMISATION AND LTDS CORE PATHWAY IDENTIFICATION

2.2 'Systems thinking' workshops

We have covered steps 1 and 2 in the Zonal Resilience Master Planning **(figure 28)** process through section 1 - the following detail in this section will outline the remianing steps in the process, resulting in the identification of an unconstrained list of investment needs and solutions for potential inclusion as part of our AMP8 plan, including those that are deemed part of any core and adaptive pathway planning for the longer term within our Long Term Delivery Strategy (LTDS).

The structured process of the workshops was formulated to identify needs and subsequent solutions to take forward into our business planning process, bringing together expert insights (section 1.3), historical data and CRT captured critical risks (section 1.4) and applying these within a Water Supply Zone strategic level. Key inputs were based on:

- Water Quality – driven by Drinking Water Safety Plan held risks. We reviewed in context of the Compliance Risk Index (CRI) and acceptability of water (taste and odour) within the supply zone in question. We also reviewed areas that may be at risk from low levels of free chlorine and potential risks to the acceptability of water that may arise from us transferring water between zones;
- Unplanned outages or interruptions to supply covering:
  - non-infrastructure assets – we reviewed source station outages and trips at booster stations since 2015 as identified from our telemetry records in terms of both frequency and root cause;
  - infrastructure assets – we reviewed both trunk mains and small diameter historic burst rates and the number of bursts per kilometre of main within each zone. The trunk mains data we used dated back to 2000 and the small diameter data used dated back to 2015.
- Our newly built supply zone resilience model (see section 1.5)
  - this assesses the resilience of our supply zones to climate change, demand, operating environment, and reservoir level
- Additional insight and review of the long term position for each zone, including:
  - future demand forecasts encompassing all new proposed housing and commercial growth contained in Council Local and Structure Plans;
  - our Water Resources Management Plan (WRMP) in terms of our deployable output, supply demand balance and leakage position;
  - emerging trends in raw water quality at our source stations;
  - regulatory changes (pertaining to licence changes and water quality); and
  - between zone water transfer capabilities and constraints (for example mains sediment and turbidity risks);
- A review of previous and current proposals for investment in AMP7 in order to confirm what actions to mitigate the risks identified are already planned and when they will be delivered so we could ensure any outstanding mitigation identified as being required could be added to the business planning process.
- The use of hydraulic models to simulate failure scenarios in better understanding our asset resilience under average and peak scenarios, linking in with our non-infrastructure production asset and storage resilience modelling (sections 1.6.3 **and** 1.5 respectively) and providing an objective analysis of expert elicited risk in the session.
- True systems thinking around existing asset maintenance strategies and the whole life costs associated with them in context of the solutions identified. We recognised that vulnerabilities or failure in one area of our network, whether above or below ground asset, can affect the whole system, potentially leading to a cascade of failures. These knock-on effects are due to interdependencies in the system, which can be exposed by stresses and shocks such as extreme weather conditions. Hence, we overlaid the results of our supply zone resilience modelling as part of this systems thinking approach to truly understand whether our policies and ambition were being matched in our identification of investment need and solutions.
- Appraisal of potential Nature based, or Green Solutions in our process, which followed through to our longlisting stage and Multi Criteria Analysis (section 3.2.1) ranking against the relative merits of any potential schemes that fell into this category.

With so many of our colleagues involved in the process, the outputs of the workshops were diverse, ranging from specific non-infrastructure assets, specific infrastructure assets; strategic supply capability, and, more generic strategies relating to our internal procedures such as emergency planning.

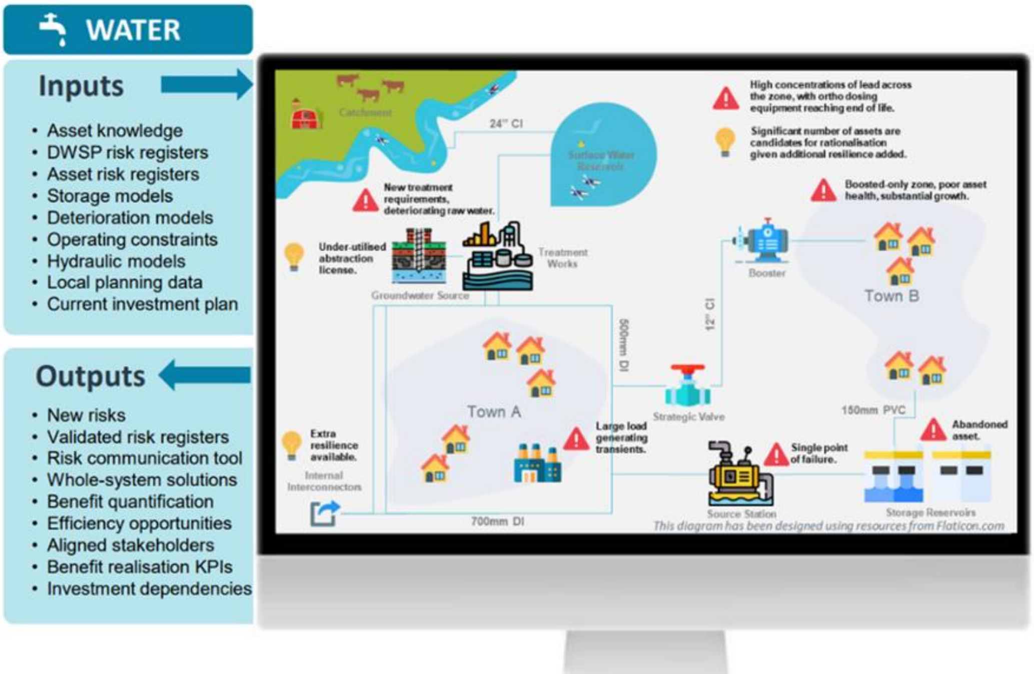


Figure 29 - Systems thinking inputs and outputs

The process was valuable in sharing people's knowledge and experience, in highlighting areas for improvement - both to our service as well as our internal processes and, in facilitating joined up thinking and communication across our business.

Sixteen Zonal Study workshops brought experts across the business together to strategically review issues across the 27 WSZ's, including dedicated sessions for our two Water Treatment Works at Hampton Loade and Seedy Mill. The visualisation of network risks was critical in facilitated discussion and the production of potential investment solutions to address and mitigate these issues. A 'one to many' relationship between risk driven need and identified solutions was used, resulting in:

>400 needs raised across the entire network;
>1,200 costed potential source to tap solutions proposed to address the needs identified and to improve resilience; and
timescales required for implementation of the proposed solutions.

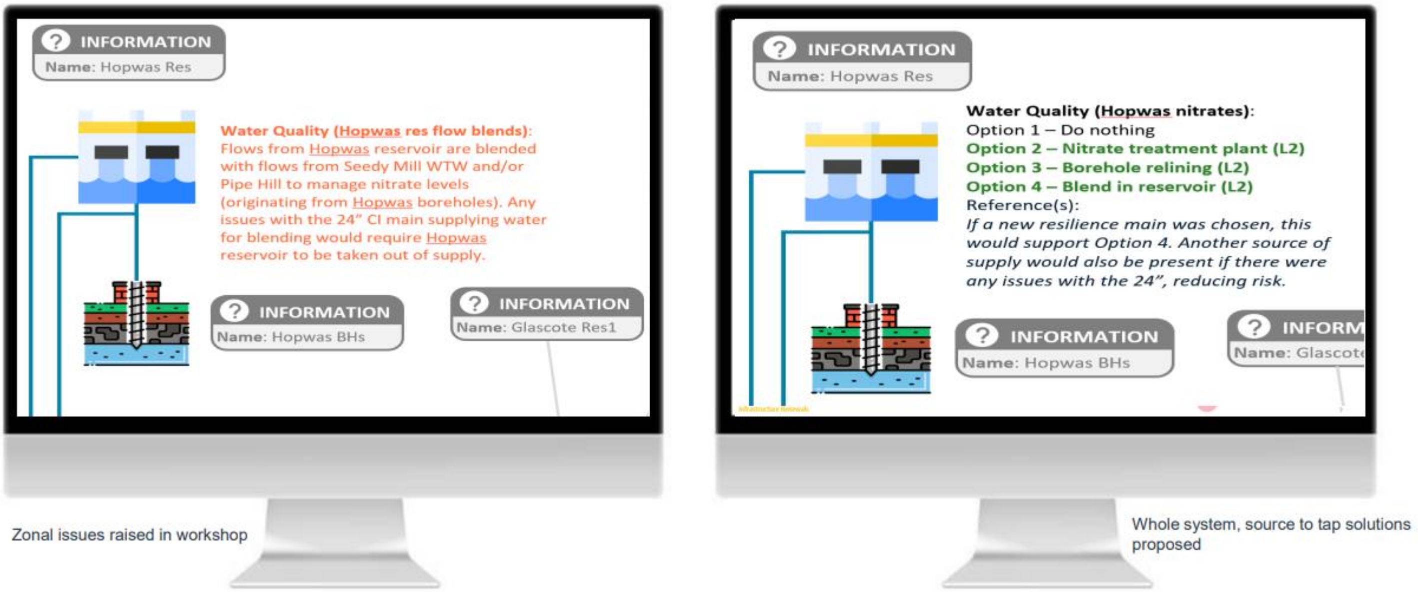


Figure 30 - Systems thinking one need to many solutions example

2.3 Investment need and solution pathways – AMP8 or future core requirement?

Through our holistic system wide reviews across all of our supply zones, we carefully analysed the configuration of each zone as described above in section 2.2, assessing hydraulic constraints, areas of growth, and dependencies on other assets or zones to determine a feasible list of options..

As a resulting output from steps 1 to 3 of our master planning process, we developed long-lists of investment options for each supply zone across both of our regions, in tandem with recognition of whether they were potentially required as a priority in the period 2025-2030, or as part of a core or adaptive investment pathway over the longer LTDS horizon.

To facilitate clear understanding of this categorisation of our options, we developed and embedded decision trees rooted in the need to understand and agree whether the arising schemes could be classed as 'low or no regrets,' through a series of tests based on the likelihood of each delivering against the required level, or step change, of resilience in a given zone. **Figure 31**, below, illustrates an example decision tree related to our storage and infrastructure resilience model, to support identification of the investment solution pathway (more detail on the creation and use of this decision tree can be found in the operational resilience **section 5.4** of our LTDS document, '**SSC02 South Staffordshire Water – long term delivery strategy.'**)

As a final step, we then looked to identify a preferred option in conjunction with stakeholders, through initial cost and benefit assessment (section 3.1).

Having done this, we further refined the option to explore innovative, alternative ways of delivering the scheme that supports adaptive planning (for example, if a new storage asset is required – exploring the opportunity for modular storage rather than large new reservoirs). This principle would then be further tested and reinforced through the Multi Criteria Analysis and shortlisting process in our detailed Phase 2 costing process in section 3.2 below, with an additional review of adaptive planning principles.

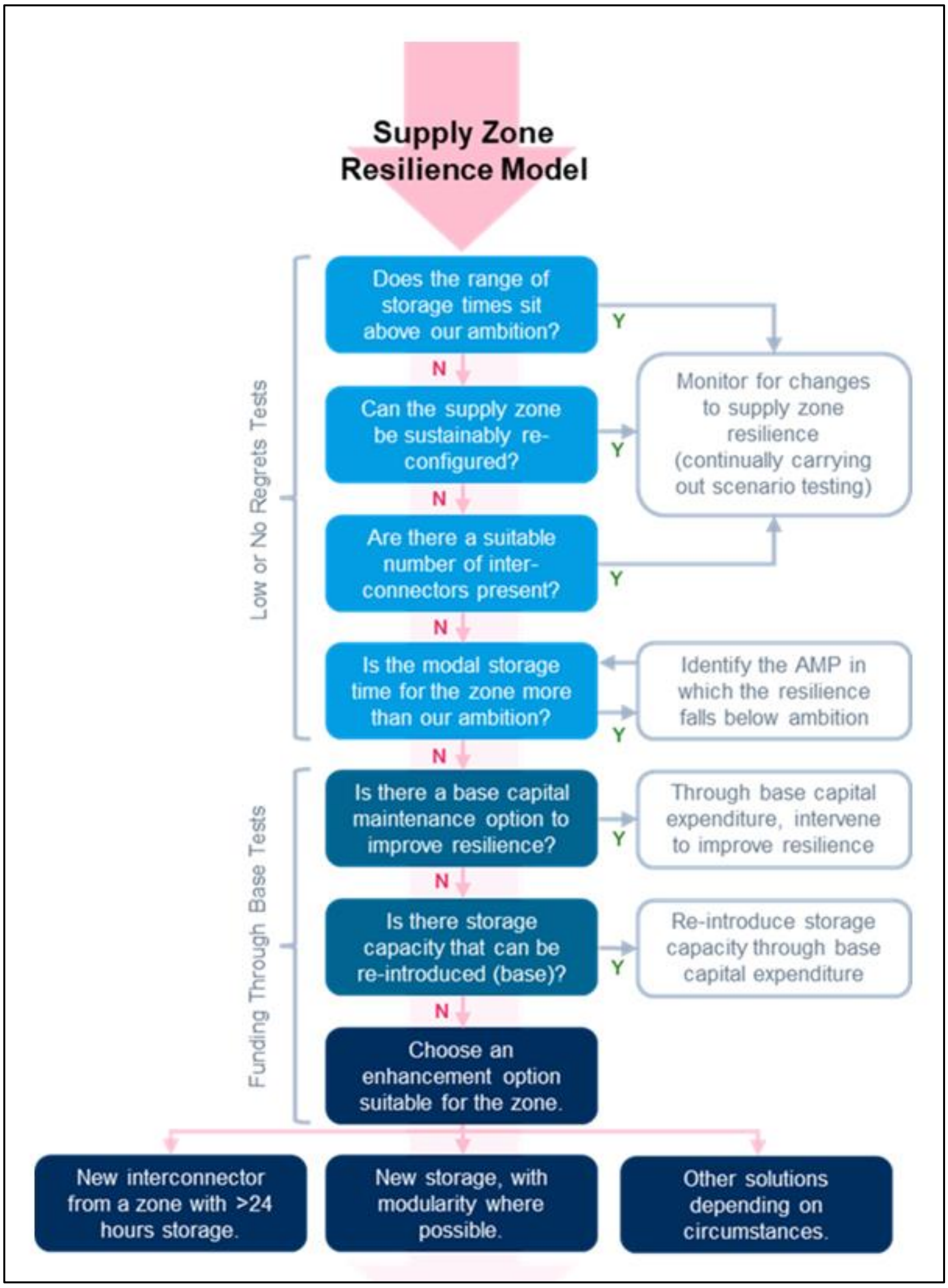


Figure 31, an example decision tree related to our storage and infrastructure resilience model, supporting the identification of the optimal investment core pathway and timing for our production and network resileince investment

2.3.1 Summary master planning outputs for our LTDS

Enhancement – Network Resilience

Achieving our supply interruptions ambition will largely require us to maintain asset health and operate effectively to minimise disruption when there are loss of supply events. However, after consideration of all potential areas for enhancement expenditure on Network Resilience over the next 25 years, our current LTDS includes expenditure for:

- New potable water storage within our supply zones.
- New interconnectors that allow us to move water between supply zones.
- Renewal of our infrastructure above the base expenditure allowance of 0.4%.

Enhancement – Production Resilience

After consideration of all potential areas for enhancement expenditure on Production Resilience over the next 25 years, our current LTDS includes expenditure for:

- Continuation of our power resilience programme (not including new sources of energy).
- New control systems to better manage processes on site.
- Duty/Standby streams for sites that are critical to supply.

2.3.2 Case study of storage resilience in our Cambridge region

We set out below a case study around storage in our Cambridge region. Supply zones that have a range of storage times lower than the 24-hour ambition are ones that we have targeted first, as part of our low or no regrets assessment (see policy development in **figure 13**, above). As with our South Staffordshire region, these outputs (discussed below), informed both our base and enhancement expenditure in AMP8 and also our LTDS core pathway.

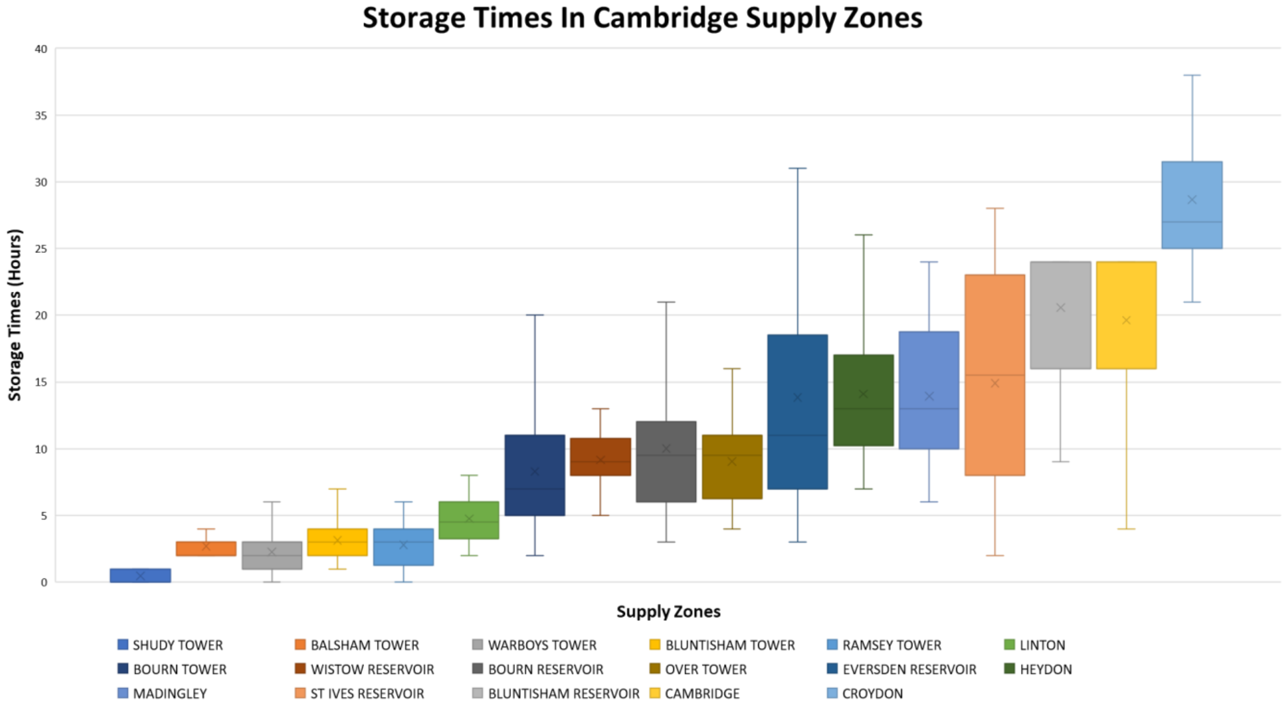


Figure 32 – Cambridge region outputs from our storage supply zone resilience model

- A significant amount of storage in the Cambridge region is concentrated in the Cambridge, Maddingley, Croydon and Heydon zones.
- Linton in the south-east of the region, and Bluntisham in the north-west appear to be the zones that have the least resilience given the large number of water towers that do not provide any significant amount of storage. Some local DMAs within these WSZs could be adequately supplied by the reservoirs, but there is still a risk that substantial customers would be lose supply if source stations were lost.
- As a result, base investment in source stations such as Linton PS, Rivey PS, Horseheath PS, Great Wilbraham PS, Fleam Dyke, Dullingham PS, Westley PS, Weston Colville PS and Fulbourn PS will support resilience in the Linton WSZ. We evidence this in our base non-infrastructure maintenance activity in section 5.1.1 and also in our resilience and water quality driven enhancement cases in **sections 5.2 and 4.1** of our appendix **'SSC36 Evidencing our enhancement expenditure in 2025-2030.'**
- The north-west of the region could be subject to substantial future network changes due to the introduction of Fens reservoir. There are challenges associated with these – which makes it difficult to identify enhancement that is low or no regrets.

2.3.3 Categorising our priority solutions

Through section 2 we describe how the base and enhancement programmes have been built in parallel, with a wealth of modelled and SME input to generate a clear view of investment needs and an unconstrained list of options. We decided that, ahead of moving into more detailed solution development and costing phases, it was important to clearly define whether those solutions we had identified as being required in the period 2025-203 should be classed as either base or enhancement investment. The following flow process in **figure 33**, below, demonstrates the questions we asked of ourselves in this sense, with the main focus being on what the investment was delivering for our customers.

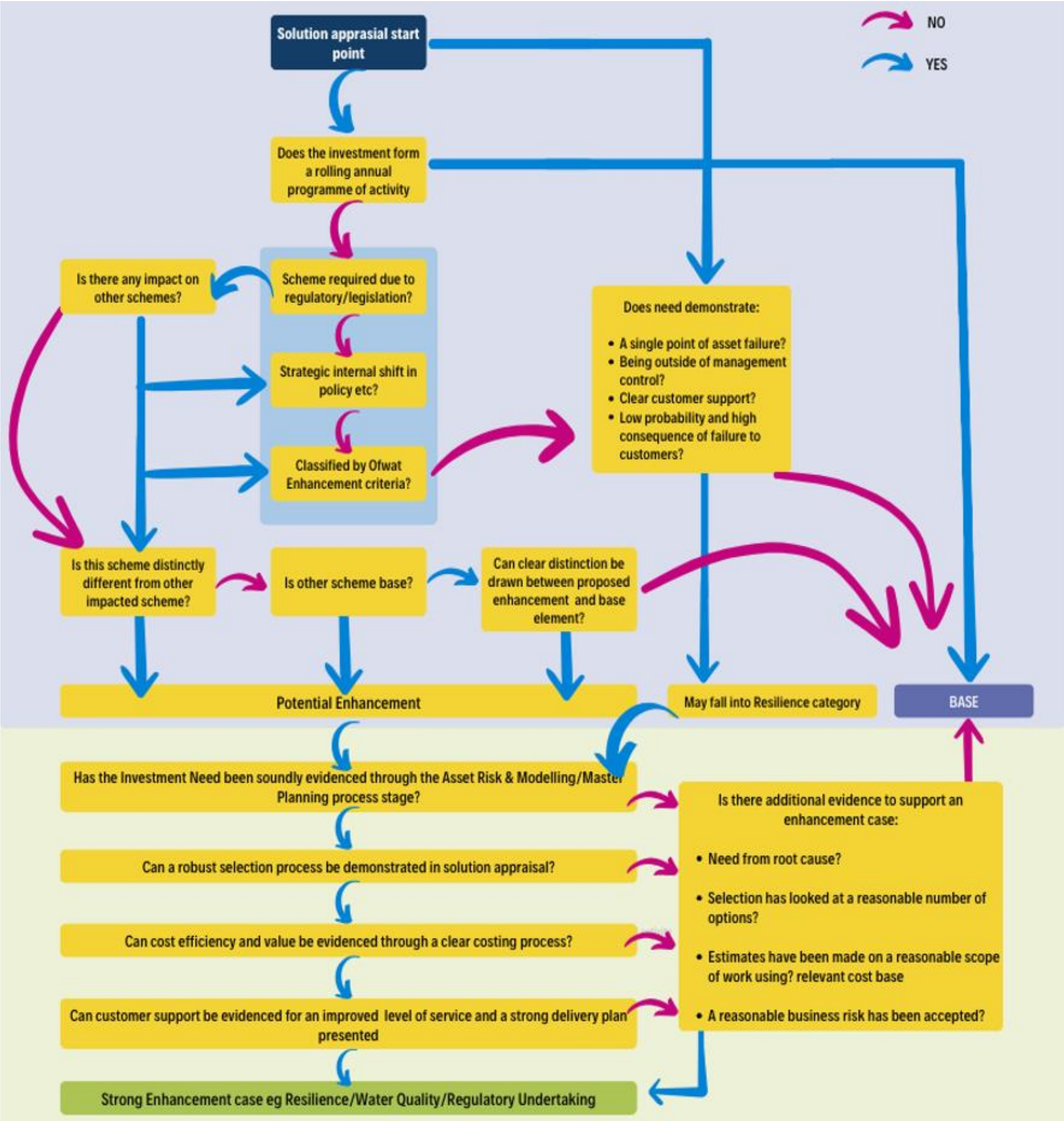


Figure 33, decision tree used to determine the categorisation of our priority schemes across our base and enhancement programmes

3. Solution appraisal and costing of our plan

Having described how we have identified our investment needs and an initial view of potential investment solutions through sections 1 and 2, we set out below the steps we have been through to develop maturity across all of our base and enhancement solutions, along with associated cost and value. We do this to ensure we are driving cost efficiency in our investment proposals for customers, and that we are able to demonstrate where the optimal value will be achieved utilising our Six Capitals valuation framework that has been developed to align with our customer priorities and our Performance Commitments. This framework is outlined in detail in section 1.2, and serves to ensure consistency in our valuation approach across multiple investment types and constraints.

Our process in achieving this core objective of a robust cost and valuation is a thorough one, recognising the importance of utilising historical delivery costs where practicable, but also in engaging with industry expertise to ensure appropriate use of cost modelling within our detailed 'Phase 2' process outlined in section 3.2 below. This has given us a level of certainty in our costs that is aligned with the level of complexity and risk associated with our investments. Accordingly, we assigned cost confidence grades to all investment needs and solutions to ensure we could quantify the levels of uncertainty in our investment optimisation outputs.

Level 1, 2 and 3 costing estimation -

Throughout our costing approach we refer to Level 1,2 and 3 costs as we have built increasing detail and complexity into the composition and accuracy of the costs in line with solution design and scope maturity.

Level 1 – High level costing approach, historic trend analysis and extrapolation validated by SME's.

Level 2 – Improved scoping information available – High level costing approach adopted supported by bottom-up costing using quantities and rates where available

Level 3 – More granular information available – High level of costing approach adopted supported by bottom-up costing using quantities and rates where we can improve the cost accuracy. Undertaken Opex Costing and Whole Life Costing and Carbon.

3.1 Phase 1 - Initial outline cost and value assessment

Following completion of the zonal studies, our aim was to produce a first draft of these priority needs with a long-list of unconstrained solutions captured within our Investment Planning System, Copperleaf H20. This phase of our build was designed to allow us to use our captured solutions to begin to test our investment planning framework and in particular, our ability to use the Copperleaf system. Further, it allowed us to begin engagement with our supply chain, establishing workflows, the types of investment requiring cost and value and also our costing specifications, (for example cost base year of 2022/23), necessary for use in the system.

Our supply chain was mobilised to carry out an accelerated process of costing across the whole, unconstrained plan, through a Level 1 and 2 costing estimation effort. IWS did this for our base capital maintenance plan at production site, OSM for our surface water reservoirs and service reservoirs and Aqua completed this for the remaining parts of our Totex plan.

To complete the Phase 1 process, we then developed a set of Problem Statement Templates (PST) to facilitate this process, used to effectively capture data to support quantification of risk, and an understanding of the significant investment drivers in terms of the Six Capitals value framework. Annex 7.2.2 provides an example of a PST used for this purpose.

3.1.1 Initial plan validation

With Phase 1 cost and value estimations complete, and a functioning investment planning system in place, we moved through a validation process with the wider business to test early outputs in terms of preferred solutions and sensitivity in the value framework and associated parameters (for example our applied Discount rates and Willingness to Pay value sets – see section 4.2 for more on uncertainty and sensitivity testing of our plan). **Figure 34**, below, defines the steps we took in ensuring a level of understanding and sense checking of our plan and associated cost and value in its early stages.

This validation included initial cost & benefit estimate (**step 4 in figure 34**), which was then applied in rapid fashion to each option in the long-list, allowing us to gain insight with our first plan optimisation scenarios within Copperleaf, based on value and total capex constraints alone.

This activity informed early Board and Senior Leadership Team (SLT) review sessions, as well as providing an initial indication of the plan composition to customer research teams for customer testing. This link through to customer engagement was a recurrent theme through the development of our plan – see section 3.2.3 for further detail.

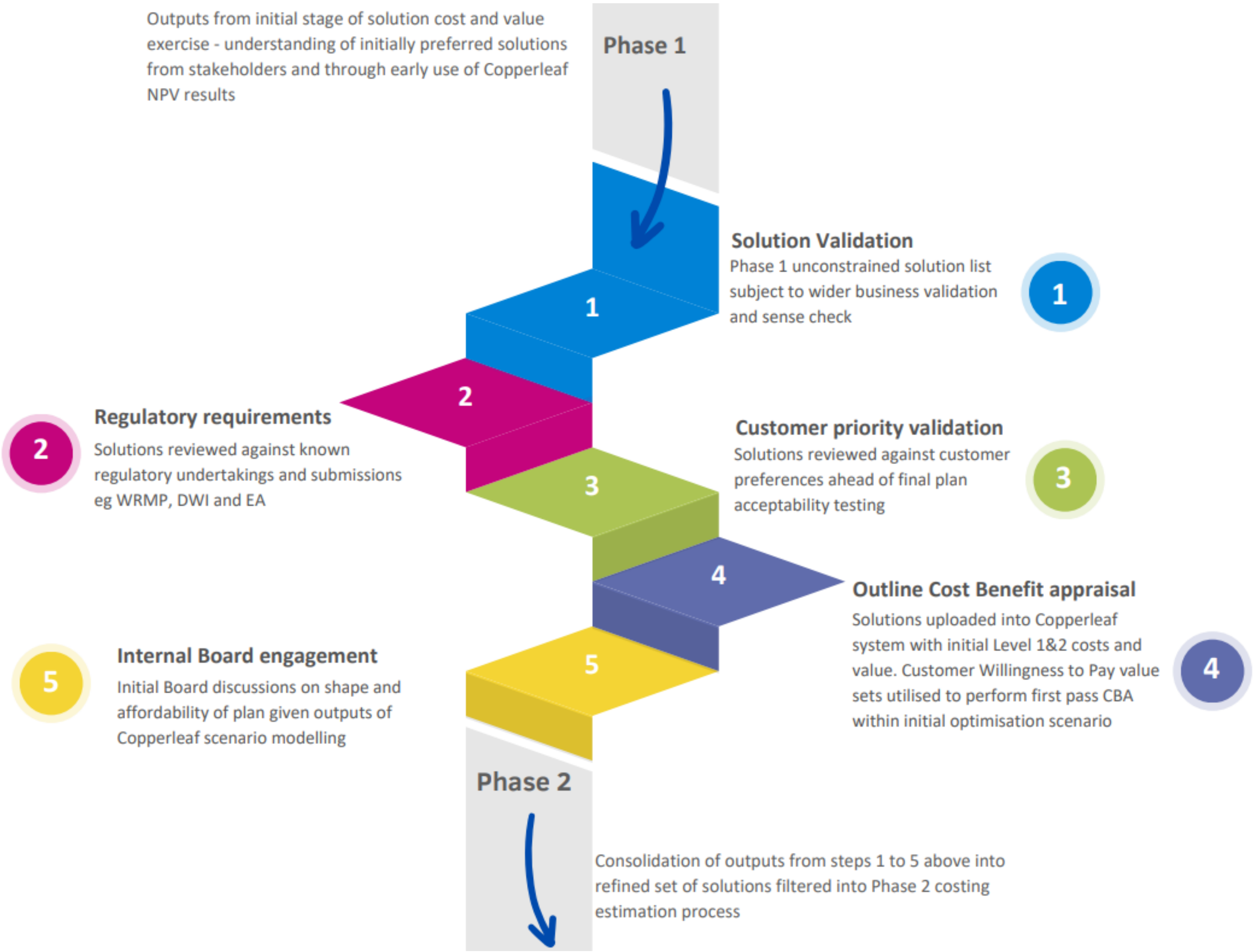


Figure 34 - our validation process demonstrating the movement from initial outline cost and benefit assessment to detailed assessment in phase 2

3.2 Phase 2 – Scope development and detailed cost appraisal of our investment proposals

Having developed the initial shape of our plan through Phase 1 cost and value estimation, and having subjected the plan to validation as outlined in **figure 34** above, we were then in a position to execute a detailed Phase 2 approach, which built on the level of detail around our set of filtered and validated solutions.

Figure 35 steps through this process, developed with Aqua Consulting. Beginning with a refresh of investment need through the use of the PST's with stakeholders, it then steps through solution design, and a longlisting and Multi Criteria Analysis process, before the production of a resulting shortlist. The final steps outline how these shortlisted options are subject to a Level 3 costing effort with increasing scope complexity, following which we have also benchmarked through engagement with Gardiner & Theobald to ensure confidence in our costed programmes.

We were clear in our need for internal assurance and governance through this process in working with third parties supporting the costs and value in our plan.

This took the form of gateway sign off meetings at key milestone stages, with the Asset Management team leading in both this area and also in any Request for Information (RFI) arising through each stage. We also set out clear quality guidelines with our partners to ensure consistency and useability of the cost and value outputs forming a core part of our base and enhancement programmes. Annex 7.2.1 provides details of the Quality Plan process put in place with Aqua consultants demonstrating the overarching process governance and deliverables.

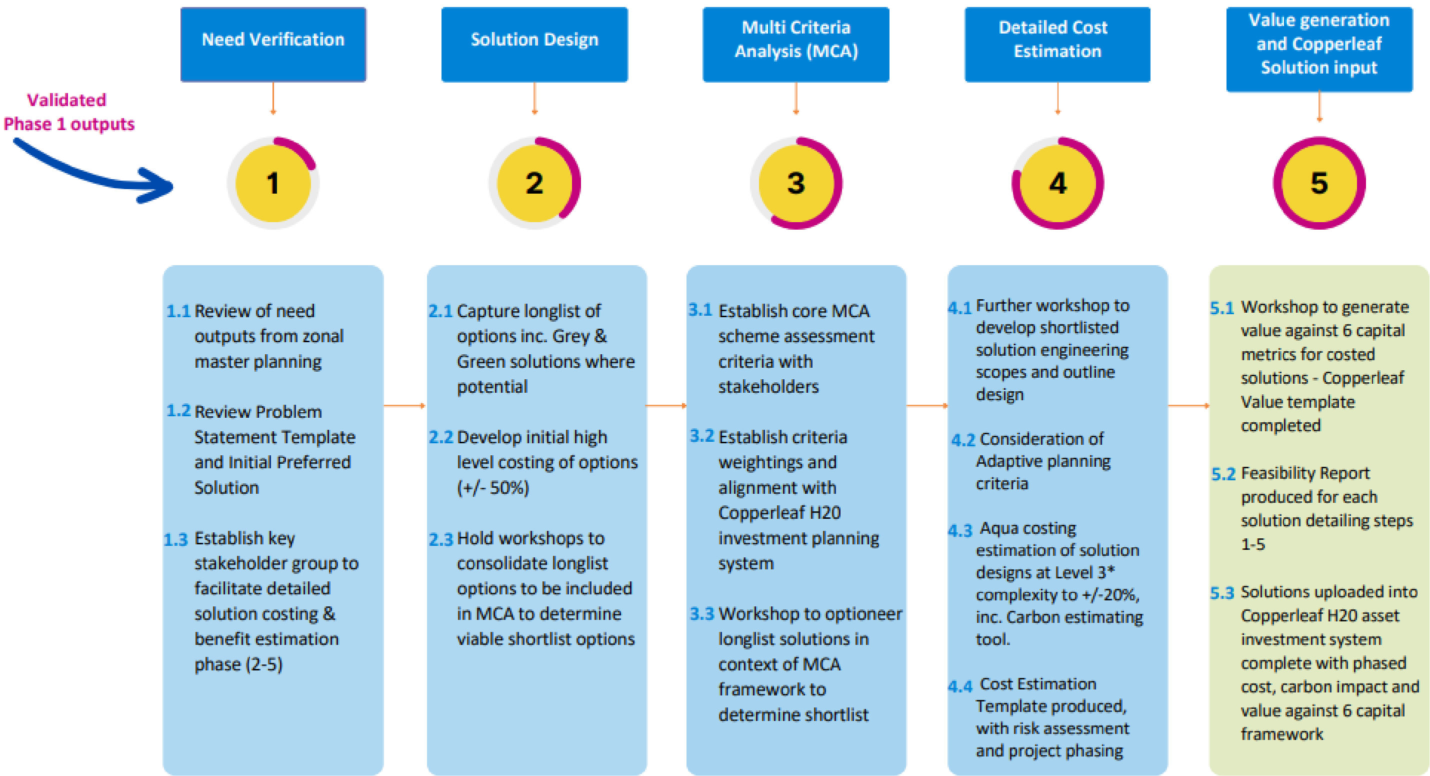


Figure 35, our detailed 'Phase 2' costing process carried out with Aqua Consulting to develop solution scope, cost and value

3.2.1 Long listing and Multi Criteria Analysis in decision making

> Longlisting -
>
> The Green Book, Central Government Guidance On Appraisal And Evaluation, Published by HM Treasury in 2020, states:
>
> 'Longlist refers to the initial, wide set of possible option choices considered in the first stage of appraisal using the options framework filter before selecting the shortlist.'

Both our longlisting and shortlisting processes, highlighted through steps 2-5 in **figure 35** above, adhere to the principles of option appraisal and evaluation in the Governments Green Book. This guidance is also rooted in effective asset management practices around investment planning and decision making, and we set out in the design of our Phase 2 process a longlisting and MCA based selection framework filter that encapsulates these principles to support our decision making.

In conjunction with Aqua, we set out a number of factors for consideration in our longlisting approach, covering steps 2 and 3 in **figure 35**, namely;

1. Constraints and dependencies around the investment need
2. A set of solution categories
3. Agreed MCA solution assessment criteria and associated weighting, aligned with known customer preferences
4. A set of adaptive planning considerations
5. Final sign off process for solutions to proceed to shortlist stage

Following the first step of reviewing the PST documents and establishing a working group of stakeholders relevant to the investment need, the longlisting process began with a high level look at any external constraints and scheme dependencies that may have previously been omitted in option analysis. We considered any regulatory, legal, land rights and wider social acceptability considerations. Further, we took time to understand any potential dependencies that investment solutions may have been subject to, that is, any infrastructure or other investment solution funding that an option is reliant upon to be successful but not necessarily within the control of the solution in question.

Critical to the success of the process was in then obtaining agreement across stakeholders in terms of specific solution categories for considered options, shown below in **table 7**.

Longlist Solution Category
Manage Demand
Manage operation or use of the existing asset or service
Maintain the existing asset or service
Replace the existing asset like for like
Enhance/upgrade the existing asset or service
Mothball/dispose of the existing asset or service
Create/acquire a new asset or service

Table 7 - solution categories utilised for longlisting

3.2.1.1 MCA solution assessment criteria

We also collaboratively agreed the most relevant MCA solution assessment criteria that covered a broad range of factors (**figure 36**) and against which associated weightings were also agreed and applied in terms of their materiality to the outcome of the final score and ranking of a given option.

‘Importantly, we considered customer feedback through our engagement channels in assigning the MCA assessment criteria weighting, ensuring appropriate representation of their preferences in this initial scheme selection phase.’

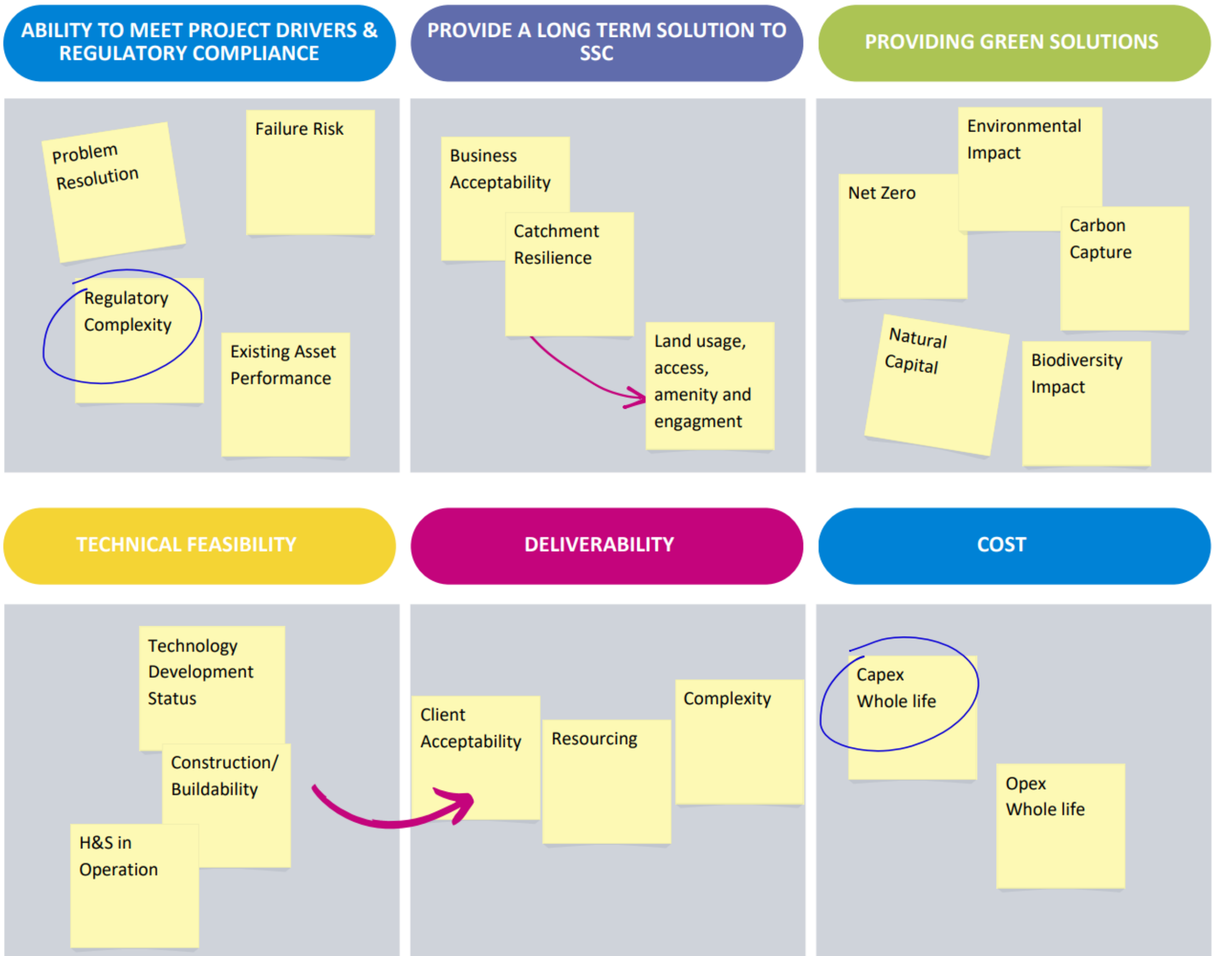


Figure 36 - MCA longlist solution assessment criteria and sub categories utilised for longlisting

The example in **figure 37**, below, illustrates an example of solution assessment criteria and sub criteria in context of the 1-5 scoring framework and allocated weighting of that criteria.

Solutions Criteria	Sub Criteria	Description	Score			Weighting
			1	3	5	
Ability to meet project drivers and regulatory compliance.	Regulatory Complexity	How complex will this option be to regulate as a solution? (e.g. will there be a complex licence/permit).	Higher complexity than current solution	Largely in line with current process	Improvement on current complexity.	35%
	Problem Resolution	Will the option address the obligation identified? How much certainty is there that the option will deliver the benefits required?	Not Certain	Certain	Very Certain	
	Existing asset performance during Construction	How do existing operations maintain performance during construction phase.	Integrated asset requires shutdown, I2S, standby pumping etc	Some dependency on upstream assets	Stand alone asset	
	Failure Risk	Is the option resilient to a range of future external factors/pressures, such as water quality, climate change and political and legislative changes?	Significant risk present	Moderate other risk present	Very Resilient	

Figure 37, example of the scoring matrix within our MCA approach

Table 8, below, outlines the adaptive planning considerations reviewed at longlisting. This grouping and assessment, along with the costs developed through Phase 1 supported a thorough appraisal of the relative merits of each solution ahead of full workshop review against the solution assessment criteria.

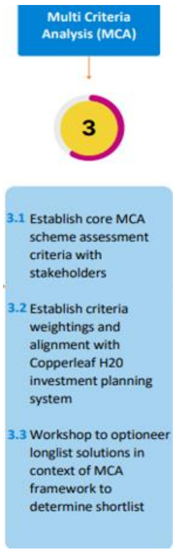
Category	Description
General Site Requirements	Idiosyncrasies of sites that should be considered when planning to design horizon. This can include the process set up, history of assets and performance and other unique factors.
Climate Change	When projecting future demand and requirements, a conservative view should be taken on potential impacts of climate change. E.g. future water shortage, increase flooding etc.
Regulatory Shifts	License and permit conditions and anticipated changes should be incorporated into the design of any treatment or quality scheme.
Demand	Future changes in demand profiles and known/predicted development in the affected area should be incorporated into all design capacity.
Technology	Changes and advancements in technology should be anticipated and incorporated into asset selections and comparisons.
Unique Regional Factors	Conditions and variables unique to the South Staffordshire should be factored into all detailed solutions, taking into account regional conditions. E.g. industrial legacy, Cambridge Water.

Table 8 - adaptive planning considerations at longlisting

3.2.1.2 MCA scheme selection process

With a defined MCA framework in place, stakeholders were then encouraged to think broadly in determining the full longlists of options associated with the investment need.

With Phase 1 costs also in place, and weightings of MCA assessment categories agreed, stakeholders were sent information packs to reinforce the longlisted options and produce individual rankings against assessment criteria. Following this, a workshop was carried out for each investment need, and relative scoring agreed for each solution against the assessment categories in **figure 35**.



Adaptive planning factors and carbon impacts were also considered in addition to the scores, before a ranking was produced, and collaboratively agreed selections for shortlisting as outlined in **figure 38**, below.

This process was carried out across all investment needs and incorporating all of the longlisted solutions generated through our master planning process.

Shortlisted schemes then proceeded through the Phase 2 detailed solution and costing process as shown in **step 5 of figure 35**.

	Technically Feasibility			Deliverability			Cost		Total Weighted Score	Ranking	Selected For Shortlist Solution
	Technology Development Status	Construction/ Buildability	H&S in Operation	Client Acceptability	Resourcing	Complexity	Capex	Opex			
Option Description/ Weight		0.15			0.10		0.10				
Do Nothing	3.00	3.00	3.00	1.00	5.00	5.00	5.00	5.00	2.89	5	
New Duty/Standby Low-Pressure UV	5.00	5.00	4.50	5.00	5.00	4.00	4.00	3.00	3.91	1	Y
New Duty/Standby Medium-Pressure UV	5.00	5.00	4.00	5.00	5.00	4.00	3.50	2.00	3.81	3	
New Duty/Standby LED UV	3.00	5.00	5.00	5.00	4.00	4.00	3.50	4.00	3.85	2	Y
New Duty/Standby Ozone System	5.00	4.00	4.00	3.00	3.00	3.00	2.00	2.00	3.47	4	

Figure 38 – example of scored MCA criteria and weighted score for shortlist decision-making

3.2.2 Costing of our shortlisted options

Whilst the Phase 2 costing process is clear in its objective to develop maturity in solution design and scope as far as is practicable, we also recognise that many of the projects contained within our proposed programme are in the early stages of the project life cycle, with detailed design information, surveys and investigations still to be carried out. We took the decision to engage directly with an engineering consultancy to ensure options and costs could be developed robustly and efficiently using mature costing models and external expertise. We also benchmarked costs generated to establish confidence in the shortlist costing estimation outputs – this benchmarking process is outlined in section 3.2.2.3.

So we appointed Aqua Consultants to lead on our Phase 2 shortlist costing estimation process, who used a parametric cost modelled approach supported by bottom-up costing where it was not possible to use a modelled approach. Aqua consultants have a wealth of data in databases that consist of actual outturn costs within the water industry that inform their cost models. Where necessary, third party companies were consulted to get exact quotations for bespoke equipment or solutions. Aqua have also been involved in benchmarking exercises for Ofwat in previous work they have completed.

Parametric cost modelling is a widely recognised approach within the water Industry to enable companies to price their capital investment programmes as part of Price Review submissions. Where we have identified specific asset interventions for AMP7 and there is relevant historical cost information for delivering similar work, this was used this to cost individual projects within the business plan. Many of the assets delivered across the sector are similar and therefore it is appropriate to utilise this approach at the early stages of a project. It is understood that this approach is not be appropriate for all items of work, and this is where a bottom-up approach was used. This is based on using standard estimating principles, quantifying work and applying framework rates or labour plant and material rates, to calculate the cost of the works items.

We costed the works under three cost headings, with an objective in our shortlisting of achieving +/-20% accuracy on our costing estimation outputs:

- **Direct Works Costs** - The construction works in providing new assets, upgrading, modifying and repairing existing assets. This includes the labour, plant, equipment and materials.

- **Indirect Costs** - The construction indirect costs are associated with the direct construction works, which do not form part of the works or service. These costs include the following:

    - Preliminary / General Items – Mobilisation, Site Compound, Site Accommodation, Site Storage, General Site Plant not included in Direct Works, temporary Works, Investigations and testing & commissioning.

    - Contractors Project/Construction Management – Project Management Pre and Post Construction, Costs associated with CDM, Site Supervision, Site Security, Training, Public Liaison, Instrumentation and Setting Out.

    - Contractor's Risk – Risk owned by the contractor.

    - Contractor's Design – Design work carried out by the contractor, investigations and surveys at feasibility, outline and detailed design.

- **Project Costs** – Costs outside of the Construction contracts, including consultant fees, project management, client overheads, legal costs, associated operations costs and corporate overheads.

Direct Works

Parametric cost models were used for direct works, for similar comparable work across the water industry. Taking actual historical project cost data, they assign to assets to form a costed work breakdown structure, and capture against a given yardstick. The yardstick is decided based on the most influential size factor that decides the overall cost of that asset. Aqua then used cost data from experience across the water industry, without exclusion for regional variance, as the costs for direct works are comparable. These costs are updated to a common date, 2022/2023, using CPIH, as advised by Ofwat in PR24 as the best indices to reflect inflation in the water industry. The costs for each asset are plotted against the assigned yardstick to generate a trendline formula. It is this formula that is used to estimate the project costs, where the project scope identified the yardstick value for the assets for construction.

Aqua use cost data from across the UK and from AMP4 up to and including AMP7. When revising their cost models, they review data from over 5 years. If the older data does not fall in line with the recent cost data after adjustment for date, then this is excluded from the parametric cost model. The data includes both large and smaller water company costs which reflects the different scale of work seen across the industry.

Indirect Cost

Indirect costs are split from the direct works costs in our estimation breakdown, as these are generally influenced by the amount of direct works being carried out. This results in larger, more complex schemes allocated a lower proportion of indirect works costs, than that of a smaller scheme. Aqua advised that a modelled percentage increase on direct costs to elicit a more accurate indirect cost was the most accurate approach to take, reflecting their industry experience on direct and indirect cost splits across varying scales of scheme.

For our PR24 Costing Aqua developed different modelled indirect cost percentage for infrastructure and non-infrastructure as their indirect costs are very different between the two workstreams. This allowed for the adjustment of oncosts depending on the value of direct works costs. It was appropriate to used different indirect cost percentages for infrastructure and non-infrastructure work for various reasons, such as the site set up and project commencement on a treatment works being wholly different to that on the distribution network for example, or that contractor design is carried out on a different scale and that contractor management and supervision can be variable within specific working areas.

To develop the indirect models, the direct works costs for projects in each work stream were plotted against their indirect cost percentages. A trendline formula was produced and used to make the indirect cost allowance in our PR24 project costing.

There can be variances in these percentages between water companies as this would depend on the allocation of costs in Direct Works and Indirect Works. For this reason, the indirect works cost percentages become specific to the direct works cost models, and if we were to adjust one, it is likely to have an impact on the other. We had considered combining these however, this would not allow us to make adjustment for the size of projects.

Project Oncosts

A flat percentage of 14% was used for the Project Oncosts allowance in our estimate, again through consultation and agreement with Aqua. Internally benchmarked against our average oncost actual spends within our historical delivery costs and captured within our Oracle accounting system, we verified an acceptable oncost percentage to be applied by Aqua, appropriate to our size and structure, and efficiency targets. We have centralised overheads and own work capitalised costs into our programme in this way to ensure consistency in approach and to support an ongoing understanding of the expenditure required to deliver our proposed programme.

An example of Aqua's Cost Estimation Template (CET) outputs can be seen in Annex 7.2.4, evidencing how we captured the above costs for use against our shortlisted options.

Opex, Carbon and Whole Life costing

The Opex models utilised as part of the Phase 2 costing process have been produced in line with the Capex models and will calculate the change in OPEX costs that the scheme will deliver. Aqua industry benchmarked Opex costs were applied as the relative change in Opex delivered by the solution. This was captured across the following categories;

- Chemicals
- Labour
- Maintenance
- Power
- Rent & Rates
- Other Opex

Consistency checks were made across our base and enhancement investments were carried out internally, along with a benchmark against those costs held within our Oracle accounting system for similar investment types.

The Phase 2 detailed estimations also included the generation of operational carbon impacts of the schemes being appraised, modelled through Aqua's carbon estimating tool based on their reference database of known actual project carbon achievements for similar asset types.

To complete the costing assessment, and ensure readiness for inclusion within the CBA approach within Copperleaf H20, we captured whole life costs across our base and enhancement programmes based on asset life and established maintenance and replacement periods. Where possible we performed consistency checks against our non-infrastructure model outputs (section 1.6.2) to support accuracy in whole life costing.

Category	Cost (£k)				
CAPEX Direct Costs*	1,110.50				
Change in Annual OPEX Cost	163.85				
Project Cost Profile**	Year 1	Year 2	Year 3	Year 4	Year 5
	222.10	888.40			
Project Start Year (where available)	25-Apr				
Whole Life Cost ***	1,496.85				
Benefit to Cost Ratio	21.47				

Table 9 – example summary table of Phase 2 Totex outputs

Governance

Both Phase 1 and Phase 2 included all completed estimates being checked and approved internally before issue to the Solution Development Team. These estimates went through a further checking process before options went into the selection process. We also set out clear quality guidelines with our partners to ensure consistency and useability of the cost and value outputs forming a core part of our base and enhancement programmes. Annex 7.2.1 provides details of the Quality Plan put in place with Aqua consultants demonstrating the overarching process governance and deliverables.

Aqua Consultants undertake various project benchmarking exercise for a number of water companies throughout the AMP, and their cost data is regularly checked against the industry, which allows them to review and adjust their models where necessary. In our extensive engagement with Aqua, we have ensured that the costs underpinning our plan are robust. We have done this by using the most detailed costing approaches outlined above with the highest level of certainty for our most complex and material investments – this includes, in particular, our enhancement spend. For our more 'business as usual' activity (our base maintenance spend), where the costs are less material in the context of our overall expenditure, we have tended towards using the costs of recently purchased or undertaken works and modelled costs. This has given us a level of certainty in our costs that is aligned with the level of complexity and risk associated with our investments. We assigned cost confidence grades to all investment needs and solutions to ensure we could quantify the levels of uncertainty in our investment optimisation outputs

3.2.2.1 Solution cost risk

Risk was appraised for each shortlisted solution in terms of general delivery site based risk and then specific known risks around the solution being developed, factoring in an optimism bias in acknowledging the HM Treasury Green Book guidance in assigning a project risk allocation.

Figure 39, below, provides evidence of the former, with a detailed risk component breakdown carried out for all shortlisted projects as part of the overall solution cost estimation. A RAG process was used during the shortlisting workshop stage, drawing on information gained through solution scope maturation, directly from stakeholders in these sessions, and also from detail captured through the earlier PST development phase, for example from site schematics highlighting complexity of proposed delivery sites and associated technical risk items..

	Option 1		Option 2
Possible Delivery Risks / Areas of Uncertainty (All Asset Types)	Upsize Exisitng x-connections	*Justification (med/High)*	Lay new 400mm pipe
Contaminated land	Low		Low
SSSI locations	N/A		N/A
Seasonal habitat removal	N/A		N/A
Low depth of cover / shallow bedrock	Low		Low
Major road closures	Medium	*Road closure req*	Medium
Proximity to sensitive locations limiting access times e.g. schools, hospitals etc.	Low		Medium
Loss of revenue for businesses	Medium	*TM will lead to disruption to businesses*	Medium
Presence of third party utilities, electric, gas, telecoms etc.	High	*Small town roads with extensive utilities*	High
Requirement for river, road or rail crossings	N/A		Medium
Easements	N/A		N/A
Land ownership	N/A		N/A
Land purchase	N/A		N/A
Electricity supplies	N/A		N/A
Construction vehicle access	Medium	*Narrow roads*	Medium
Archaeology	N/A		N/A
Flooding	Medium	*Dependant on time of year*	Medium
Ground conditions	N/A		N/A
Ground slope	N/A		N/A
Security requirements	Medium		Medium
Shut down impacts	High	*shutting the main is not an option*	High
Temporary bypass facilities	Medium	*Required for cross connections*	Medium
Reliance on existing assets (isolation valves, pipework etc.)	Medium	*Existing Valves require testing*	Medium
Seasonal operating windows	Medium	*winter should be avoided due to river levels*	Medium
Constrained space on site	Medium	*work in narrow roads*	Medium
Existing 3rd party utilities / pipelines	N/A		High
Electrical capacity	N/A		N/A
Proximity to stored chemicals COSHH	N/A		N/A
Asbestos in ceilings, tiles and equipment	N/A		N/A
Equipment obsolescence	N/A		N/A
Unseasonal weather	N/A		N/A
Legislative change (interface with adaptive planning criteria)	N/A		N/A
Planning	N/A		N/A
Ground water/proximity to watercourse	Medium	*Unknown at present*	Medium
Abandonment costs	N/A		N/A
Welfare facilities	Medium	*no nearby facilities*	Medium
Interaction with Rail	N/A		N/A
High pressure system	High	*10bar*	High

Figure 39 - an example of the generation of solution risk capture, developed through Phase 2 and reflected in shortlisted cost outputs

3.2.2.2 WRMP and WINEP costing process

We recognise that there are a number of schemes in our proposed enhancement programme that are driven through requirements from both the WRMP and WINEP plans that we are submitting to the EA for investment in AMP8. Need, solution and costing approaches for these schemes are detailed in our appendix, **'SSC36 Evidencing our enhancement expenditure in 2025-2030'.** Within said appendix we draw attention to the following sections that relate to distinct costing approaches used to ensure costing efficiency across these areas;

- **Section 2.1.6** – WRMP Supply investment for Grafham Transfer main. Costed by Atkins using the WRC TR61 costing tool.
- **Section 2.2.6** – WRMP Water Efficiency. Costed by Artesia using a database of benchmarked costs.
- **Section 2.3.5 and 2.3.6** – WRMP Smart Metering. Costed by Artesia and based on current framework contract arrangements and forecast activity in relation to delivering our PCC target.
- **Section 3.1.6** – WINEP programme. A range of activity costed through historical EA restoration cost actuals and existing delivery framework providers.

We have worked with the range of third parties listed above to ensure that consistency in approach is achieved where practicable, and consistency in costing component allocation (for example splits between direct and indirect costs) remain aligned with other cost estimations in our plan.

3.2.2.3 Benchmarking

We appointed Gardiner & Theobald (G&T) to carry out a review of our costing process, with the objective of our engagement being to benchmark the accuracy and reliability of the cost estimates provided by Aqua Consulting across a representative sample of our key base and enhancement schemes. The process set out by G&T is set out below in figure 40, covering four defined stages in building up an assessment to support a benchmarked cost.

Figure 40 Gardiner & Theobald cost benchmarking process

An example of some of the cost benchmarking outputs are shown in **figure 41** below. These point to a positive reconciliation against shortlisted costs, providing confidence in our submitted efficient and accurate costs.

SCHEME SUMMARY

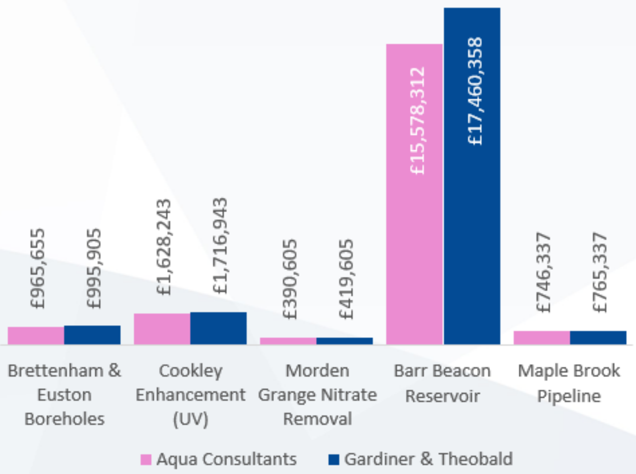
RAG Breakdown:

- **Blue** – No action required
- **Green** – Minor recommendations to be incorporated (within +/-5%)
- **Amber** – Moderate recommendations to incorporated (within +/-10%)
- **Red** – Action required (above +/-10%)

Scheme Name	Overall Status	Benchmarking Variance (%)
Brettenham & Euston Boreholes	Green	3%
Cookley Enhancement (UV)	Green	5%
Morden Grange Nitrate Removal	Amber	7%
Barr Beacon Reservoir	Red	12%
Maple Brook Pipeline	Green	3%

** Benchmark variance is the difference between Aqua Consultants cost estimate and G&T comparative estimate.

Cost estimate benchmarking (excluding contingency)



- Brettenham & Euston Boreholes: (+) £30,250
- Cookley Enhancement (UV): (+) £88,700
- Morden Grange Nitrate Removal: (+) £29,000
- Barr Beacon Reservoir: (+) £1,882,046
- Maple Brook Pipeline: (+) £19,000

Figure 41 an example of cost benchmarking outputs for some of the shortlisted schemes in our plan

Gardiner & Theobald summary findings from benchmark exercise -

Methodology and Process: The estimating methodologies and processes employed by Aqua Consultants are in line with industry best practices and standards. They demonstrate a systematic approach to cost estimation at project feasibility. However, further development of the solution would aid cost certainty.

Data Sources and Assumptions: The data sources and assumptions used in the estimates have been appropriately documented and appear reasonable based on the available information.

Comparison with Historical Data/Industry Benchmarks: The estimates have been compared to historical project data and industry benchmarks, and they generally align well with historical trends and industry norms. However, given the current market trends it is recommended that further supply chain engagement is undertaken to improve cost certainty.

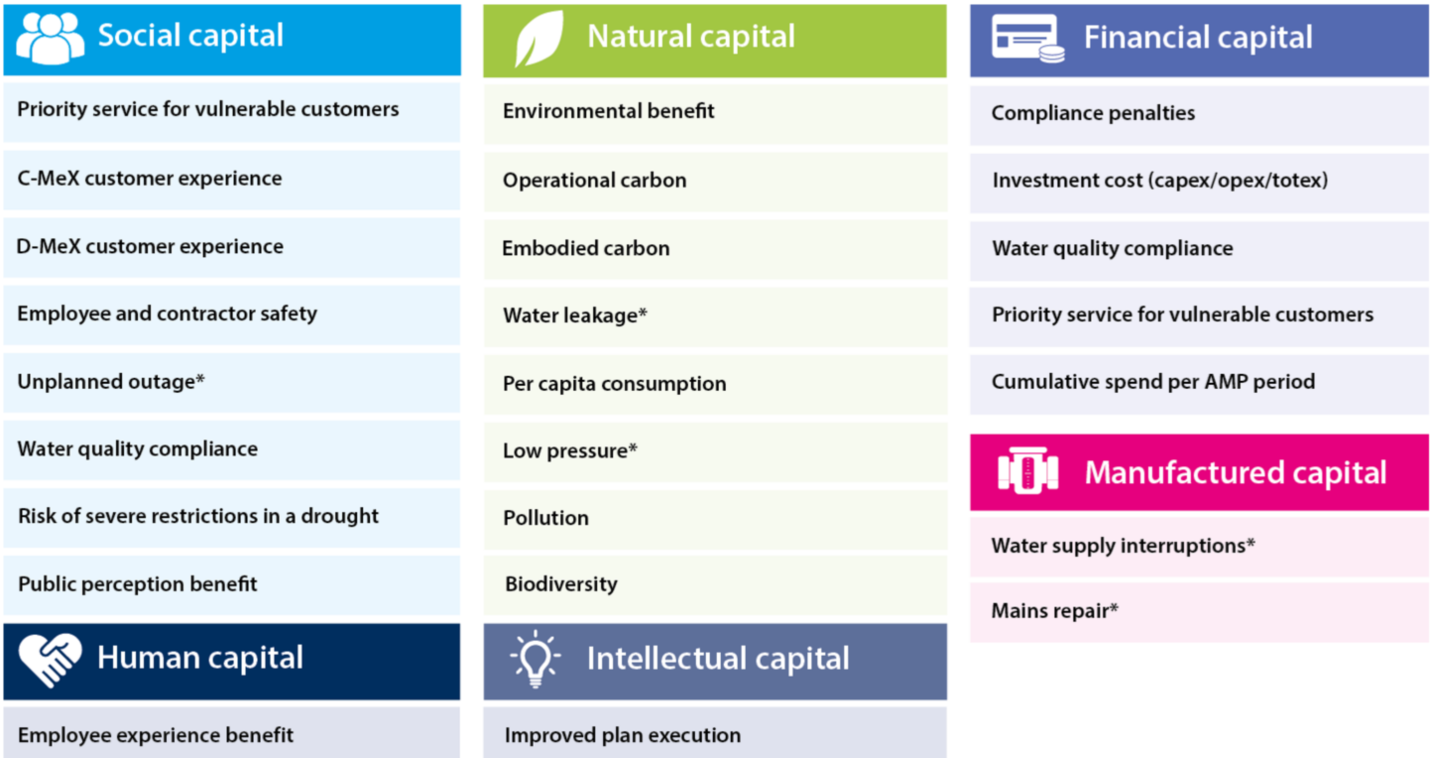
Uncertainty Documentation: G&T has adequately documented uncertainties associated with the estimates, providing a transparent view of potential risks.

Updates and Changes: Any updates or changes made to the estimates during the project's development phase were well-documented and justifiable.

3.2.3 Investment value and alignment with customer priorities

3.2.3.1 Understanding value in our plan

Having outlined our approach to solution development and costing throughout this section, we set out in this section how we have made a step change in AMP7 and at PR24 in terms of our ability to understand value in our investment proposals and their relative impact upon our Performance Commitment targets. And we do this through our Six Capitals value framework that allows us the ability to define value in a way that is bespoke to us and aligned with what we know our customers want to see from our investment planning. All stages of our business planning process have been aligned to this framework, allowing us to compare the relative benefits of risks, needs, schemes, and projects across a consistent platform.



Our Capitals value framework, aligned with our Performance Commitments for AMP8

In establishing our Six Capitals framework, we had four key principles in mind, drawing on learnings from recent AMPs, and enabling us to;

- create consistent valuations and centralised management of the capital allocation and asset management functions of our business;
- improve communication between our operations and asset management teams to help the business understand which investments have been taken forward and why;
- strengthen our understanding of the link between PC's, ODI's and investment plans;
- allow both Price Review and in-period investment programme management, enabling investment decisions to be tracked and updated, meaning our decision-making is more agile

These measures were directly informed by our customer engagement research and Willingness to Pay (WtP) studies. The generation of a well understood value framework adheres to the UKWIR 'Common Framework best practice for capital maintenance planning' and the subsequent 'UKWIR Framework for expenditure decision-making' in justifying Totex funding requirements. That is, founded on risk-based principles so that capital maintenance is justified on the current and future probability of asset failure and the resultant consequences for customers, the environment and water service providers, including the costs arising.

To define value, for every solution we enter into Copperleaf, we appraise a pre-investment and post-investment position for both Totex costs and service benefits, against one or more of the Six Capitals utilising a series of questionnaires and modelled inputs. Each of the Six Capitals contains specific value models which require differing types of inputs to enable the calculation of value over time.

The pre-investment position provides an assessment of the risk to service prior to the investment, representing the level of service risk that the business will be exposed to if the proactive investment does not go ahead. It also takes into account the fact that should asset failures occur, then the asset will never remain in a failed state and that some remedial action (usually Opex) will be undertaken to restore the asset to service within a reasonable time frame.

The post investment position provides an assessment of the residual risk to service once the investment has been undertaken.

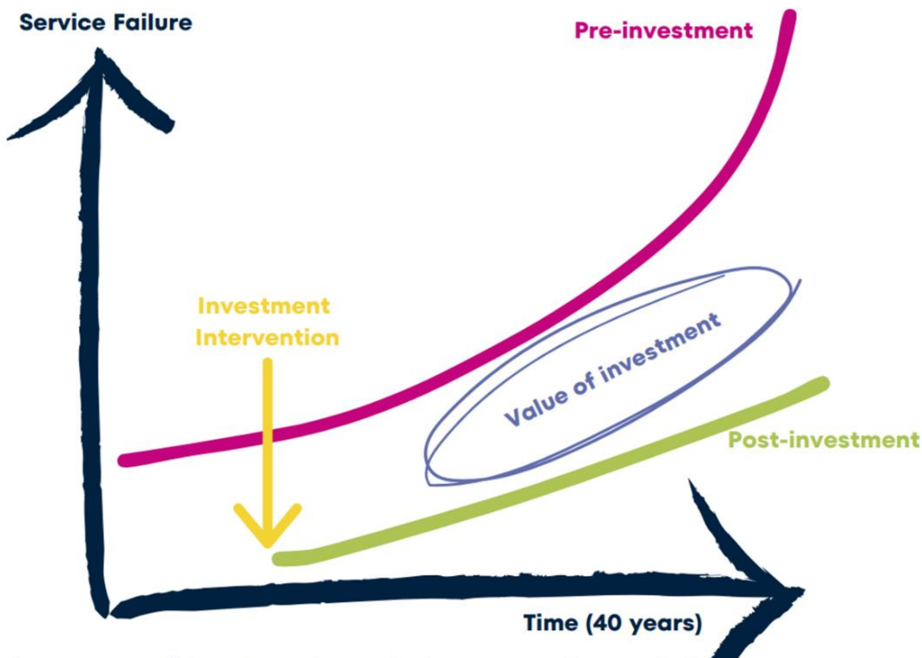


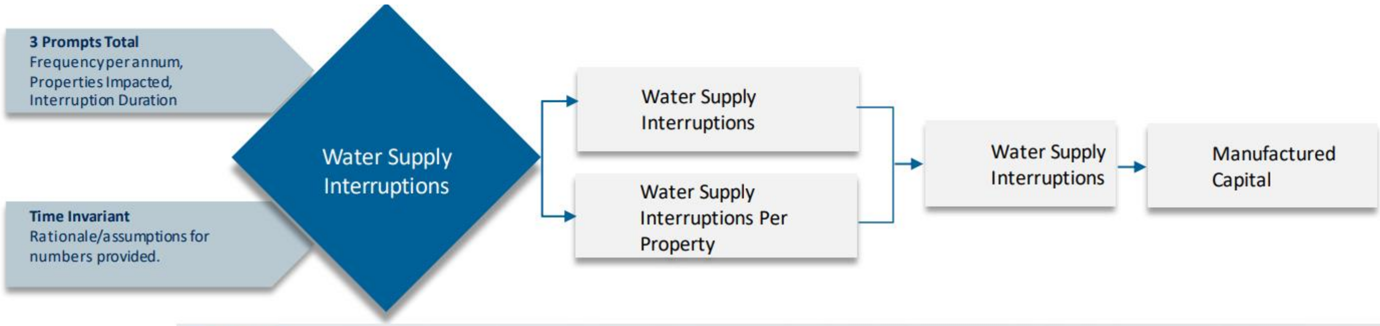
Figure 42 – quantifying value against service improvements in Copperleaf

Figure 42 illustrates the effective value function principle with which we quantify value within each value model of each of the Six Capitals.

Through the implementation period at PR24, we took the decision to enhance our value framework to ensure the inclusion of three new models - Pollution, Flooding and Biodiversity - within our Natural Capital value range. This was done following customer engagement around priority investment areas and also with an understanding of Ofwat's common PC framework requirements. The Six Capitals framework has been a step change in our ability to define value compared to our PR19 framework, in the breadth of value models and in its simplicity of use and understanding. And we have been able to better engage stakeholders through its use in promoting the understanding of value in our process and the materiality of work they have been involved in to support the risk and modelling input that feeds into the value assessments.

With a comprehensive framework in place, and the rich depth of data secured through our risk elicitation and modelling outputs aligned with the framework, we were in a strong position of being to add value to our costed shortlist investments from Phase 2 of the costing estimation process. Each value model within the Six Capitals required a defined type of input through questionnaires and modelled inputs to generate the value profile in the system.

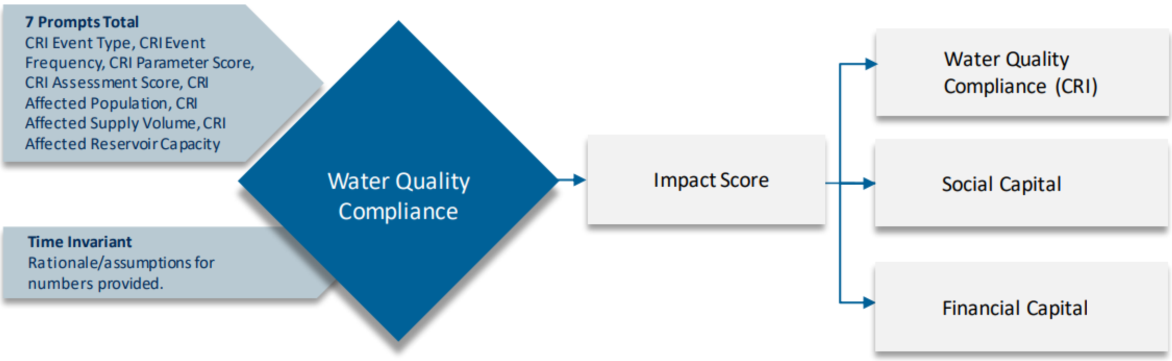
Figure 43 provides two examples of the inputs required to generate value against a number of the Capitals in our framework through the use of the water supply interruptions and water quality compliance value models.



Summary

Estimated reduction in outage time per incident based on the category of interruption. Only makes an impact if the outage is estimated to be greater than 3 hours.

- Model Inputs: System, Questionnaire Prompts, Value Measures
- The Model Outputs: Water Supply Interruptions, Water Supply Interruptions Per Property, Water Supply Interruptions Societal and Private (S&P), Manufactured Capital



Summary

Water Quality Compliance measures the Reduction of instances of Drinking Water Inspectorate (DWI) noncompliance in water supply zones, supply points and treatment works, and Service Reservoirs.

- Model Inputs: System, Questionnaire Prompts, Value Measures
- The Model Outputs: Impact Score, Water Quality Compliance (CRI), Social Capital, Financial Capital

Figure 43 – two examples of the inputs required to generate value against the Capitals

3.2.3.2 Governance around value inputs

We wanted to apply the same level of governance to the value we have generated within Copperleaf as that we applied to our solution development and costing processes. So, we identified several areas to ensure a level of tracking, monitoring and validation of our base data and associated assumptions around forecast deterioration and improvements in the system. We knew where modelled inputs were concerned, such those from our resilience and asset deterioration modelling (sections 1.5 and 1.6), there was an existing level of rigour in outputs used in the system. However, where value was being generated through other sources we followed the following principles;

- using historical levels of service to help us define our pre-investment decisions;
- working closely with internal investment owners of WRMP and renewable energy investments to understand the benefits generated by appointed consultants Atkins, Artesia and Aqua respectively
- internally and externally (Jacobs) assured assumptions and approach;
- using our document management system and Copperleaf investment manager to ensure consistency of data;
- engaging with our Board, taking into account their challenges and objectives;
- engaging with the customer panel representatives, taking into account its input and challenge

3.2.3.3 Monetisation of value

Having defined service impacts over time, we then looked to our valuation set to monetise the benefit of each scheme in order to allow us to begin to confidently start our scheme and programme optimisation founded on CBA principles. The valuation set consists of;

- **Willingness to Pay (WtP)** - the value that customers place on that service improvement e.g. an improved performance in the likelihood of experiencing discolouration or a supply interruption. Section 3.2.3.4 and 3.2.3.5 provide detail around the extensive customer engagement and data point triangulation processes that have ensured our WtP data sets are robust and representative
- **Social / environmental** - the value to society or to the environment of that service improvement e.g. a pollution incident or traffic disruption
- **Private costs of service** - those cost avoided by the business due to the mitigation of service failures e.g. handling customer contacts or issuing boil water notices

Figure 44, below, shows a case study of a proposed network investment demonstrating input value against three value models, and associated whole life benefit, monetised through the costs in the valuation set described above.

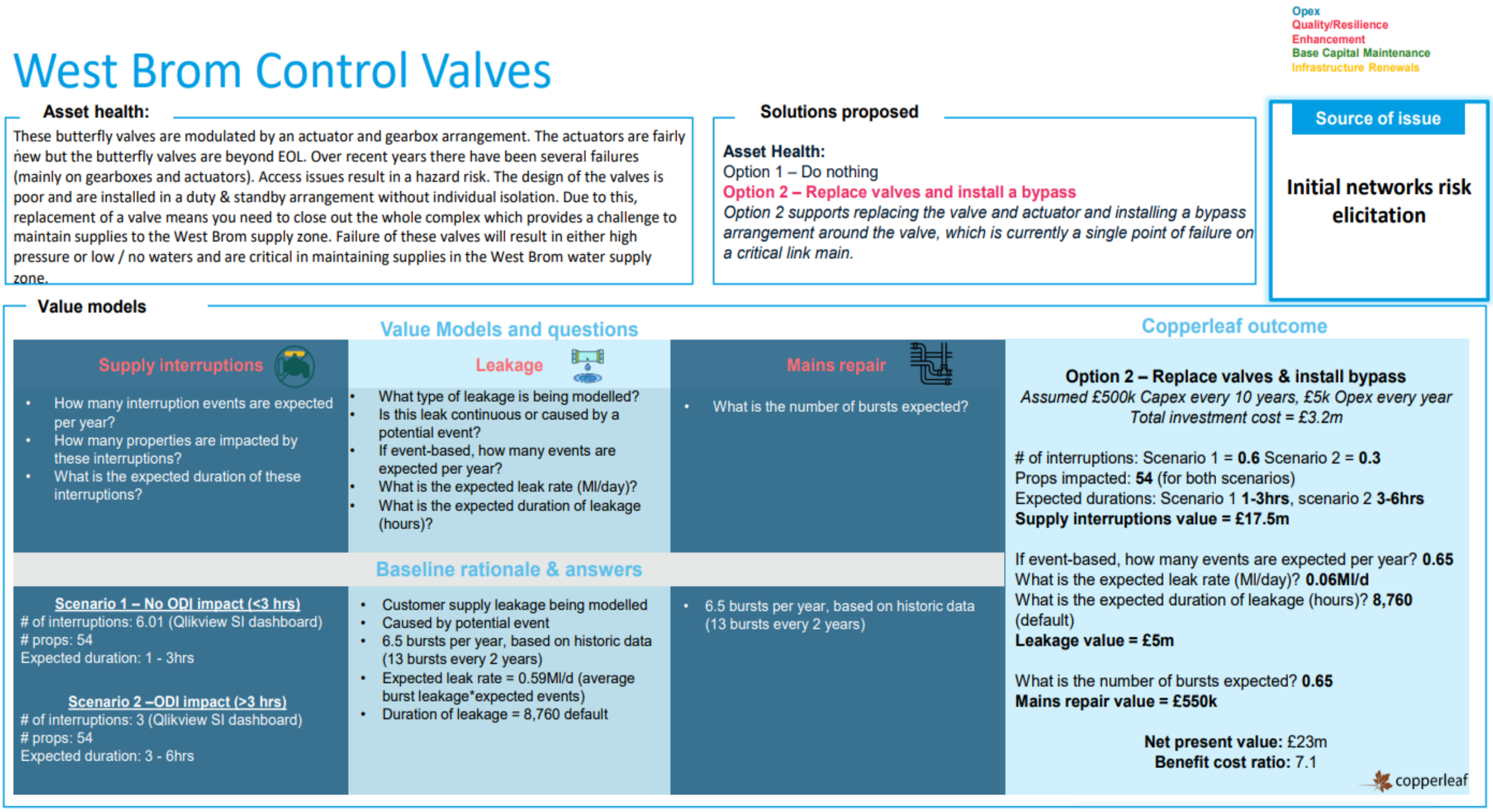
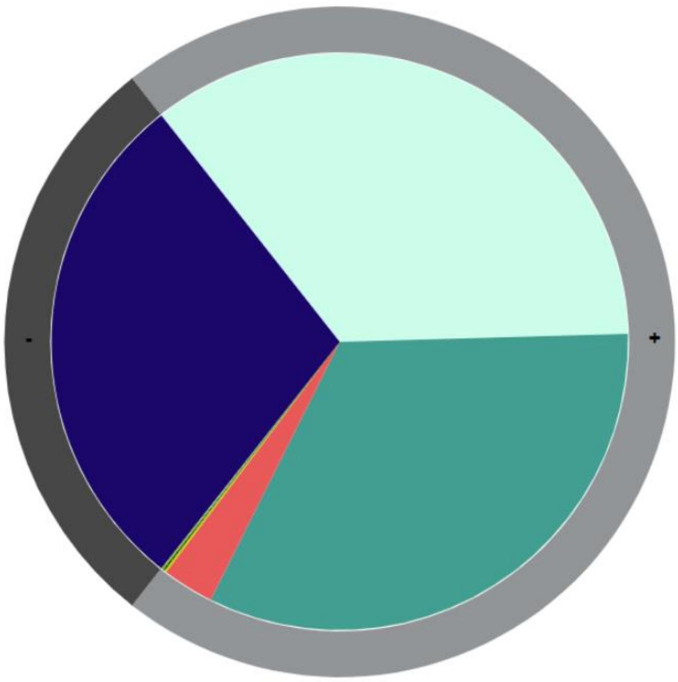


Figure 44 – an example of the valuation of a proposed network investment schemes using the Six Capitals framework

In summary, our Six Capitals framework has allowed consistent and objective definitions of value against our investment solutions, including the probability and timing of achieving benefits in relation to the critical risks we have escalated through our planning process.

Visualisation and understanding of calculated benefit has been key in gaining agreement around our plan composition, supporting clarity in our decision making in our investment optimisation process, particularly in light of the alignment with our PC's.

Value Models | Questionnaires | Risks Chart | Value Chart | Forecast Chart



Draft Investment Value
Smart water system trial

Value Measure	Value
Financial, Legal and Reputational Risk	3,351,095
Number of Bursts - Private	274,546
Number of Bursts - Societal	0
Operational Carbon Cost - Private	7,596
Operational Carbon Cost - Societal	5,611
PCC Reduction Risk Cost - Private	12,829
PCC Reduction Risk Cost - Societal	0
Safety Risk - Private	6,513
Total Investment Cost	-2,740,618
Water Supply Interruptions - Private	3,128,918
Water Supply Interruptions - Societal	0
Total	4,046,491

Figure 45 – an example of the valuation of a proposed network investment schemes using the Six Capitals framework

Sections 4 and 6 provide further information on how we combine our cost and value data and use within an investment optimisation and programme management environments, touching on innovative functionality we have developed around Copperleaf system to best visualise outputs for best value decision making. We also explain where we are planning to further develop our capability around investment planning with Copperleaf as the central component of an enhanced Asset Management system.

3.2.3.4 Customer priority alignment in our investment decision-making

We evidence through every section of this appendix our commitment to ensuring that customer preference are at the forefront of our thinking in the analysis, tools and engagement we have undertaken to develop our plan.

We use this section to set out how the different strands of customer engagement carried out through both 'business as usual' rolling customer priorities surveys and also PR24 specific workshops have played a significant part in the development of our investment plans. And we build on the understanding of our Six Capitals framework seen in section 3.2.3 to evidence how our triangulated WtP value sets serve to ensure there is a clear customer-driven input to our investment optimisation process.

We have carried out our most extensive customer engagement programme ever to ensure our PR24 and WRMP24 plans are underpinned by robust customer and wider stakeholder preferences. Specifically related to resilience, we see a clear thread from our engagement towards customers (household and non-household) and stakeholders expecting to see investment to ensure a reliable high-quality, affordable service is maintained 24/7. Customers also expect further investment in infrastructure schemes to detect and predict problems and to quickly fix and prevent any failures before their impacts are experienced. A "reliable, high-quality supply" continues to be the number one priority for investment among our customers – as evidenced in our Customer Priorities Tracker, which is a qualitative and quantitative study that has been running since 2020. Our customer engagement appendix, '**SSC07 Customer engagement strategy and key**

insights,’ provides more detail on how this engagement has driven customer priorities that have informed our investment planning.

For detailed customer support evidence as regards our enhancement business cases, please see ‘**SSC36 Evidencing our enhancement expenditure in 2025-2030,’** and specifically subsection 4 of each case. We have aligned our enhancement cases with the clear customer priorities established through our ongoing engagement in AMP7, and that form a core part of our **‘Looking to the Future’** long term vision that we published in November 2022.

3.2.3.5 Willingness to Pay

In aligning serviceability improvements measured through our Six Capitals framework with customers’ willingness to pay for them, the process adheres to the UKWIR Common Framework best practice for capital maintenance planning and the subsequent UKWIR Framework for expenditure decision-making in justifying Totex funding requirements. That is;

..’founded on risk-based principles so that investment is justified on the current and future probability of asset failure and the resultant consequences for customers, the environment and water service providers, including the costs arising.’

Our objective in our use of WtP values in our Copperleaf system at PR24 was to build on the approach we used at PR19, which was extensively peer reviewed and commented on by Ofwat as showing good evidence of triangulation. The main developments were the extension of the criteria by which sources were evaluated and weighted (the ‘RAG’ ratings) and the inclusion of an external ‘expert panel’ (Delphi method). Sources older than six years from PR14, which had featured in PR19, were removed this time around.

Questionnaire attributes, designed for customer engagement, were developed with internal stakeholders and co-created with customers through Qa Research and NERA consulting to ensure elicited responses were relevant and also that the quantitative outputs could be effectively translated into the Six Capitals framework. **Figure 46**, below, shows an example of the specific unit value required for water quality value model in terms of £/Contact.

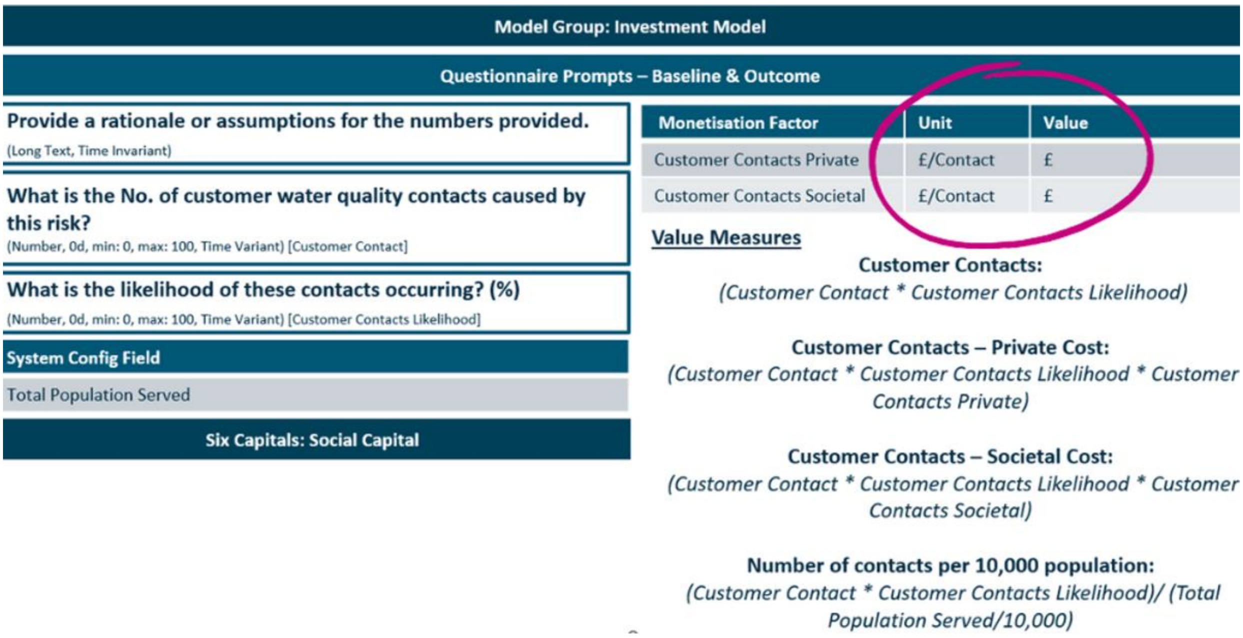


Figure 46 – an example of the Water Quality value model calculations and WtP value assignment in Copperleaf

Section 4.2 describes how we tested the sensitivity around the generated value sets elicited from our customers, and how this informed our decision making around the most appropriate value set to use within Copperleaf in the production of our best value plan for AMP8.

3.2.3.6 Acceptability testing and feedback into our plan

As the understanding of where our best value AMP8 plan and 'low, no regrets' options began to take shape through shortlisted options and initial stages of CBA outputs from Copperleaf (section 4.1), we were able to speak to customers around our specific need challenges. And in doing so, we were able to talk about bill impacts from these early stage outputs across our base and enhancement programmes.

Figure 47 illustrates an example of this engagement, with scheme specific detail arising from where we were seeing the most value at both scheme and portfolio level. Strong support came back to us from customers across these three areas. Resilience in particular was heavily favoured, with a clear recognition of the need to act now to manage our long term resilience and include our best value solutions in the core pathway for AMP8 and through our longer term LTDS planning. **Section 5.4** of our appendix **'SSC02 South Staffordshire Water – long term delivery strategy,'** details the core and adaptive pathways around operational resilience in this context.

Figure 47 – customer engagement on our key themes for AMP8, used to feedback into our final optimisation process

3.2.3.7 Intergenerational resilience

More than ever, we presented the notion of long term uncertainty in our planning to customers, along with regional specific challenges we face in the short term such as our water resource availability in our Cambridge region. We set out throughout this document our commitment to understanding our long term operational resilience strategy, for example through our new zonal resilience modelling **(section 1.5),** zonal masterplanning **(section 2.1 to 2.3)** and in our refreshed Resilience Framework **(see appendix SSC05 Integrated resilience framework).**

And in sharing our resilience investment proposals and understanding their desire for this (as evidenced through both WtP and in qualitative feedback such as in **figure 47**), we looked to understand through focused research how this need should be delivered and paid for over time and across generations.

And we have clearly seen from this engagement that customers prefer an intergenerational fairness in our investment planning. **Figure 48** shows the framework of this discussion with customers, eliciting strong support for 'Option 1 – All generations paying equally.'

Customers have been clear in that they want us to invest in climate change resilience now to mitigate future risks to service, rather than waiting for deterioration to materialise and causing bill shocks for future generations as we recover our position. And this position of wanting a smooth bill profile over time was evident regardless of whether the risk might emerge or not in the future. So we looked again at our resilience options, reviewing cost and value appraisals and ensuring our core pathway options, tested rigorously through zonal resilience models and master planning, were representative of this desire. And we're confident in our AMP8 plans being aligned with this need, delivering our best value options in terms of both scale and timing within our long term core pathway.

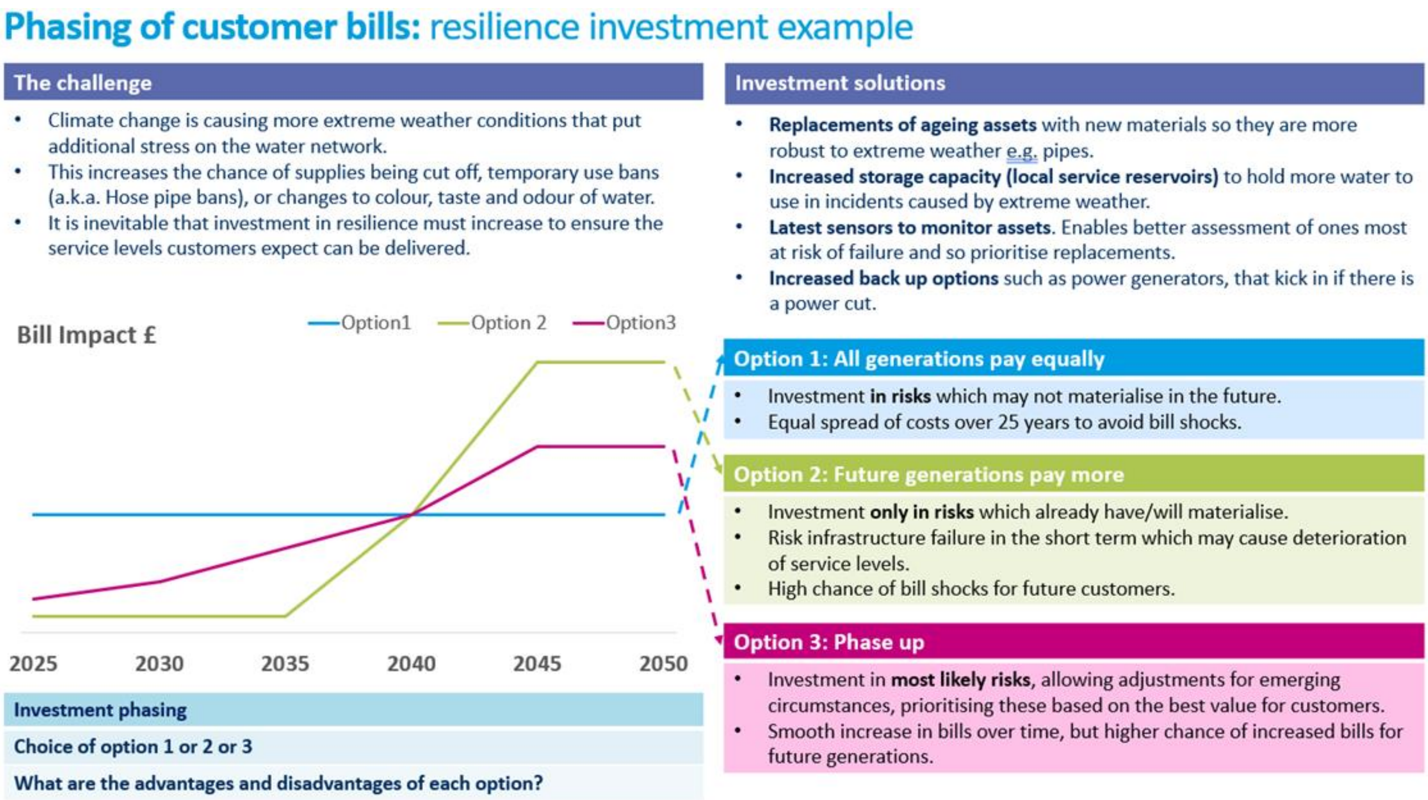
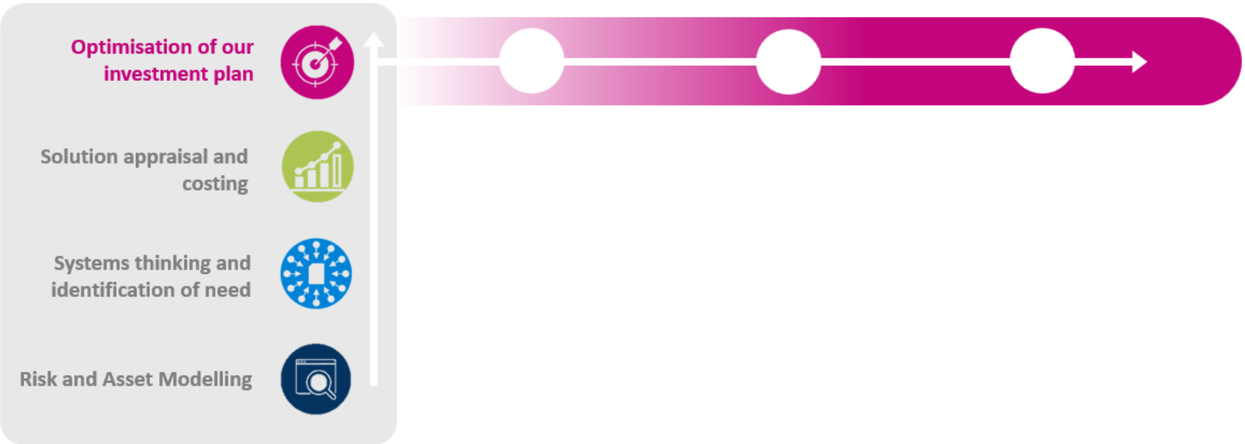


Figure 48 – customer engagement on intergenerational bill impacts

4. Optimisation and sensitivity analysis of our investment plan



We knew that the refreshed approach we have taken in developing our Asset Management approach for PR24 warranted a step change in our investment optimisation functionality. In challenging ourselves to capture and appraise risk, need and solutions with more rigour and depth in the quality of our data, we were clear in our objective in wanting to also update our optimisation capability in tandem.

So we tested the market, and engaged with a number of suppliers and different sector experiences in selecting Copperleaf H20. Our primary focus in its selection has been in our understanding of the importance of a central Asset Investment Planning (AIP) solution to underpin both Price Review and in-period investment optimisation.

And we knew that we wanted to ensure we adopted a balanced and transparent process in generating a final investment programme that visibly and consistently linked our decision making to both customer and strategic business requirements using an approach which balances costs, risks and performance improvements of competing asset interventions. **Table 10**, below, highlights our improved areas of functionality in the implementation of Copperleaf H20 at PR24;

	PR19	PR24
Established valuation framework aligned with capitals thinking	✗	✓
Ability to import outputs of existing SSW infra asset deterioration modelling	✗	✓
ODI targets for South Staff's PC's configured to support multi-constraint optimisation	✗	✓
Community group of WOC/WASC users to support data share and collaboration in approach	✗	✓
Provide greater agility within annual investment programmes to run 'what if' scenario analysis	✗	✓

Table 10 – development in our investment planning capability at PR24

We also knew from our review of existing maturity immediately post PR19, that any investment planning tool we were looking to implement needed to be one that integrates within an embedded Asset Management system. That is, driving continuity and establishment of core processes around our ongoing investment planning cycle. We looked across Asset Management standards in our decision making, to ensure alignment with core competencies of ISO55001 around planning, performance and improvement delivered by an AIP.

The critical needs we are delivering against through our implementation of Copperleaf H20 are shown in **figure 49** below, supporting in-period operating efficiency with our people and in continuing to support achievement of best value investment for customers in the face of reactive requirements we are faced with on an ongoing basis.

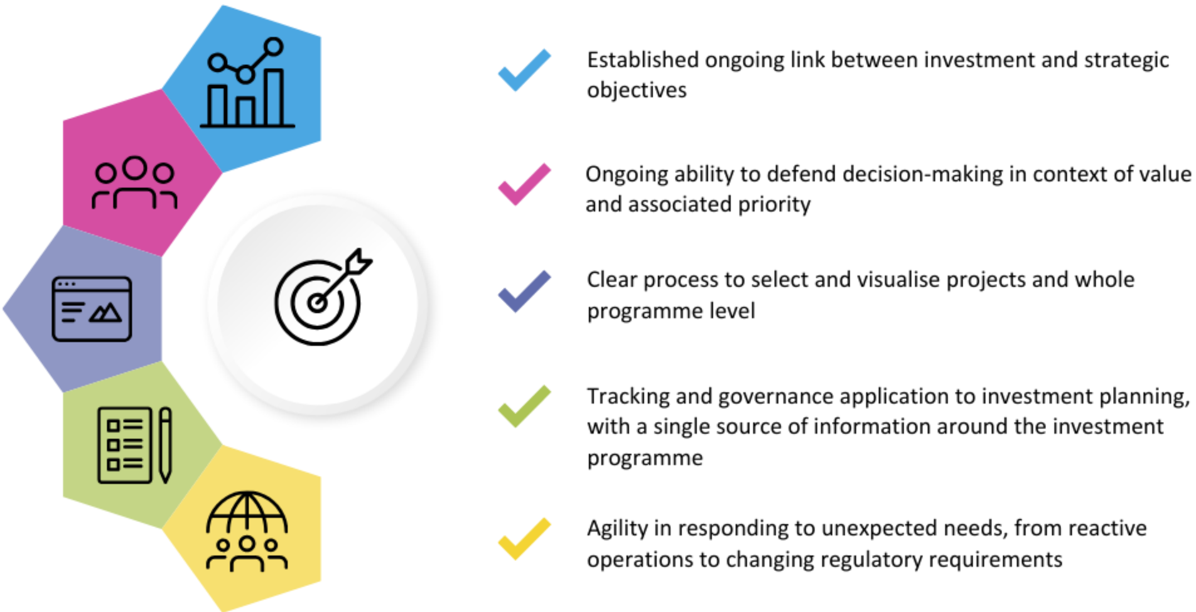
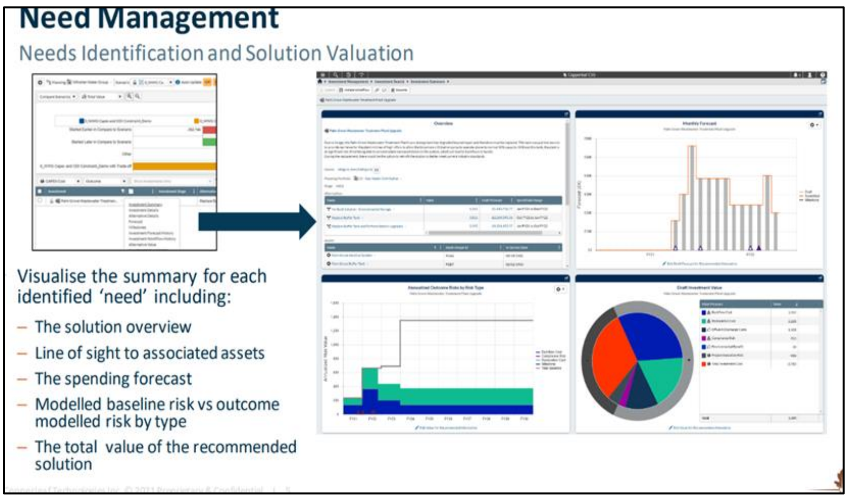


Figure 49 – areas of improvement in our investment planning being delivered against through PR24 and beyond

4.1 Full cost-benefit assessments and portfolio optimisation

Through a robust implementation process across 2021 and 2022, and subsequent period of User Acceptance Testing, we were ready to begin loading our shortlisted solutions for the whole plan into the system, populating cost and value over time (40 years), along with any other information produced during that the stage of the process that improved our assessment.



We were able to quickly visualise all aspects of our investment needs and solutions within Copperleaf, and invested in additional functionality within the system to be able to perform efficient upfront data checks across our entire database, identifying anomalies and resolving early in the process.

Our next step was to perform initial iterations of investment optimisation, founded on the principles of CBA. Copperleaf H20 utilises an optimisation engine to select combinations of investment solutions, attempting to maximise the benefit associated with a chosen investment programme, subject to meeting any cost and performance constraints set. CBA carried out produces a Net Present Value (NPV) associated with each scheme, either positive (where the value of the benefits are greater than the whole life costs) or negative (where the value of the benefit isn't sufficient to match the whole life costs), with the system working to select a combination of investment schemes that produces a plan with the highest net benefit.

Financial parameters within Copperleaf

We have calculated benefits over a 40 year planning horizon from 2025 onwards and as such whole life costs have been forecasted over that period also, with average asset lives having been applied to investments to determine the intervals between repeat CAPEX costs.

The discount rates utilised within Copperleaf system to generate cost and benefit present values are as follows;

Cost forecasts:

- **Weighted Average Cost of Capital (WACC)** = 3.23% applied to our private costs
- **Social Time Preference Rate (STPR)** = 3.50%

Value forecasts:

- **Private** – WACC (3.23%) + STPR (3.50%)
- **WtP** – STPR (Risk to life value) = 1.50%)
- **Societal** – STPR (Risk to life value) = 1.50%)

To generate Cost Present Value we have combined the STPR and WACC rates and applied them to our whole life costs for each investment.

WACC has been applied to benefits associated with private value.

STPR – Risk to Life has been applied to benefits associated with societal value, as defined by HM Treasury Green Book.

Initial optimisation testing and refined solution strategy support

Prior to implementing constraint setting within the optimisation process, we analysed the production of unconstrained plans to identify not only which investments were purely cost-beneficial and should be undertaken, but also which were deemed to be generating unrealistic benefits or incurring inordinately high negative values. This review provided an initial sense check of the assumptions being made within the CBA, enabling further investigation to subject these assumptions to greater scrutiny and provide governance across the whole process.

Establishing confidence in our capability within Copperleaf also supported developing maturity in specific investment strategies, and allowed further informed discussion using outputs from CBA appraisals at scheme level. **Figure 50**, outlines how Copperleaf was used to review and refine thinking around our universal metering strategy, in context of optimal roll out programme durations and region specific decision-making.

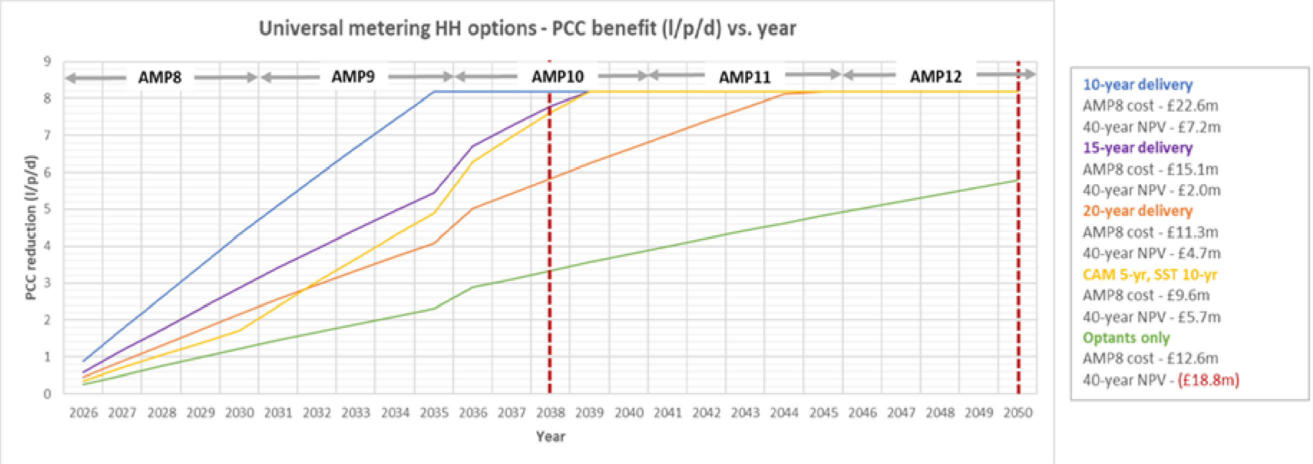
Deep-dive: universal metering rollout for our household customers.

Context

- Metering is likely to be the largest component of our enhancement plan for AMP8.
- The preferred WRMP pathway is to rollout universal metering by 2035 in both regions.
- The primary benefit of investing is PCC reduction, but carbon & energy is also saved.
- We currently have a unit rate for SST (£140), CAM (£168) and an optant rate of £280.
- We are required to hit a PIC of 110 l/p/d by 2050 with an interim target in 2038.

Assumptions

- All options are flat-phased and meters are delivered in equal volumes.
- Optants continues at 9,000 per year for the full time horizon.
- Meter installation provides a 19.5 l/p/d benefit in the year after delivery.
- Tariff introduction occurs in AMP9 and provides an extra 2.7 l/p/d reduction.
- Meter life of 20 years, with re-investment at the same unit rate of £217/meter.



What does it mean for us?

- Metering is a large complex programme foe SST and the sector as a whole. Our WRMP preferred plan requires meters to be rolled out to 287,740 properties by the end of 2035.
- There is some choice around the run rate and region selection with the universal metering programme. Non-household delivers the largest benefit so is preferential within the optimiser.

Figure 50 - an example of scheme level optimisation using the Copperleaf H20 system

4.1.1 Application of portfolio constraints and scenario analysis

Many optimisation scenarios were run throughout and in parallel with the plan development process. These runs improved over time as more detailed information on costs and benefits were received. As a decision support tool, our approach allows us to perform many iterations across a number of different modelling scenarios, using cost and performance constraints that must be met in producing a given investment portfolio. We also set dependencies between investment solutions to ensure logical and realistic outputs of the modelling.

All optimisations runs were presented to the senior leadership team, in particular the best value, least cost and a range of scenarios in between. We analysed a number of different scenarios by changing the constraints and targets set within Copperleaf H20. In the setting of financial and service performance constraints related to our PC's (such as PCC and Unplanned outage) we asked ourselves questions around the affordability of our proposals, and where the optimal balance lay in terms of cost and our PC ambition.

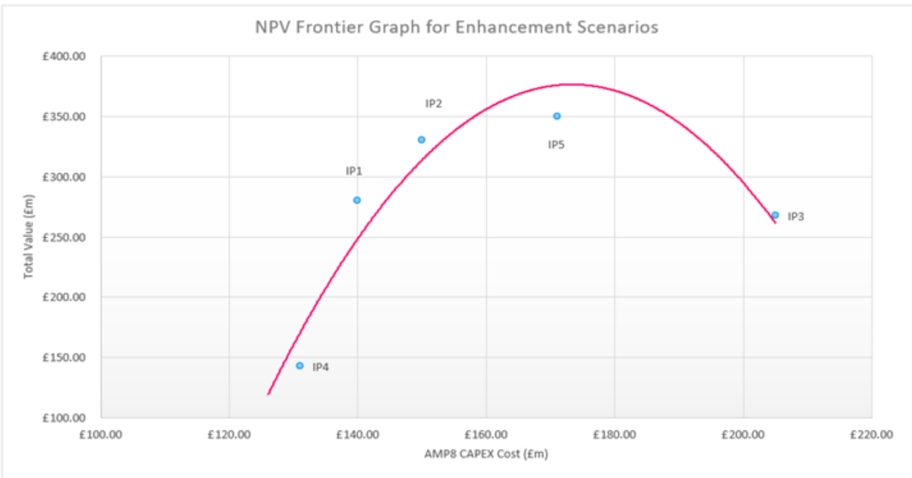
We also looked at annual cost phasing targets in light of securing an efficient delivery profile and in considering the feedback we had from customers around timing of investment across AMPs to support intergenerational fairness in terms of funding a resilient asset base (section 3.2.3.7)

Constraint Type	Benefit
Financial	Determine the optimal plan that delivers the most value for customers without exceeding affordability and financeability constraints
Performance	Determine the optimal plan ensures a specified level of performance (eg. PC and ODI target ambition)

With an iterative scenario modelling approach, we were frequently able to involve key stakeholders, in rigorous testing and review sessions to clearly understand the outputs, and ensure the transparency of our decision making. These reviews included extensive sessions scrutinising the inputs and outputs of the process. In this way, we consider that our final portfolio delivers a good balance between affordability and deliverability. The stakeholder touchpoints outlined in **figure 2** of the introduction of this appendix are examples of where these outputs were discussed through the process.

We provide an example of output optimisation scenarios in **figures 51 and 52**. They depict a range of five enhancement specific scenarios, constrained by varying affordability targets, defined as minimum and maximum Totex spend across the period 2025 to 2030. The Pareto frontier profile in **figure 51** highlights those output portfolios that are showing the optimal balance between cost and value as defined against the Six Capitals value models, described in section 3.2.3.

NPV frontier graph for AMP8 enhancement programme



Key:

Total Value (£m) – value of the investment over a 40-year planning horizon (which includes any re-investment required).

AMP8 capex cost – expenditure required in 2025-2030 to deliver the total 40-year value. This does not show costs beyond 2030, but these don't increase for any investment (only a re-investment based on asset life).

Working from left to right on the curve:

IP4 – Least cost to meet statutory obligations

IP1 – Low affordability constraint

IP2 – Medium affordability constraint

IP5 – Best value with no constraint

IP3 – High affordability constraint

What does it mean for us?

- All portfolios show a positive NPV over the 40-year planning horizon, despite the inclusion of some lower value investments that may not payback.
- The value is includes a mix of benefit type. Some investment will be spend to save, a large portion will be avoidance of future costs being incurred, and others will be to meet a PC.

Figure 51 - an optimum frontier representing the impact of stepped financial constraints upon portfolio composition

The initial steep profile of the curve illustrates the model being able to select from a wide range of solutions that have been assessed as being highly cost beneficial. These investments attract high willingness to pay valuations in terms of their impacts against value models such as water quality, uninterrupted supply of water to customers and leakage reduction. 'Must do' investments, driven by statutory obligations are included at this stage also.

As the model is run again with increased capital expenditure available, we see it begin to select investment solutions that, while having lower NPVs, still bring additional benefit to the portfolio in terms of a positive impact upon the key service measures that drive us in meeting our performance commitments. Solutions selected here move away from being purely least cost and are more centred on improving our resilience across both our above-ground and underground assets.

As the curve begins to descend with capital expenditure above £170m, the model is being forced to bring in those schemes that have a negative NPV – that is, those schemes that are not cost beneficial, thereby impacting adversely on the overall portfolio NPV.

Figure 52, represents this movement along the optimum frontier using some of the key themes of investment proposals in resilience, water quality and WRMP driven schemes. It illustrates the transition of schemes across different planning scenarios, as stepped financial and performance constraints were defined within Copperleaf.

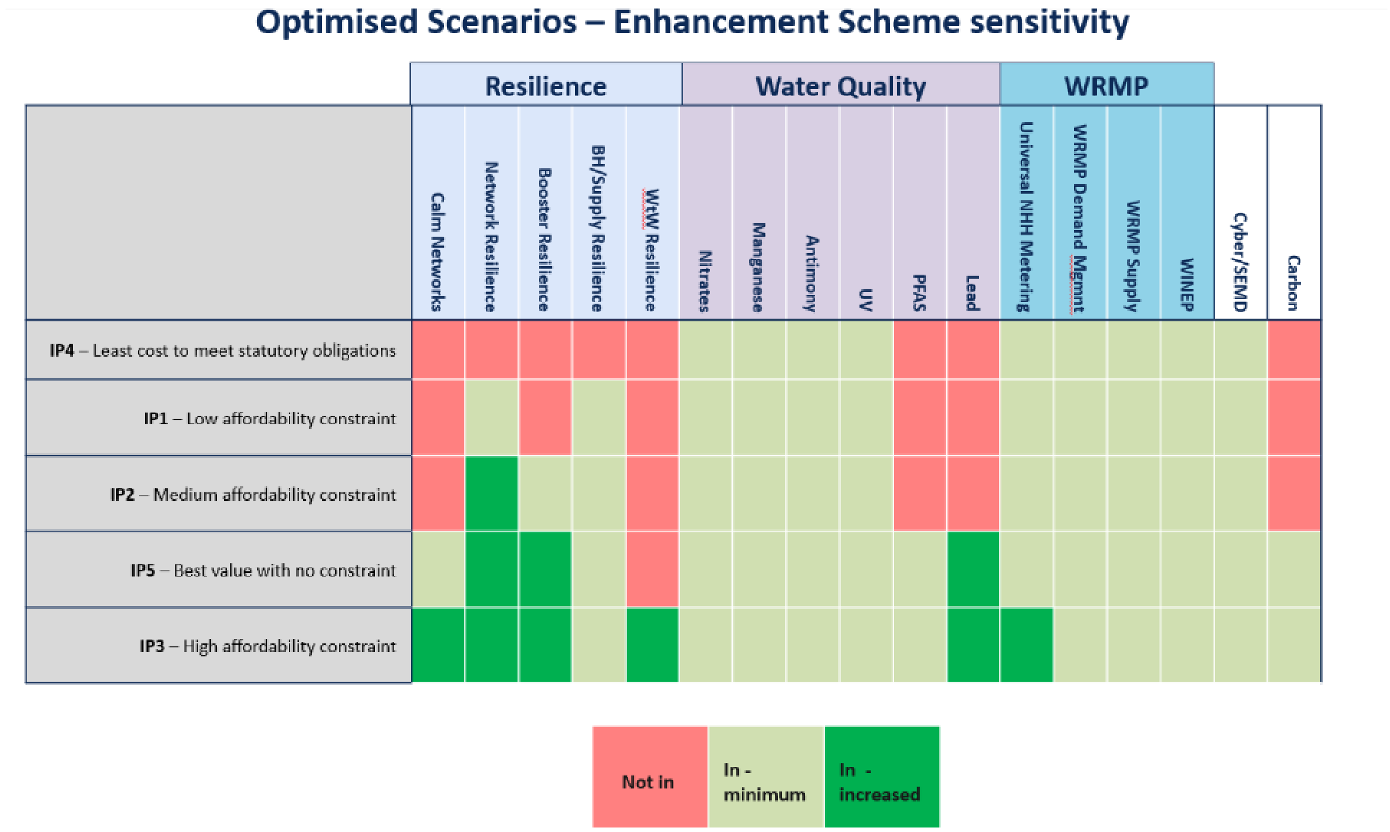


Figure 52 –theme level investment transitions through the use of financial constraints within optimisation scenarios

4.2 Sensitivity analysis of our plan – aligning customer preference

Following Impact providing a valuation workbook containing a range of triangulated figures **'SSC09 PR24 Technical triangulation – Phase 2 Results'** we carried out sensitivity analysis to inform us of the most appropriate WTP set to use in Copperleaf for optimising the business plan. We considered the household (HH) and non-household (NHH) combined figures and agreed the following sets covered a broad range of valuations (including the highest and lowest valuation sets) and would be suitable for the sensitivity analysis.

- All Highest Central Value
- All Highest Higher Value
- All Highest Lower Value
- No NERA Highest Central Value
- No ODI Highest Central Value

In summary, the first step of the sensitivity analysis was to convert the valuations from the WTP tables into Copperleaf inputs. For some of the figures, where the inputs of Copperleaf and the WTP sets are the same, no conversion was needed. However, for other figures like CRI and Supply Interruptions calculations were needed to populate Copperleaf. An investment in Copperleaf is assigned to a region (CAM, SST or SSW), so we could therefore demonstrate the differences in the valuations across the regions. Once the values were in Copperleaf, scenarios were created for each of the WTP sets.

Within Copperleaf a scenario is a version of a plan. All scenarios had the same settings so when optimised, the alternative (solution) with the highest NPV would be picked (if the NPV was negative for all alternatives, 'Do Nothing' selected). For the analysis, only WTP value was included (private and societal excluded). This would mean the best value plan based on WTP only is selected.

Figure 53, below, shows a summary of the optimised WTP scenarios. For each WTP set, the percentage of the AMP8 cost in each category was calculated. We then compared the percentages across the WTP sets. In the summary table below, the highest percentage for each category is flagged green, the lowest percentage purple, and middle values grey. The table shows when comparing the sets, No NERA and All Highest Central Value have the highest proportion of the cost in Quality/Resilience schemes, which are key priorities for customers evidenced throughout our engagement.

In areas like WINEP, Demand reduction and WRMP there are statutory obligations driving these investments and as such will be in the plan regardless of the value set used. These were therefore the sets we believed best represented the customer preferences when going beyond the investment we must make to deliver statutory targets.

Figure 53 - outputs of our WtP sensitivity analysis

Between the two sets, All Highest Central Value and No NERA, we believed based on all the evidence that the No NERA set provided the most realistic customer valuations for use in Copperleaf. For example, the valuation from the NERA study was over inflating the CRI value in Copperleaf (Water not safe to drink per property affected- c.£73k for All Highest Central Value and c.£6k for No Nera) which was leading to highly inflated NPVs. It was therefore agreed to use the No NERA valuation set in Copperleaf for optimising the plan to best reflect customers' preferences for investments.

Figure 54, shows a deeper dive into our sensitivity testing, with an example of how we tested scheme level impacts in the movement from the use of private cost value only in optimisation scenarios in comparison to the introduction of WtP value sets. In this way, we were able to test specific sensitivity of isolated schemes to variable WtP valuation sets, as well as understanding the alignment of our strategic business. The movement from left to right across the waterfall represents additional schemes being selected from customer driven preference in WtP valuation, bringing in resilience driven improvements through enhanced network connectivity, reduction in single borehole sites and additional power resilience at critical sites.

In providing us with a triangulated willingness to pay dataset, we worked with our preferred partner, Impact, to understand a range of sensitivity around the core values. We were able to produce scenarios comparing upper bound, lower bound, package scaled numbers and also a portfolio generated on just private cost beneficial schemes only. The analysis demonstrated that customers value those schemes that ensure secure, reliable supplies and additional resilience. It also demonstrated that higher bound valuations drive the selection of those schemes that improved resilience. We reviewed these choices and included those schemes where they are both deliverable and affordable within our preferred portfolio

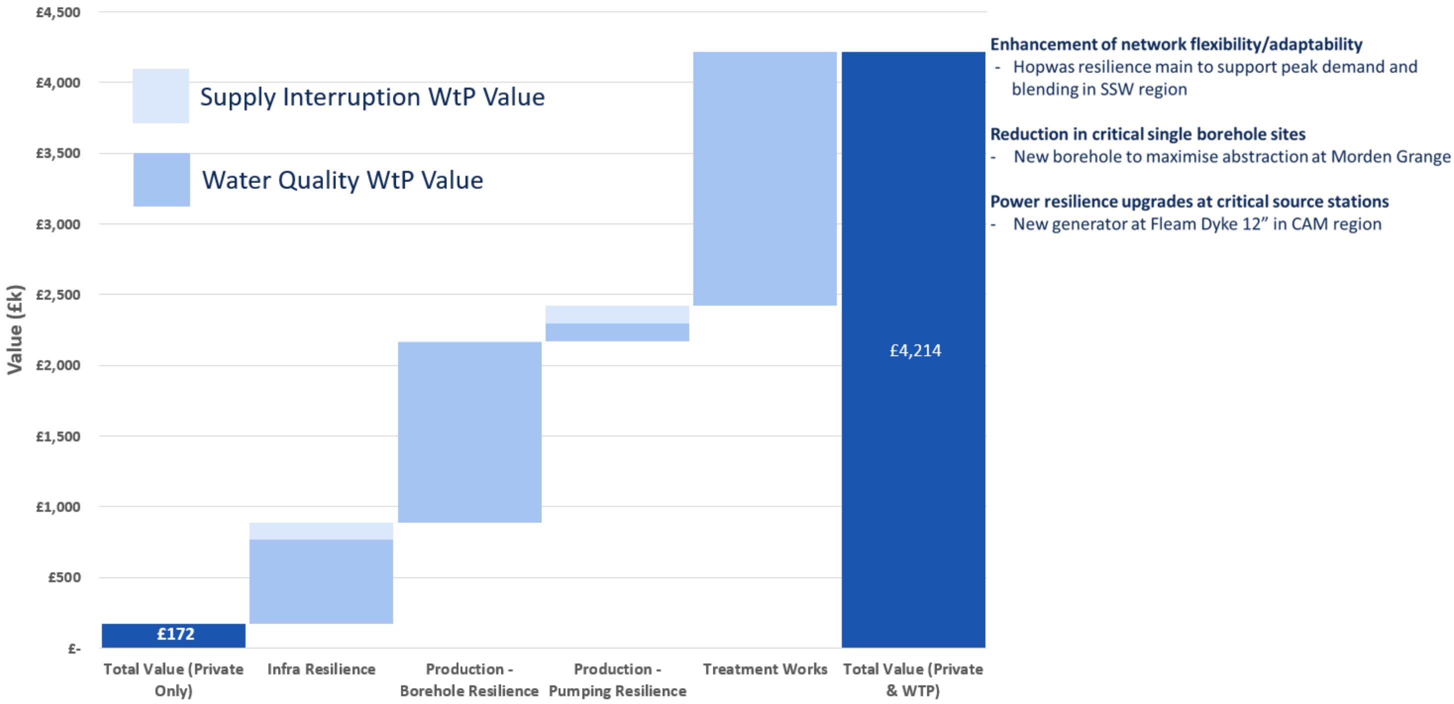


Figure 54 - an example of our sensitivity checking across private and social valuation sets

4.3 Visualising and communicating our business plan

During the PR24 planning period, comprehensive data has been gathered through the efforts of the Asset Management team. This data compilation involved collaboration with stakeholders from various departments across the organisation, such as production, water resources, and water quality.

The collected data encompasses risks and investments derived from workshops and Copperleaf outputs, as well as valuable insights from various predictive models that aid in determining future investment necessities for assets. Additionally, specific location data for our water resource assets has been extracted from our asset databases, contributing to a more comprehensive dataset, and providing valuable spatial context for analysis and decision-making.

4.3.1 Copperleaf H20 output visualisation

Our implementation of Copperleaf H20 has seen the development of bespoke functionality specific to our need to fully understand and maximise the data we have available in terms of value driven investment and the decisions we make using it. And so as well as developing three new value models in our Six Capitals framework (sections 1.2 and 3.2.3.1), we worked with Copperleaf to develop a suite of optimsation scenraio comparison dashboards, our Reporting Visualisation Interface (RVI).

RVI has become an important tool for us to bridge the gap between scenario optimisation outputs in Copperleaf and what we can quickly portray as meaningful data to business wide stakeholders. We utilise cost and value parameters in context of meaningful information to our internal stakeholders, in a way that clearly illustrates the relative merits of comparative scenarios. This is important in terms of decision making around our plan composition, for example, we are able to quickly visualise how given scenarios are performing against business level Performance Commitment targets that are part of our regulatory undertaking, and where specific investment interventions are driving this value. This in turn has supported informed discussions around our level of ambition in both AMP8 and beyond. **Figure 55** shows an example of our scenario comparison summary page.

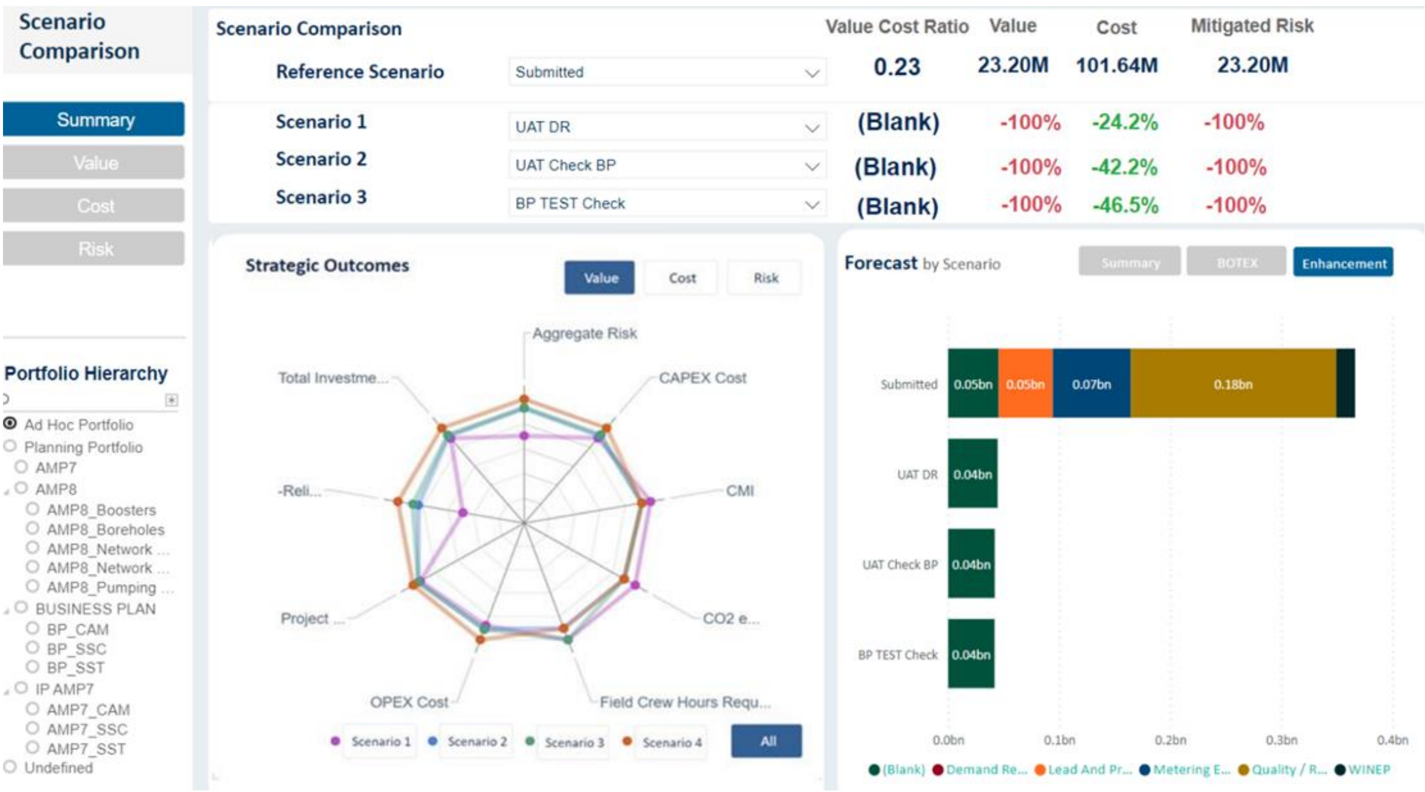


Figure 55 - Our Copperleaf RVI suite of portfolio comparison dashboards

4.3.1 Visualising our chosen plan in GIS

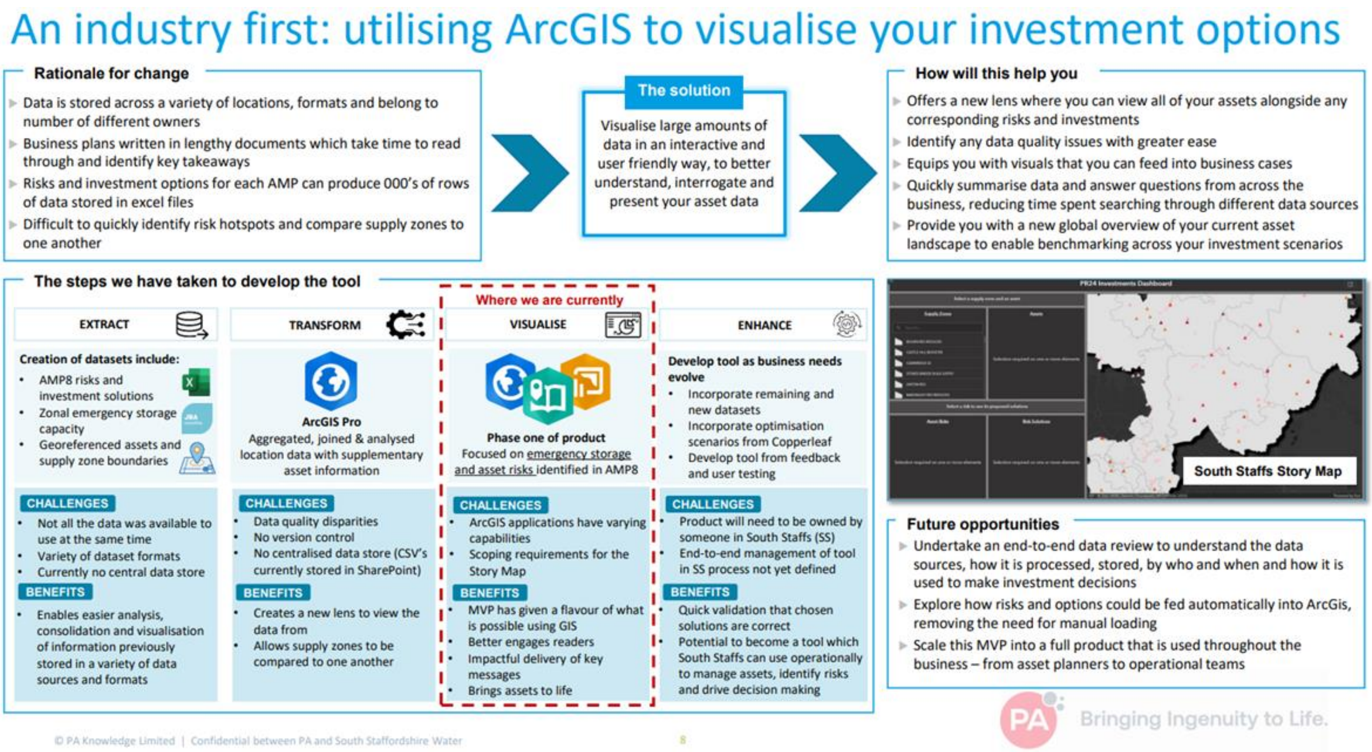


Figure 55 - the journey to deliver improvements in our investment plan visualisation

The data was compiled into a CSV file and then translated into an ArcGIS Map, presenting asset locations and their respective investment information. The map was subsequently transferred to Arc Online, facilitating the creation of an interactive dashboard for data exploration and analysis.

Figures 56 and 57 display the interactive dashboard presenting the preferred investments for PR24. The map showcases assets in the Staffordshire and Cambridge regions, each represented by distinct color-coded points. To facilitate the quick identification of asset types, the dashboard includes a map legend positioned on the left-hand side. The dashboard allows us to select any asset (or point) on the map. By doing so, gaining immediate access to comprehensive information related to the chosen asset. This feature enabled in-depth exploration and analysis of each specific asset.

The dashboard includes filters located at the top row, facilitating the narrowing down of search results based on specific criteria. We can choose an area (Staffordshire or Cambridge) and further refine our search using the supply zone filter (e.g., Barr Beacon). The dashboard also allows for filtering by asset types (e.g., Boreholes), the specific assets themselves, and investment types (base or enhancement investments).

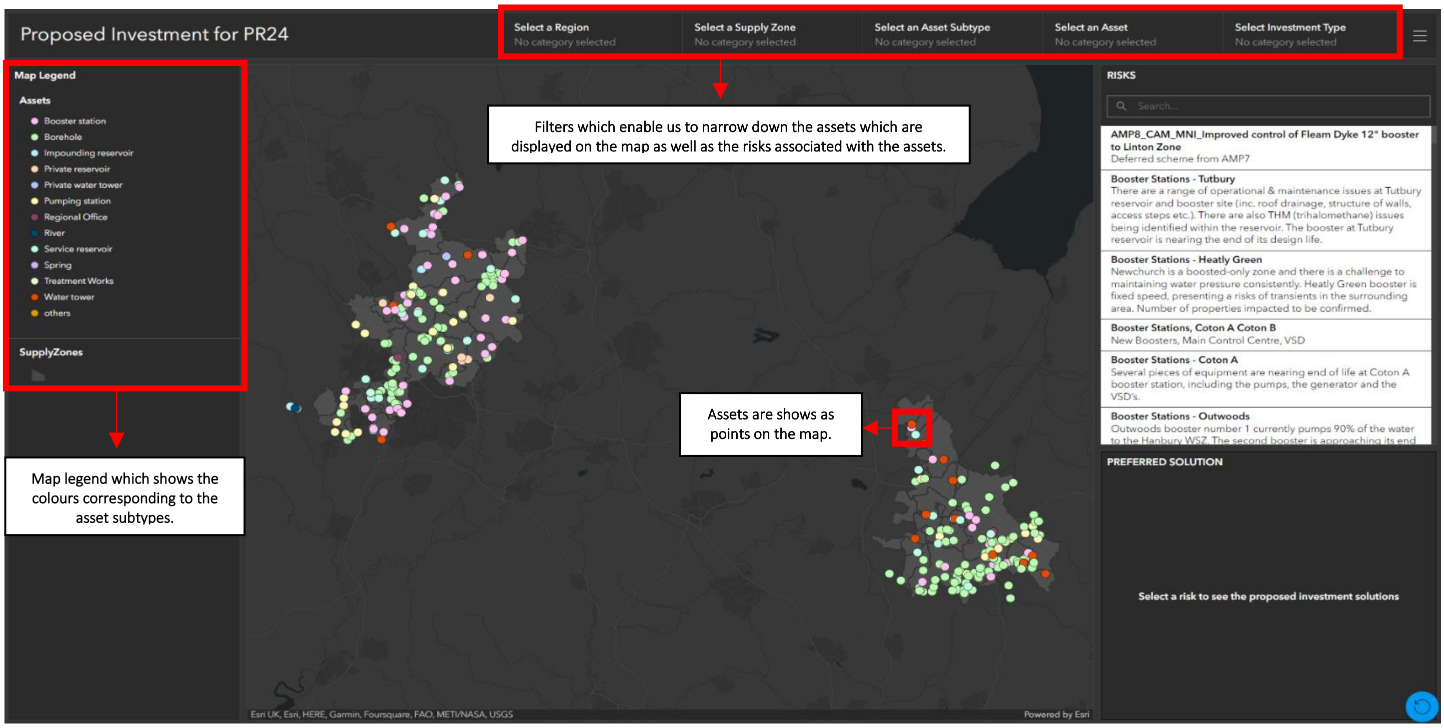


Figure 56 - our investment plan dashboard functionality

Figure 57 depicts the dashboard with applied filters, showcasing assets on the map that conform to the selected filters. Additionally, the dashboard lists the associated risks for each asset, including the asset name and a summary of the risk. Clicking on a specific risk reveals the preferred solution at the bottom right of the dashboard, along with its corresponding cost. This setup allows for the data to be presented in a user-friendly and easily understandable manner, providing convenient access to the necessary information for us.

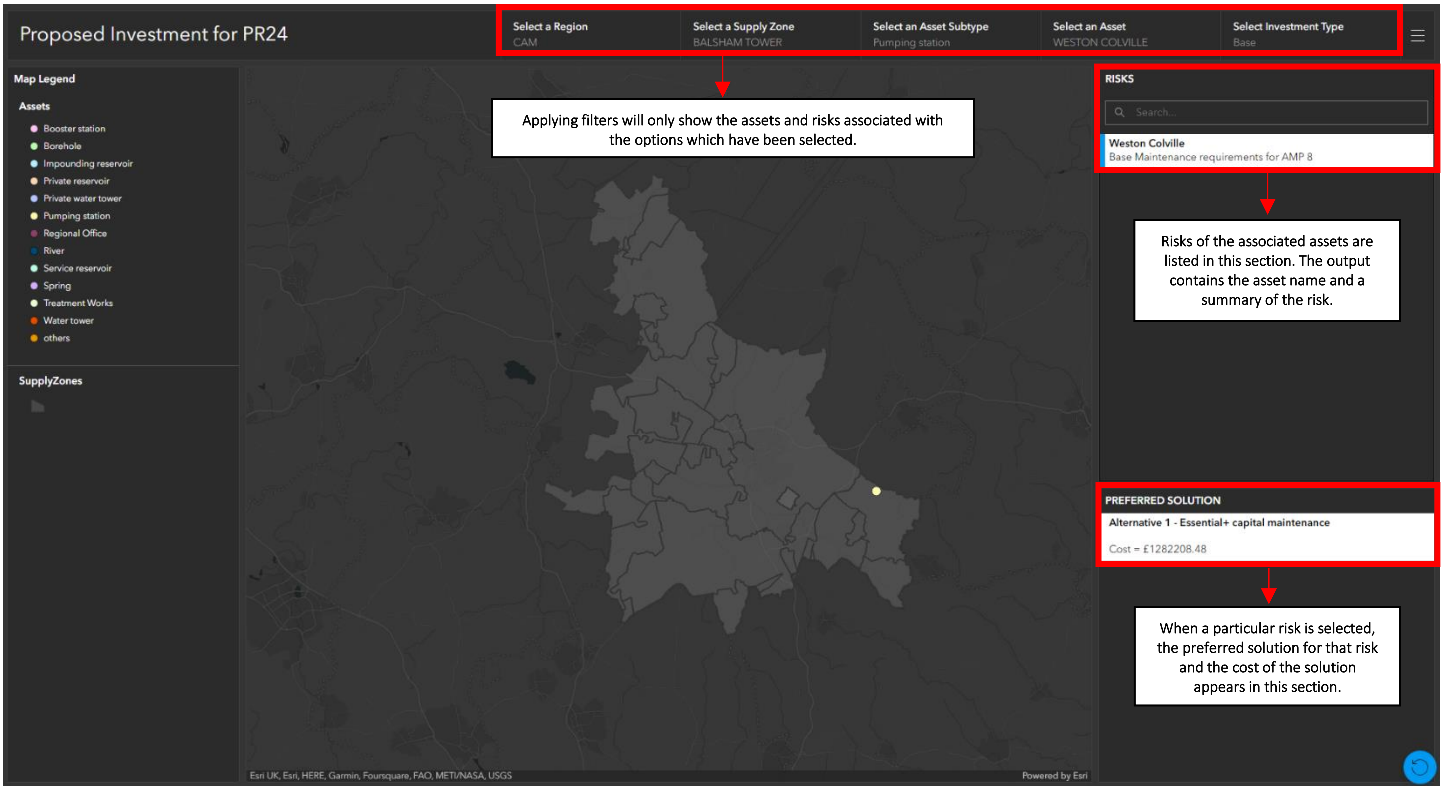


Figure 57 - Our investment plan dashboard functionality

5. Our plans for the period 2025 to 2030 and beyond

This section details our headline investment areas for the period 2025-2030 and beyond – the needs for which have been identified as a result of the approaches we have outlined above. The investments are separated into base maintenance (**Section 5.1,** below) and enhancement (Section 5.2).

For a detailed evaluation of our delivery plans for the base and enhancement programmes in AMP8, see **section 6** in '**SSC01 Securing your water future – South Staffordshire Water's business plan 2025-2030,'** and also our identified enhancement case detail **in 'SSC36 Evidencing our enhancement expenditure in 2025-2030.'**

5.1 Base maintenance

5.1.1 Non-infrastructure assets

We will invest £150 million net capital expenditure in the base maintenance of our non-infrastructure assets between 2025 and 2030. This represents a programme of base spend that has been appraised as the best value, most efficient plan for delivers a critical level of operational resilience across our asset base in AMP8. As detailed in section 1 – Risk and asset modelling, the identification of risk through bottom up and top down engagement carried out by Asset Management and the Central Risk Team, has been overlaid with asset condition assessment using core system data and built into non-infrastructure deterioration model outputs in identifying our priority investment needs. Proposed solutions, generated both internally and through supply chain engagement (section 3 – solution appraisal and costing of our plan) are then appraised through our value framework and costed. The main investments arising from this process are summarised in the following sections.

5.1.1.1 Reducing risks to raw water quality

A fundamental part of providing clean, high-quality and reliable water supplies now and in the future is protecting the raw water quality of our sources. The quality of our raw water dictates how effective our treatment processes can be. And compromised raw water quality can result in prolonged outages at our groundwater pumping stations, for instance, if we need to shut a site down until a risk to water quality has subsided.

- continuing our rolling programme of foul drainage inspections and remedial works at our groundwater pumping stations;
- undertaking improvements to our delivery areas at our groundwater sites to ensure the risk of spillages are further reduced;
- making improvements to the headworks on some of our boreholes

5.1.1.2 Continued borehole maintenance programme

Our boreholes provide the means by which we abstract groundwater. In our South Staffs region, boreholes provide approximately 40% of our customers with water.

In our Cambridge region, all of our customers are supplied by groundwater from boreholes. Therefore, any problems with the operation of these boreholes puts at risk our ability to keep our customers' taps flowing. As such, it is fundamental that we maintain these assets throughout 2025-2030 and beyond. To do so requires a continued understanding of the current condition of our boreholes. We started an inspection programme in AMP5 and continued this throughout AMP's 6 and7. We will continue to invest in this borehole inspection programme, undertaking further surveys of our boreholes. The surveys involve inspections of the borehole chamber and headworks combined with a camera inspection of the full extent of the borehole, and geophysical logging. Following the surveys, we acquire an interpretative report identifying any defects and areas of concern together with proposals for any remedial works. Further, in addition to continuing our rolling inspection we will undertake remedial works that our inspection programme to date has identified as being required.

5.1.1.3 Continued maintenance of source pumping station and booster assets

Our pumping and treatment assets require maintenance day-in day-out to ensure that our sites remain operational and that we can continue to supply our customers with clean, high-quality water now and in the future. Throughout the period 2025-2030 we will invest in a proactive maintenance programme for our pumping and treatment assets. Key themes related to our planned investment in our pumping and treatment assets include:

- Full site refurbishments at a small number of aged and deteriorating sites;
- Replacement of aged dosing equipment;
- Contact tank maintenance;
- Installation of fixed air conditioning units where overheating is a cause of site trips;
- Replacement of monitors which are approaching obsolescence and will no longer be supported in the near future
- Replacement of failing control valves or valves that are life expired; and
- Surge vessel maintenance and automation.

Through **sections 5.1.1.1 to 5.1.1.3** above, we have built into our investment needs the outputs of our storage and infrastructure resilience modelling, as well as that of our resulting master planning sessions with internal SME's. We know, for example, that in Cambridge, we have less system interconnectivity across our network when compared to our Staffordshire region and a greater reliance on groundwater sources.

Accordingly, we have prioritised our source station resilience investment in our base programme to reflect this need and to provide the greatest level of resilience of supply as possible to our customers in doing so. To this end, see a case study driven by our resilience modelling in Cambridge, and associated borehole investment requirements, in section 2.3.2 and also in our resilience and water quality driven enhancement cases in **sections 5.2 and 4.1** of our appendix **'SSC36 Evidencing our enhancement expenditure in 2025-2030.'**

5.1.1.4 Continued maintenance of our two major Water Treatment Works

We have established a programme of priority base maintenance works at our two critical Treatment Works at Hampton Loade and Seedy Mill. Recognising the work that has been and will continue to be carried out in AMP7, including the significant enhancement investment we are making at both sites as part of our Long Term Plan. We have worked to develop a consistently appraised bottom up SME view of risk (section 1.3 and 1.4), overlaid with outputs from our non-infrastructure deterioration model to drive investment need identification. Significant works include:

- Permanent covers on our clarification process;
- A solution to mitigate the proliferation of Zebra Mussels;
- Power resilience with a Transformer replacement programme;
- Replacement of critical component assets for High Lift pumping;
- Installation of new chemical treatment storage and associated bunding;
- Mitigation of potential environmental hazards through redesign and refurbishment activity;

5.1.1.5 Rebuilding of two critical storage assets and inspection and maintenance of existing asset base

Our PR24 master planning process (detailed in section 2), highlighted a need for investment in two strategic service reservoir assets at Barr Beacon and Langley, forming part of our core pathway of resilience investment in AMP8 in context of the LTDS. **Figures 58 and 59**, provide summary detail around Barr Beacon No.1 need and proposed solution, the reservoir at which we plan to rebuild across the period 2025-2030.

A brief history…

- Barr Beacon 1 (constructed in 1899) was taken out of supply in October 2017 for routine maintenance work.
- Upon inspection there was clear evidence of roof failure with the "flex cell" expansion joints.
- There are concerns with the west structural embankment and the risk of failure. The risk was deemed too great, and the reservoir wasn't returned to supply and remains out of supply today.

Current average emergency storage times in hours for Barr Beacon

Average day demand (Av hours)			Peak day demand (Av hours)		
Present	10 year (10%)	20 year (20%)	Present	10 year (10%)	20 year (20%)
14	12	11	8	8	6

Summary of the investment need…

- **Security of Supply** – Barr Beacon 1 is identified as a strategic reservoir within the South Staffordshire storage system. It has a storage capacity of 46.19 ML. Without this storage capacity Barr Beacon 2 (storage capacity 44.38 ML) is at risk due to the low emergency storage available to a large water supply zone (88,814 properties).
- **Surrounding zones** – Barr Beacon supply zone also provides resilience to many other supply zones. For example, should there be a loss of Seedy Mill TW, Barr Beacon can support the Northern and Eastern areas. It can also do the reverse and support the Sedgley supply zone if there is a loss of Hampton Loade TW.
- **Legal & Regulatory** – Managing safety of our reservoirs is the one of the most critical roles we undertake as a water company and is subject to strong regulation. A failure of one of these assets would lead to the disruption of water supplies to a significant number of people (and in the worst scenario potentially result in loss of life).
- **Statutory Obligations** – SSW have a statutory duty to ensure our bulk storage of water complies with legislation on health and safety under the Reservoir Act 1975[i], with a requirement to carry out detailed inspections (Section 10 reports) every 10-years supported by annual statement (Section 12 reports).

Options appraised and costed…

Option 1: Return the existing structure to supply
Option 2: Demolish and rebuild in existing location to same size capacity
Option 3: Demolish and upsize reservoir
Option 4: Build a new reservoir in a new location to the rear of No 2 and demolish No 1.
Option 5: Build part of a new reservoir in AMP8 and complete the second half in AMP9

Value appraisal against our 6 capitals framework…

Value Measure	Value
Water Supply Interruptions WTP	84,610,300
Water Supply Interruptions - Private	80,738,936
Social Capital	7,178,147
Water Supply Interruptions - Societal	6,996,442
Water Quality Cost - Private	4,049,882
Total Investment Cost	-21,299,354

What does it mean for us?

- This scheme has been well-researched and storage modelling carried out in late-2022 indicates that the Barr Beacon reservoir is critical to securing resilient supplies for many of our customers in SST (at the intersect of our northern & southern networks and supplies both).

Figure 58 - a deep dive into Barr Beacon No.1 investment need

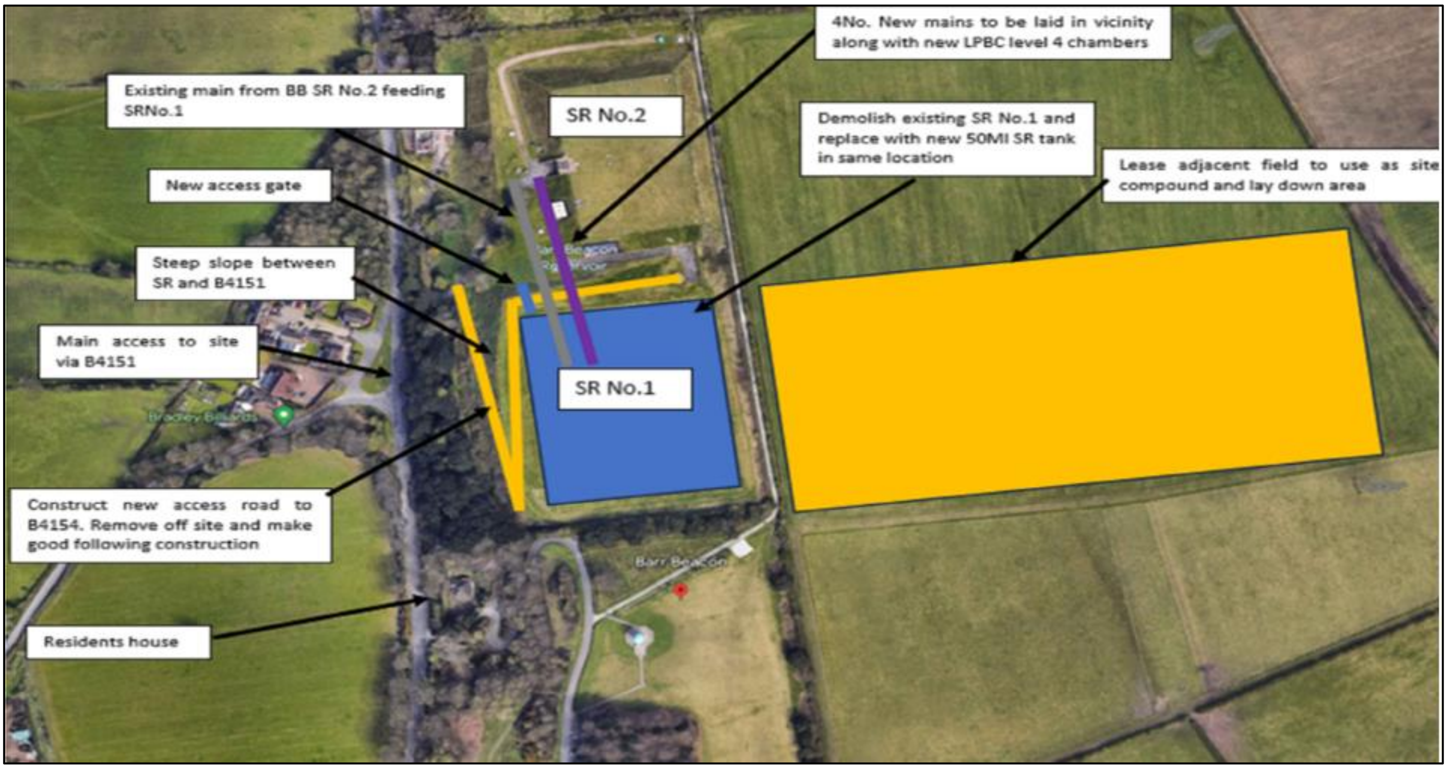


Figure 59 – proposed Barr Beacon solution

Our investment at Langley service reservoir will see a decommissioning of the existing reservoir and subsequent rebuild which sees an upsizing of the existing 4Ml capacity to 10Ml, providing additional resilience in a key strategic zone. This investment is further detailed in **section 5.1** of our enhancement appendix **'SSC36 Evidencing our enhancement expenditure in 2025-2030,'**in the context of capital enhancement spend, but it is emphasised that the maintenance-enhancement split has been proportionally allocated (by storage volume) within our plan (40% maintenance, 60% enhancement). This staged approach to delivery across Barr Beacon and Langley throughout AMP8 will enable us to:

- ensure resilient supplies to our customers through investment in critical storage assets
- provide two storage units at Barr Beacon that we can remove from supply one at a time when required, for example, during our inspections in the future, or to undertake remedial works

5.1.1.6 Continued maintenance of our service reservoirs and towers

The ongoing maintenance of our service reservoirs and towers is essential to our service. We must maintain these assets in a condition that allows wholesome water to be stored without posing risk to water quality and without risk of structural defects that could make the reservoir unsafe to operate. Maintaining the assets in this way requires us to have a good understanding of their condition which is best obtained through a rolling inspection and cleaning programme as we have undertaken in previous years. As part of our plans for 2025-2030, we will continue our rolling cleaning and inspection programme on our service reservoirs and towers.

A continued cleaning and inspection programme is extremely important in helping us minimise the occurrence of unforeseen issues or failures of our storage assets. We will also undertake proactive remedial works on specific service reservoirs and towers where the inspections we have undertaken to date have identified risks requiring mitigation within the timescale of 2025-2030. For example, in our Cambridge region, this includes:

- installing new roof membranes
- reinforcing floor and wall joints
- applying protective coatings to floors, walls and internal pipework

We clean and inspect our service reservoirs which store water from our surface water sources more regularly than our other storage units. This is because surface water has more naturally occurring organic matter, contains treatment by-products and has a greater risk of trihalomethanes (THMs) 20 than groundwater. THMs are becoming an increasing risk for us as we are finding increasing amounts of organic matter in our raw surface water.

5.1.1.7 Improving operational efficiency

Improving operational efficiency will improve our service to our customers by reducing the time it takes us to respond to events or issues with our assets. By becoming more efficient we will also reduce our operational costs. We will continue to mitigate the effects of generally rising energy prices through our pump efficiency programme (PEP). Through our on-going programme, we will undertake pump performance tests which detect when pump performance is less than economically acceptable. This test programme enables us to intervene thereafter to improve efficiency.

We will also continue to invest in site automation technology. Our operational staff have praised investments we have made recently to automate site processes and, where possible, enable remote operation of our sites. They have found the technology valuable in improving responsiveness to site failures and minimising the time operatives spend travelling between sites. We will continue to invest in the required technology to deliver further operational efficiencies in this regard. In addition to site automation and pump efficiency, our predominantly proactive base maintenance programme enables us to manage our risks in a controlled way which will ensure we continue to run an efficient business.

5.1.1.8 Operational Technology and control systems

Our extensive Operational Technology asset base enables us to monitor and control our sites. And whilst we make every effort to future proof our investments, we are finding that equipment obsolescence is an increasing driver for capital investment. We need to be confident that we can respond to a failure in our control system assets, and therefore, we will invest in a programme of proactive replacement, targeting unsupported or incompatible control systems where the potential impact on our service is considered high.

5.1.1.9 Management and General (M&G)

Our M&G assets are the supporting assets which enable us to maintain our day to day business operations. They are diverse and perform a wide range of functions across our business. These assets include our IT and business systems - both hardware and software, equipment, vehicles, buildings and facilities, security and our health and safety assets. We need to maintain investment in these assets to maintain our business capabilities and operational efficiency, and to enable our people to perform their daily duties proficiently so that we can continue to provide high levels of customer service whilst achieving our customers' expectations. Therefore, we will continue to invest in our M&G assets. This investment will ensure our levels of service can be capably maintained whilst delivering the long term strategic outcomes of our business. The investment in our M&G assets includes:

- maintenance of our IT and business system hardware and software, including investment to build maturity in asset management/condition assessment data and investment planning capability to support effective delivery for our customers in AMP8;
- maintenance of our fleet – vans and cars;
- maintenance of electronic security assets at our sites such as access control systems, CCTV, intercoms and alarms and, the installation of new CCTV at our storage assets
- maintenance of our emergency response assets notably those used to provide alternative supplies;

5.1.1.10 Leakage

Our plans for leakage reduction in AMP8 fall into 4 different categories:

- Customer side leakage improvements,
- Proactive Trunk Main detection,
- PRV optimisation and
- intensive DMA leakage work

The Customer Side Leakage (CSL) improvements involves purchasing, developing and trialling new equipment to help us find and temporarily/permanently fix CSLs. For example, there is currently equipment on the market that claims it can quickly fix a CSL in the short term whilst we await for the permanent repair to be done. There is also a several different types of sensors that can be used to detect CSLs, currently this isn't something SSW has investigated, but with funding in AMP8 we can.

Proactive Trunk Main detection involves purchasing and deploying different types of sensors on our trunk main network that can not only alert to be new leak, but also find existing long standing as well.

PRV optimisation involves developing new pressure management schemes that can then be build and optimised on our network. This could be small DMA schemes or larger zonal schemes.

Intensive DMA leakage work involves undertaking intensive surveys and analysis on all our DMAs and firstly determining its main issues and then undertaking work to act on whatever that issue is. We are currently trialling AI/machine learning algorithms that can do this and the aim is to continue this into the next AMP. Once we have a better understanding of the issues, different equipment can then be installed to help us solve this. For example, if it is determined to be DMA with high outbreak levels we can purchase and install permanent acoustic/leakage sensors.

In AMP8 we also plan on accelerating our WRMP plans to bring some works from AMP9 forward into AMP8. This will mean that extra maintenance work will be required in order to maintain the additional work we plan on undertaking in AMP8 (compared to original plans and budgets in the WRMP). This stretching leakage ambition is further detailed in **section 3.2** of our enhancement appendix **'SSC36 Evidencing our enhancement expenditure in 2025-2030.'**

5.1.2 Infrastructure assets

We will invest £84 million net capital expenditure in base maintenance of our infrastructure assets between 2025 and 2030. The main investments driving this spend are summarised in the following sections.

5.1.2.1 Mains Renewals

We need to renew our mains to manage the long term serviceability of our network to maintain our service to our customers. Replacing mains that are at the end of their useful life also contributes to improved resilience, particularly to variability in the weather – and we explain in detail in section 1.6.1 how we have built a comprehensive mains infrastructure model that builds in both historical and robust datasets, but also looks to account for uncertainty in factors like climate change as we plan into the future.

We will continue to invest in a mains renewals programme, renewing 254 km of our mains network between 2025-2030. This equates to 179 km in our South Staffs region and 75 km in our Cambridge region. In Cambridge, this includes some renewals of urban/town centre locations which are costly to renew. To maximise service benefit, our mains renewal programme will target:

- mains with high leakage;
- mains which burst often;
- mains that when they burst have a large impact to customers such as long duration supply interruptions, road closures, property flooding and damage to third party infrastructure;
- mains that are susceptible to bursts in extreme weather conditions;
- mains that are under capacity causing poor pressures;
- mains that are over capacity causing potential water quality issues.;

5.1.2.2 Mains condition monitoring

We will also continue to invest in our mains condition monitoring programme to ensure we continue to collect valuable information regarding the condition of our infrastructure assets to prioritise investment interventions. The most critical trunk mains have been identified (through our resilience modelling and critical link analysis carried out by hydraulic modelling teams).

In AMP8 we include investment in our plan to deliver a step change in our ability to better understand the condition of these critical strategic mains across our network. This will be done through collaborative working with two experienced suppliers in Advanced Engineering Solutions (AES) and Hydrosave, which will see;

- development of a robust asset inspection strategy led by AES. Centred around the understanding of the Wellness, Fitness (how the asset performs under variable operating conditions) and Life Expectancy of our strategic mains, this research will utilise an Asset Health toolbox of assessment techniques. This will allow us to better understand the capabilities of critical, high priority mains that we know are essential to our ability to provide a resilient service to our customers.
- innovative use of non-invasive condition assessment system, p-CAT, led by Hydrosave, to further support our asset knowledge of those mains we would otherwise find it very difficult to assess, with minimal disruption to normal operation and to our customers. With strong existing use cases across the global water sector, the novel use of introducing a minor transient wave to determine condition from tracking of wave reflections along the length of main will support our understanding of asset health and produce data that will allow us to build more robust datasets in terms of large diameter deterioration modelling and associated investment prioritisation.

Work is also ongoing around building in a greater understanding of how infra asset condition impacts on water quality, and this is reflected in our uptake of new technology around WQ monitoring devices that support a number of operational initiatives, and in leakage benefits, through our base smart network activity.

We will also enhance our smart network capability through a trial we are proposing in the Outwoods zone in AMP8. This will see a step change in our understanding of the most effective approach for us to adopt to a wider smart rollout across our network in AMP9 and beyond, supporting delivery of improved service levels to our customers. This case is referenced in **section 5.3** of our enhancement appendix **'SSC36 Evidencing our enhancement expenditure in 2025-2030.'**and also in terms of our LTDS core pathway in **section 5.4** of our appendix **'SSC02 South Staffordshire Water – long term delivery strategy.'**

Condition monitoring of these critical lengths of our network has also been driven through our PODDS project, run in conjunction with Sheffield University, an innovative methodology to remove accumulated material by mobilising into the flow in critical supply mains identified through hydraulic modelling at low, safely managed levels. This increases our operational resilience by allowing increased flexibility within our network in terms of de-risking the transfer of large volumes of water across our strategic network, informing decision making around investment proposals.

5.1.2.3 Diversions

We are required to undertake mains diversions when requested by a third party, for example by a developer. This may be for new housing developments or road or rail improvements for example.

Much of this cost is covered by the developer requiring the works to be undertaken, however, we do have to pay a proportion of the costs and this is therefore something we have to factor into our business planning process.

The most significant scheme we have had to accommodate is to divert mains in preparation for the High Speed railway (HS2) and as part of the HS2 project we are looking at opportunities to improve resilience in the future.

5.1.2.4 Miscellaneous infrastructure maintenance

As well as mains renewals and diversions, there are other activities we will undertake on our infrastructure assets to maintain service to our customers. The investment areas include:

- replacing communication pipes where there is leakage, poor pressures and/ or a risk to water quality;
- maintaining air valves to reduce the risk of catastrophic failure of trunk mains and surface water ingress;
- inspecting and maintaining pipe bridges to reduce the risk of long duration supply interruptions and damage to transport infrastructure
- maintaining cathodic protection to protect steel mains from corrosion, which reduces the risk of bursts;
- replacing marker posts, chambers and lids, stop taps;

5.2 Enhancement

We have identified a range of investment needs that are enhancements, as they either improve service levels or risk, or relate to growth or statutory obligations. The enhancement cases we have developed for PR24 have been subject to more rigour than ever before in assessing whether they deliver those step changes in those areas customers have told us they see as priority. And in response, we will deliver a combination of regulatory driven and risk-based enhancements covering five key work programmes; water quality, resilience, supply side enhancements, demand side enhancements and the environment.

We have classified these enhancement investment needs into five work programmes, and through these we will invest £140m net capital investment in the enhancement of our assets in the period 2025-2030.

Further detail regarding the expenditure under each work programme is provided in our enhancement case appendix **'SSC36 Evidencing our enhancement expenditure in 2025-2030.'**

- improving water quality – either due to a change in raw water quality or a change in water quality standards
- improving resilience – through mitigating or minimising the effects of an asset failure;
- supply side enhancements driven through our WRMP process – including new infrastructure, to meet growth and future uncertainty such as climate change
- demand side enhancement driven through our WRMP process, including reducing leakage and helping customers use less water;
- improving the environment – aligned with our Water Industry National Environment Programme (WINEP) obligations;
- Delivering against our Net Zero ambition wit investment in renewable energy;
- meeting statutory obligations – such as those as part of our cyber security commitments to the Cyber Assessment Framework (CAF) and those surrounding the Security and Emergency Measures Directive (SEMD)

We will continue to invest to meet our regulatory requirements including those defined by our Water Resource Management Plan (WRMP), and the Water Industry National Environment Programme (WINEP), with notable schemes relating to a new transfer main at Grafham in the Cambridge region, together with a significant uplift in our demand side investment through our Universal metering, enhanced leakage detection and water efficiency programmes. We also include a number of water quality improvement schemes supported by the DWI as recognised needs in AMP8, including enhanced nitrate and manganese treatment in addition to our cyber security commitments through the Network and Information Systems regulations. We have also worked to develop a key part of our Net Zero strategy as investment in renewables at sites across our network.

In addition to the significant base programme investment supporting increased resilience of our production and network assets, we also include enhancement solutions across both areas to ensure we are protecting customers in the long term from the impacts of climate change and growth driven events that can have catastrophic consequences to our continued ability to provide high quality, reliable supplies to our customers in any scenario.

5.2.1 Enhancement case detail and structure

Our Enhancement Case appendix **'SSC36 Evidencing our enhancement expenditure in 2025-2030,'** provides a set of full business cases for enhancement expenditure contained within our AMP8 business plan. These enhancements are a critical part of our Long-Term Delivery Strategy, working towards achieving our 2050 ambition we developed with our customers. Each business case follows a common structure, setting out the evidence behind each investment aligned with the Ofwat assessment criteria. As outlined extensively through this appendix, we have made substantial improvements to our underlying tools, techniques, methodologies and processes to generate these business cases. The cases have also been developed following the widely recognised HM Treasury Green Book principles.The gateways we have used in setting out our enhancement cases are:

- Why is the investment enhancement?
- Why do we need to carry out the investment?
- What customer support do we have for the investment?
- Why is the investment the best option for customers and how are they protected against under-delivery?
- Are the cost estimates robust and efficient?
- What protection do customers have to ensure delivery of funded costs for the investment?
- Is there a robust delivery strategy/vehicle in place giving confidence of project completion?

6. Asset Management continued improvement roadmap

6.1 Planning for AMP8 and beyond

Since our previous business plan submission at PR19 in September 2018, we have looked to develop our core Asset Management competencies. In doing this we have looked within and outside of the water sector, researching best practice and learnings through engagement and interaction with a number of internal and external stakeholders. These include;

- supporting the Ofwat AMMA review and findings in 2021
- a dedicated review by PA Consulting of our Asset Management capability early in AMP7 in early 2022
- leading Asset Management bodies such as the Institute of Asset Management and ISO55001
- membership of asset management focused forums with other water companies, regulatory bodies and technical working groups to understand synergies and best practice

And, as we have highlighted in **table 2** of the introduction to this appendix, since the AMMA review we have established clear Asset Management objectives addressing those areas of development highlighted. These initiatives have supported the generation of our PR24 plan, as evidenced throughout this appendix, and also support the enhancement of our capability across the breadth of our business going forward through AMP8 and beyond, that is, our roadmap to advancing our asset management competency. We have done this to ensure our investment plans continue to be developed through robust processes that are sustainable and credible in the face of both in - period challenges and in the face of future uncertainty. **Figure 60** below illustrates where our specific areas of development, aligned with the AMMA assessment categories, have been established in context of our ongoing Asset Management maturity.

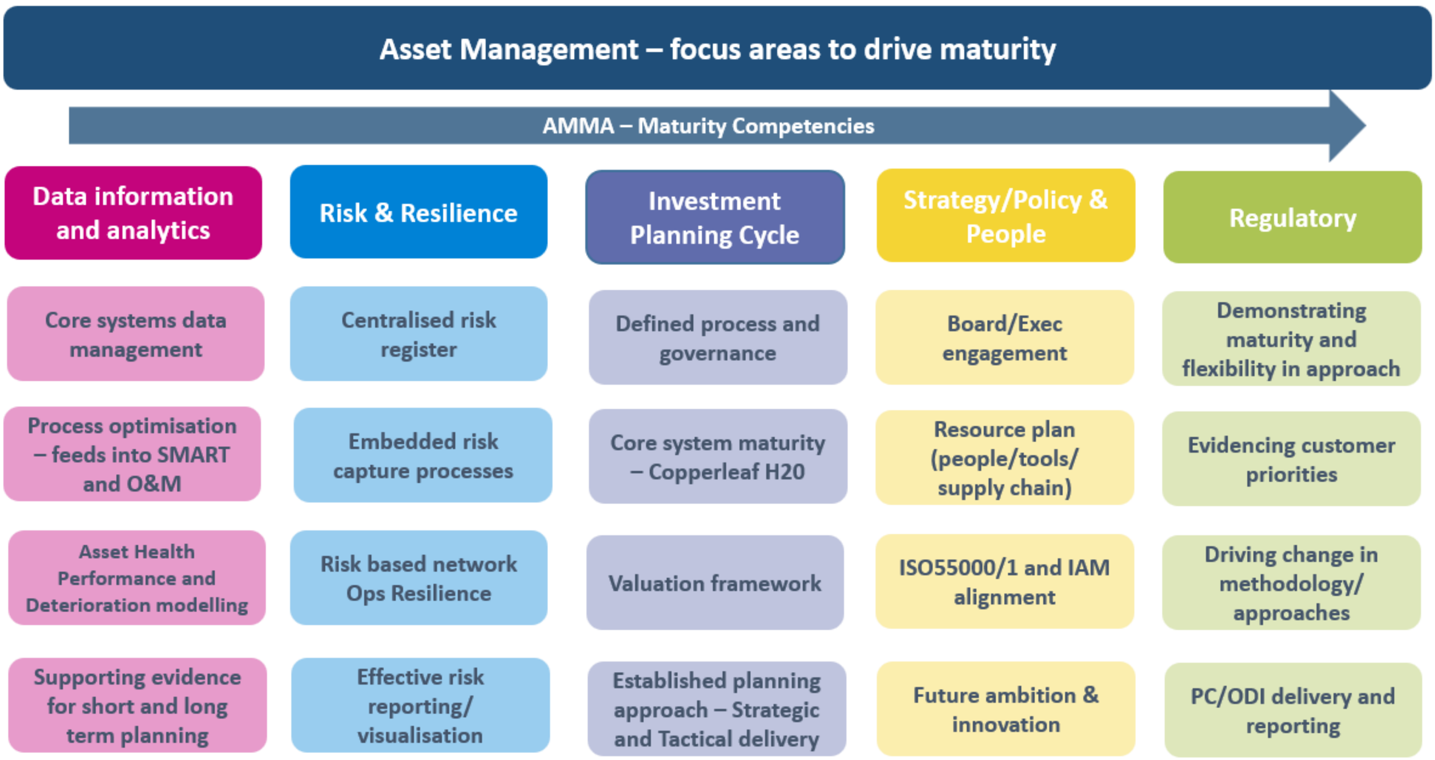


Figure 60 – our Asset Management maturity focus areas through PR24 and beyond

Both following PR19 and in August 2023, we also carried out an internal benchmarking exercise against some of the ISO550001 quality framework that specifies requirements for any asset management system. The framework is designed to standardise effective asset management practices.

		Ad-Hoc	Developing	Core	Institutionalised	Optimised	Excellence
Assessment	AM Function Link (ISO)	1	2	3	4	5	6
Does the organisation have a value framework? Is it aligned with organisation objectives? Is it in alignment and integrated with the AM Objectives and SAMP?	Strategic Direction (4.1)	Awareness of environment demonstrated.	Value framework is in place. It does not cover fully align to strategic objectives. Long-term planning may not be integrated with asset management	Value framework is in place and aligns with strategic objectives of the organisation	The value framework shows complete alignment with current strategic objectives, Strategic Asset Management Plan and Asset Management Objectives	Value assessments consider fitness-for-purpose (current and future).	Regular environmental scans are in place to identify strategic changes implicating the AM System and required changes are managed through SAMP, AMP and Value Framework review processes

Table 11 – an example of our internal Asset Management maturity assessment, aligned with ISO550001 principles

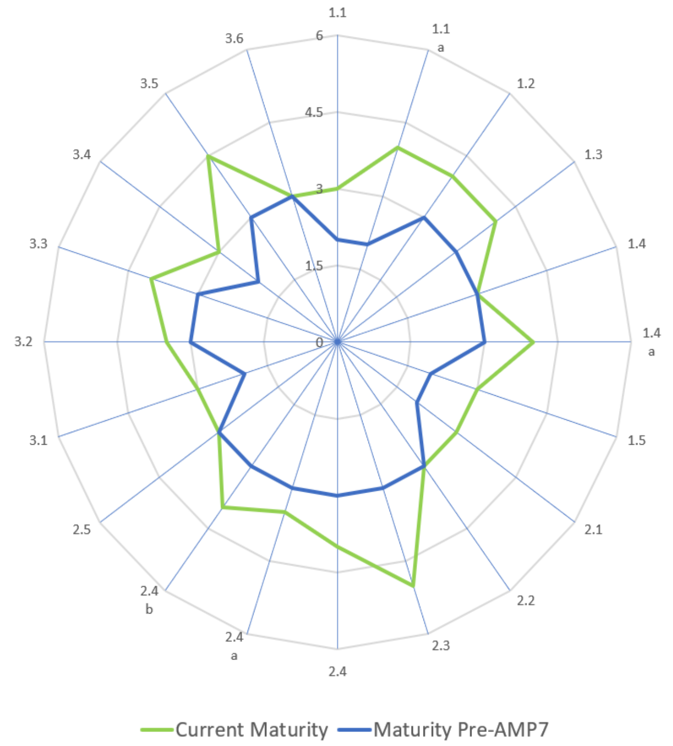


Figure 61 – benchmarking results against ISO550001 competencies

Table 11, above, shows an example of the competency assessment we undertook, with **figure 61**, to the left, illustrating the results pre and post our developments through 2020 to 2023 across the different areas of competency. We acknowledge in this way that we are progressive and continuing to build our capability, **but understand that there are areas for continued improvement and opportunities.**

Recognising this initial score after PR19, in the immediate period following the AMMA assessment, we engaged PA consulting to support our development with a review of our processes around investment decision-making. There were some clear areas evidenced as being well established across our teams, together with some clear opportunities to develop both through the PR24 period and beyond into AMP8. The latter were centred around four distinct areas, namely, the consistent application and reporting of risk within a central framework, long term understanding and reporting of asset health, optimal use of systems (particularly those that exist and weren't being used to their full potential, and finally, clear ownership and accountability for defined asset management planning processes.

The deep dive into these areas looked at the current 'as-is' and compared to future objective in a 'to-be' setting that was reviewed with stakeholders critical to each area and related processes.

Figure 62, highlights some specific deliverables to support improvements in these four areas, prioritised through their materiality to our ambition within our overarching asset management strategy, and an understanding of risk exposure to making inefficient decisions around investment in our asset base. Throughout this appendix, we evidence where we have moved towards and met a number of these outcomes, and where we have identified further areas of activity to strengthen our capability. And we will continue to utilise and refresh these findings as we mature our asset management framework.

Figure 62 – risks and opportunities identified through PA Consulting investment planning review in 2021

Developed through the wide-reaching internal and externally led reviews discussed in this section, we set out below further areas of activity we have commenced in the PR24 planning period, and where we will continue to develop, across our asset management system. These include;

- Reinforcing asset management team structure to provide specific focus areas – see **figure 63** below
- Production and refinement of core investment planning policies
- Further maturity of our non-infrastructure modelling ability (such as in our infrastructure model capability)

Figure 63 – focus areas of Asset Management established in AMP7 to be further developed in AMP8

7. Annex – supporting information

7.1 Risk review evidence

7.1.1 CRT risk templates

Fradley Pumped Supply

Average flow: 9.4 Ml/d

Treatment process: 3 boreholes → 4 filters → UV Reactor → contact tank → 2 boosters → supply

Main concerns: Iron, arsenic and turbidity – removed via pressure vessel sand filters. Ammonia – removed via breakpoint chlorination.

R.A.:

Risk	Current Controls	Further Controls
Fe failure	Online monitor on treated and final water Weekly sampling Dosing of ferric sulphate followed by sand filtration.	Addition of a second online Fe monitor. Potentially use new monitor to read final water Fe and use current monitor to read raw and treated intermittently. If there was an issue with one of the Fe monitors, there would always be the other to ensure Fe is being removed sufficiently from water supply.
Single coliform detection in raw water in last 5 year (BH2)	UV installed in March 2020. UV minimum dose of 40 mJ/cm^2 Chlorination using sodium hypochlorite	Get a hydrogeological report of borehole to understand any causes of risk. Apply mitigation methods on back of this.
High turbidity/particulates in raw water	Pressure vessel sand filters for turbidity/particulate removal Turbidity monitoring at all filter outlets and dual val pre-UV	
High antimony in borehole 2	Blending with borehole 1 and 3 to achieve compliance	Get a detailed hydrogeological report of borehole 2
High SO4 in borehole 1 – SO4 levels increase when borehole not pumping.	Blended with BH2 and BH3 to achieve compliance	Get a detailed hydrogeological report of borehole 1 - potentially deepen borehole below sulphite ores.
Arsenic in raw water supply	Weekly sampling. Dosing of ferric sulphate followed by sand filtration.	Add online monitor to raw water
Manganese in raw water	Oxidation with chlorine Removed during sand filtration	Add online monitor to raw water
Failed PO4 dosing	Weekly samples for PO4 concentration	Online PO4 monitor on final water
Contact tank streaming	Baffle walls to reduce potential for streaming	

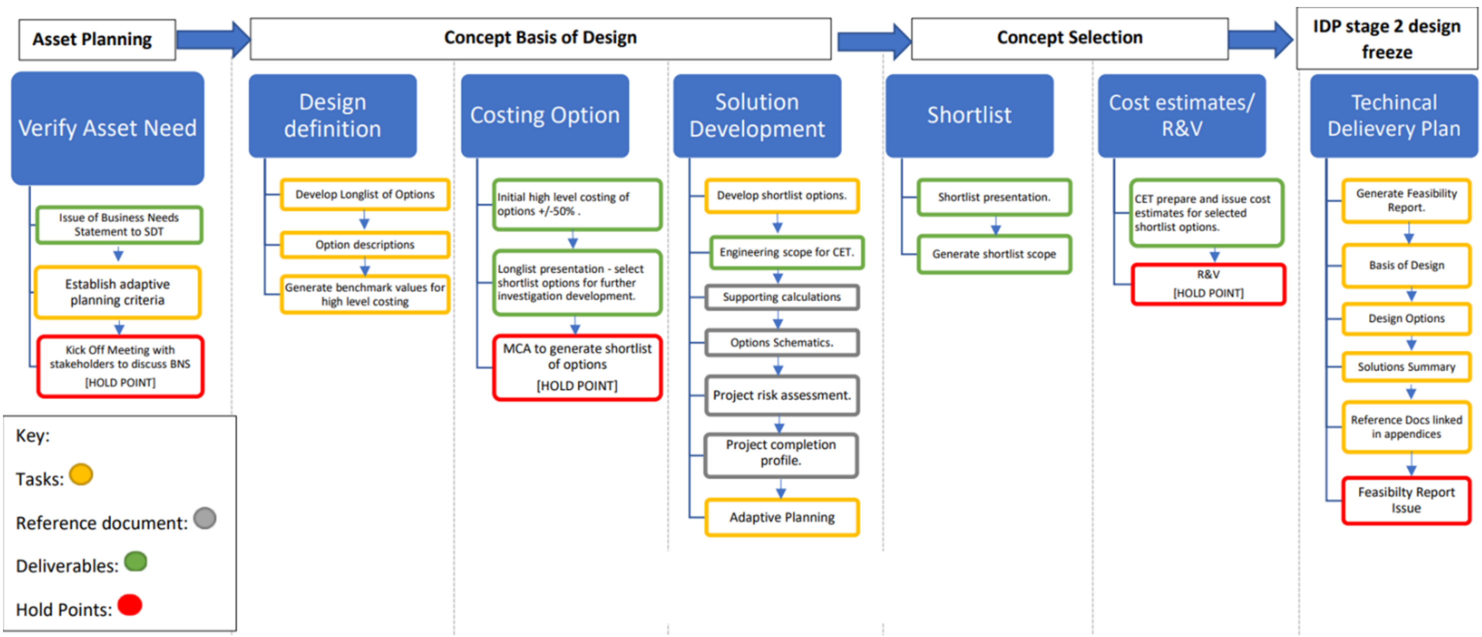
Site: Fradley **Un-Mitigated Risk Score** 13.22727

Date: 25/03/2022 **Mitigated Risk Score** 10.14773

Risk							Current Risk Mitigation	Residual Risk				Risk findings	DWSP
Risk	Risk Hazard	Event	Likelihood	Impact	Score	Future Score	Observation	Likelihood	Impact	Score	Future Score	Future controls	Linked
ID	*e.g. the incident or situation that can lead to the presence of a hazard*	*Biological, chemical, physical that may impact water quality, supply &/or have the potential to cause harm*	*Unmitigated Likelihood*	*Unmitigated Impact*	*Unmitigated Risk Score*	*10 years +*	*Document the observed risk*	*Mitigated Likelihood*	*Mitigated Impact*	*Risk score*	*10 Years +*	*If the risk controls are not sufficient, what mitigation is needed?*	*Y/N*
Environment													
9	Over Abstraction	Prosecution	4	4	16	16	Telemetry Alarm - SCADA Controlled - Station Checks - BH Pumps are sized correctly with VSD's - individual abstraction flow meter, Water Resources monitor (Olly to confirm Licence conditions for each BH).	2	4	8	8		Y
10	Breaching a discharge consent	Fish Kill, destruction of aquatic environment/Prosecution	5	2	10	10	combined BH discharge (duty of care) into a nearby ditch. Possible discolouration on start up. Flooding of farm land during RTW. Maintain reduced output to waste	2	4	8	8	(1) Review site RTW and route (2) Repair / replace valve on BH3 RTW due to leak	Y
11			4	3	12	12	RTW Contact tank *overflow into nearby ditch. Marginal chlorination water. Dechlorination and chlorine measurement manual Working Instruction.	2	3	6	6	(1) Auto RTW with dechlorination	Y
12			4	3	12	12	Boosted RTW. chlorinated water. Dechlorination and chlorine measurement manual.. Working Instruction.	2	3	6	9	(1) Auto RTW with dechlorination	Y
13			3	4	12	12	**Diesel** - No delivery bunded area, station checks, WI, Level instrumentation	2	4	8	8	(1) Consider need for bunded delivery area	Y
14			5	4	20	20	DWW Tank discharge through sludge plant is currently not within the limits of the discharge consent (Iron, flow rates).	5	4	20	20	(1) Review and re-design the sludge treatment plant	Y
15			4	4	16	20	STP- Routine maintenance and checks. Biannual empty.	2	4	8	12	(1) Routine - Sample every 2 months to confirm plant performance. Need to establish life expectancy of asset.	Y
16	Integrity of tanks	Chemical spill to environment	5	4	20	20	**Hypo** - Tank is 2700L, internal and bunded w/alarm - Level instrument in Tank - IBC delivery on level - Station checks , Building secured, spill kits.	2	4	8	12	(1) NDT test on tank integrity	Y
17			3	5	15	15	**Fluoride** - Bunded w/alarm - level instrument, delivery of set amount, Station checks, Building secure, spill kits	2	5	10	10	(1) On-going programme to upgrade Fluoride equipment	Y
18			5	4	20	20	**Phosphate** - Bunded, site levels, site checks, SCADA, day tank.	2	4	8	12	(1) NDT test on tank integrity	Y
19			3	4	12	12	**Bisulphate - 25l Carboys** mostly bunded - manual pump over - Station checks , Building secured, spill kits.	2	4	8	12	(1) asses bund integrity (2) Chemical dosing room requires for a full review along including bunding	Y
20			4	5	20	20	**Ferric** - 2x10,000l bulk, outside in constructed bund. Bulk delivery on level, Station checks, Secured compound	2	5	10	15	(1) NDT test on tank integrity and assess bund integrity	Y
21			3	4	12	12	**Diesel** - Tank part of generator and *double skinned, but not bunded, station checks, WI, Level instrumentation	2	4	8	8	(1) Consider need for bund	Y
22			2	2	4	4	**Polymer bags** 2x25kg - Stored inside on bunded pallet	2	2	4	4		Y

7.2 Costing estimation evidence

7.2.1 Aqua Quality Plan process flow



7.2.2 Aqua Problem Statement Template example

South Staffs Water

Morden Grange

Problem Statement:

PR24 Business Plan

Document Number: 2050-AQUA-NINF-PST-029a-BNS-Z-0114

Prepared by: Aqua Consultants

Problem Statement: Morden Grange PS					
PR24 Asset Management Team					
Version	Purpose	Author	Checked	Approved By	Date
1	Draft	Aqua Consultants (JO)	CJ		March 2023
2	Problem Statement Uprev	Aqua Consultants (JO/JS)			May 2023

Document RAG – Outstanding	
Issue	**RAG**
Root cause analysis complete	Information included from SSW identified risks
Sign off achieved	Pending SSW review
Data sources referenced and available	See table in Section 3.
Risks quantified	Risk score from CopperLeaf

Confidentiality Statement

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The information within this document should not be relied upon by any other party, or for any other purpose other than what is outlined within the document.

Contents

1. Introduction

This document demonstrates the need for investment in Morden Grange (NINF-PST-029a) driven by:

Table 1. List of Drivers

#	Six Capitals	Value Model Driver	Relevant?	Copperleaf RAG Status	Comments
1	Social Capital	Water Quality Compliance. Unplanned outages.	✓		Rising level of Nitrates.
2	Human Capital		☐		
3	Manufactured Capital		☐		
4	Financial Capital	Water Quality Compliance	✓		Rising level of Nitrates.
5	Natural Capital		☐		
6	Intellectual Capital		☐		

2. Executive Summary

Morden Grange WTW is located near Royston, approx. 23km South-West of Cambridge, England. The PS abstracts 3No. boreholes and is classed under B1 Non-Simple Groundwater. Morden Grange PS directly supplies the Heydon WSZ, as indicated in Figure 1 below:

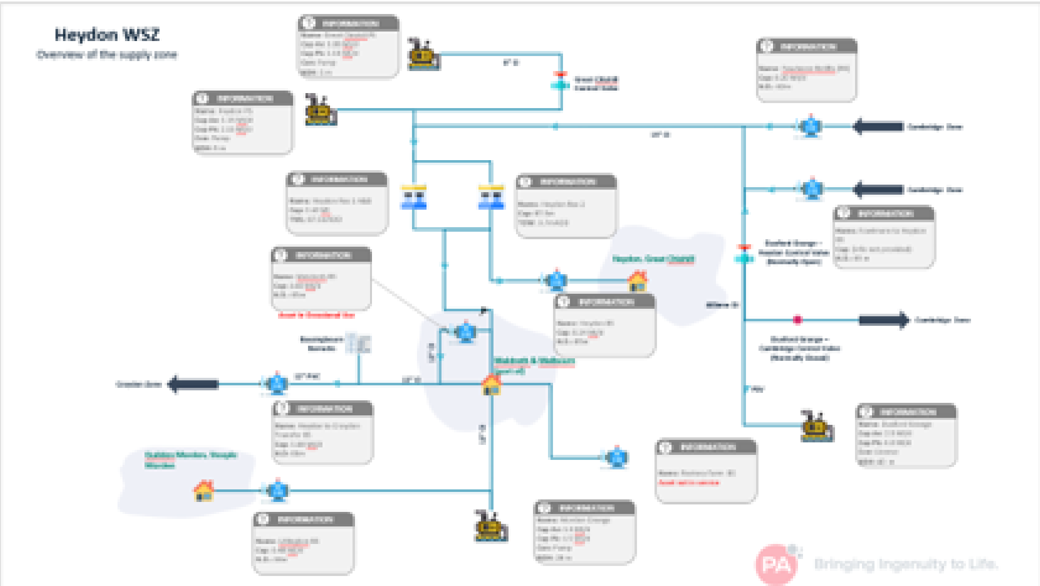

Figure 1. Heydon WSZ

There are several risks and needs across Morden Grange that are to be addressed as part of this scheme. Key Operating Parameters for Morden Grange PS are shown in Table 2 below:

Table 2. Key Operating Parameters

	Units	Value	Comments
Design Capacity	Ml/d	1.50	
Current average output	Ml/d	1.13	
Peak License Capacity	Ml/d	1.50	

Morden Grange PS has been identified to have the following associated risks:

NINF-PST-029a

L3 – Treatment Works Enhancement – Nitrate Removal. Rising levels of Nitrates in the raw water from Borehole 1 (Also rising in Boreholes 2/3 but only BH1 in operation currently).

Looking at the data from 2017 onwards, the elevation in Nitrate levels appears marginal. However, looking at data from 2007-2011, where the average was 38.99 mg/L, a clearer increase in Nitrate levels can be seen.

Company modelling forecasts that the average Nitrate concentrations will exceed the SSW internal trip limit of 45 mg/L between 2025-2030, which would cause the station to stop production.

Examination of the catchment has shown limited viability for management concentration using catchment management techniques. In particular, delay/lag times for land use changes (impacting nitrate concentrations in aquifer) are calculated to be between 50 and over 200 years for the majority of the catchment. This provides little alternative but to implement a Nitrate removal solution at the PS.

3. Data Sources Used

SSW have undertaken extensive investigations into the asset condition and criticality of Morden Grange PS. Links to relevant reports are provided below:

Table 3. Documentation

Report Name	Date of Issue	Issuer	Link
PR24 Zonal Studies Master	2023	SSW	PR24%20Zonal%20St udies%20Master.pptx
PPS 911 (MG)	2022	SSW	PPS 911 (MG) January 2022 draft.do
DWI Submission – Appendix B	2023	SSW	Appendix B PR24 su bmission Morden Gra
Sample Data	2022	SSW	Raw%20Nitrate%20tr ending%202022%20u

4. Current Performance

Existing Treatment Process

Morden Grange is currently operating below design capacity and below license capacity due to only 1 of 3 Boreholes being in operation. Currently only 1.13 Ml/d is abstracted out of a possible 1.50 Ml/d (License capacity).

There is also a trend of rising Nitrates at the station, which has been flagged by SSW Water Quality. The Nitrate concentration has risen from 38.99 mg/L in 2007-2011, to 42.32 mg/L in 2017-2023. Current modelling indicates that average nitrate concentrations shall exceed SSW Trip Limit of 45 mg/L between 2025-2030, causing pause in production. The elevated Nitrate levels should look to be reduced to ensure the station remains in supply.

Abstraction

3No. Boreholes, 2 Out of Service due to higher Nitrate levels, 1 in Operation – Current Operational Capacity 1.13 Ml/d, Design Capacity 1.50 Ml/d.

The abstracted water is elevated in Nitrates from all 3No. Boreholes, with Borehole 1 measuring an average of 38.64 mg/L, and Boreholes 2/3 an average of 41.07 mg/L.

Primary Treatment

None

Secondary Treatment

None

Tertiary Treatment

GAC Plant – Not in operation

Disinfection

Chlorination using Chlorine Gas.

Super-chlorination disinfection in contact tank using chlorine gas to achieve a minimum Ct value of 15 mg/l.min

Partial de-chlorination for final waters using sulphur dioxide.

Continuous initial chlorine residual monitoring (post Contact Tank) with alarm and automatic shutdown on breach of flow dependent set-points to ensure that the minimum Ct15 achieved.

Continuous final water free chlorine residual monitoring with alarm and site trip on reduction below 0.09 mg/l and above 0.21 mg/L.

A minimum Ct value of 15mg/l.min is designated for this site.

Final water free chlorine is adjusted at this site, by dosing sulphur dioxide, to achieve a residual of **0.15 mg/l**.

Waste Handling

Run to waste stream requires manual operation.

General

Shown in Figure 2 and Figure 3 below is the Morden Grange Operational Diagram and the Morden Grange Process Schematic respectively.

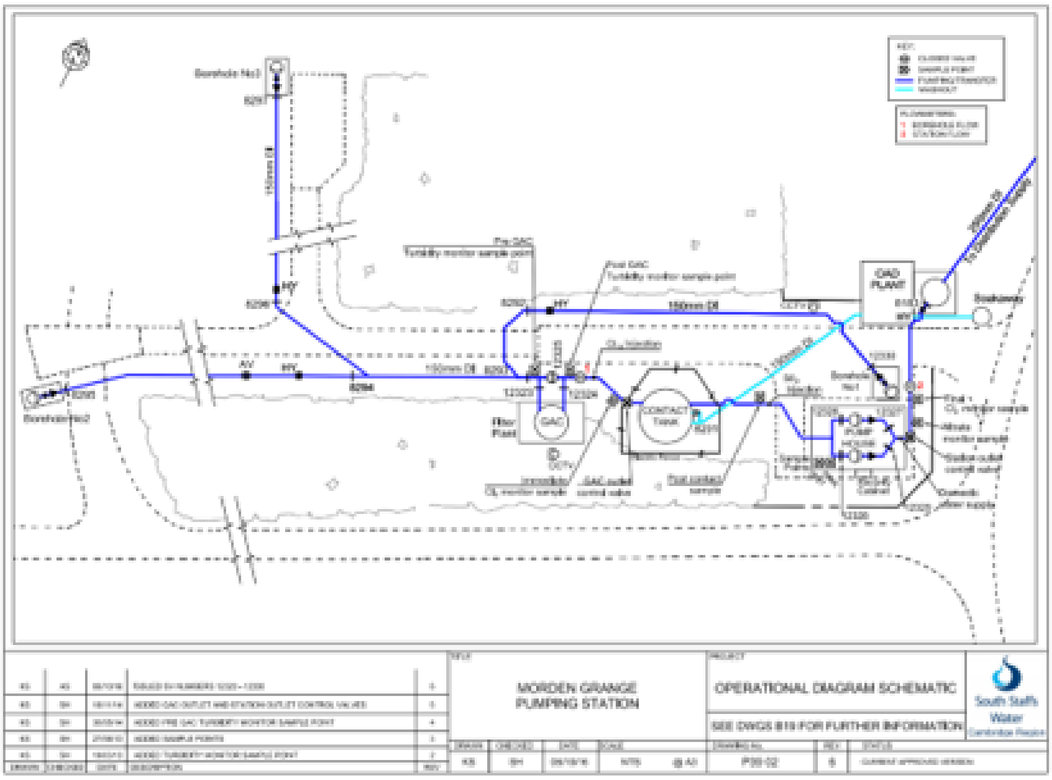

Figure 2. Morden Grange Operational Diagram

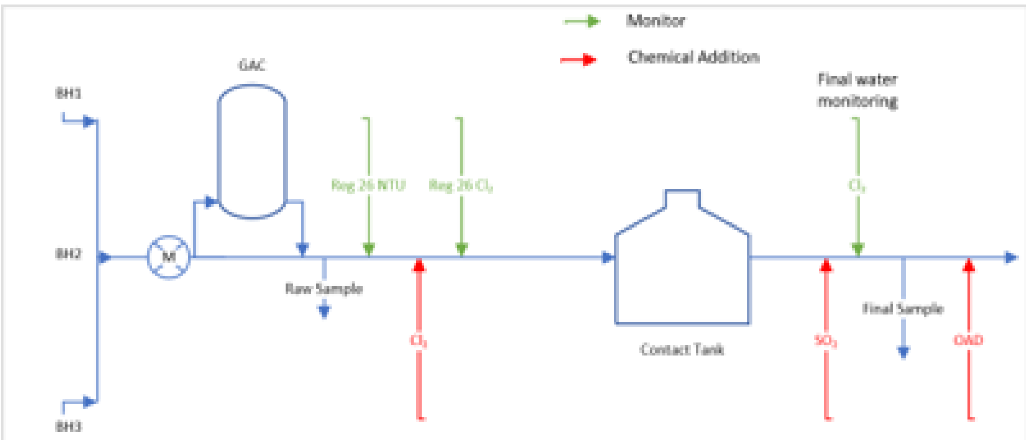

Figure 3. Morden Grange Process Schematic

5. Methodology: Review of risks to Morden Grange PS

Raw source water data has been provided and is linked in Table 3.

The site has been taken out of supply 3 times in the last 4 years for a combined period of 330 days. The sum of this is over 350 Ml loss of production during those periods. With elevated Nitrate levels continuing to rise predicting to reach the SSW Trip limit by 2025-2030, this is only expected to increase in the future if investment is not made to mitigate against rising levels of nitrates in the raw water. When coupled with the impending abstraction licence restrictions coming into force within our Cambridge reason asset availability will be more critical.

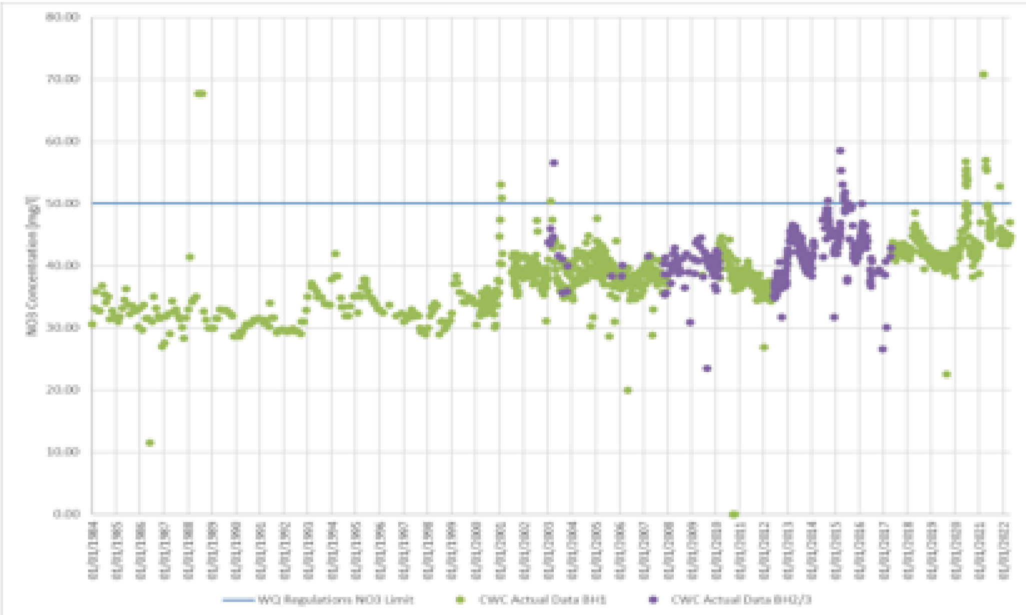

Figure 4. Morden Grange Nitrates

Table 4. Nitrate Raw Water Data analysis

Parameter	CWC Actual Data BH1	CWC Actual Data BH2/3
MAX	70.80	58.50
MIN	11.50	23.50
95% Percentile	46.21	48.13
AVERAGE	38.64	41.67

6. Future Outcome Performance

The issues being experienced by the site are summarized below along with the relevant risks and needs that need to be addressed.

Table 5, Morden Grange PS Risks and Needs

Six Capitals	Value Model	Risks	Needs
Financial Capital	Water Quality Compliance	Increasing nitrate levels at Morden Grange PS, with average Nitrate concentration breaching the SSW Limit of 45 mg/L by 2025-2030.	Nitrate removal treatment option required to remove elevated levels of Nitrates from the raw water.
Social Capital	Water Quality Compliance	Increasing nitrate levels at Morden Grange PS, with average Nitrate concentration breaching the SSW Limit of 45 mg/L by 2025-2030.	Nitrate removal treatment option required to remove elevated levels of Nitrates from the raw water.
Social Capital	Unplanned Outage	Risk of site being removed from supply due to increased Nitrate levels in raw water.	Nitrate removal treatment option required to remove elevated levels of Nitrates from the raw water.

7. Risk Position

Table 6. Risk Position

#	Six Capitals	Value Models	Baseline Risk £k	Comments
1	Social Capital	Water Quality Compliance Unplanned Outage	-£578 -£71	Copperleaf annualised risk
2	Human Capital			
3	Manufactured Capital			
4	Financial Capital	Water Quality Compliance	-£578	Copperleaf annualised risk
5	Natural Capital			
6	Intellectual Capital			

A total annual risk of -£649k

8. Conclusions

Morden Grange PS needs investment in AMP8 as to mitigate the risks identified of Water Quality Compliance and Unplanned Outage.

Based on historical and current data (2007-Present), Nitrate concentrations have risen from 38.99 to 42.32 mg/L. With site investigation and communication with SSW staff, it is perceived within 2025-2030, the site will breach internal Nitrate trip limits at the station, resulting in loss of production. It is recommended that the following is undertaken to address the site needs:

- Solution to provide Nitrate removal treatment at Morden Grange PS. to ensure nitrate levels of 45 are not present in the final water.

7.2.3 Aqua MCA longlist criteria

Solutions Criteria	Sub Criteria	Description	Score 1	Score 3	Score 5	Weighting
Ability to meet project drivers and regulatory compliance.	Regulatory Complexity	How complex will this option be to regulate as a solution? (e.g. will there be a complex licence/permit).	Higher complexity than current solution	Largely in line with current process	Improvement on current complexity.	35%
	Problem Resolution	Will the option address the obligation identified? How much certainty is there that the option will deliver the benefits required?	Not Certain	Certain	Very Certain	
	Existing asset performance during Construction	How do existing operations maintain performance during construction phase.	Integrated asset requires shutdown, I2S, standby pumping etc	Some dependency on upstream assets	Stand alone asset	
	Failure Risk	Is the option resilient to a range of future external factors/pressures, such as water quality, climate change and political and legislative changes?	Significant risk present	Moderate other risk present	Very Resilient	
Provide a long term solution to SSW	Business Acceptability	Is the option acceptable to all stakeholders?	Unlikely	Some adaptation would be required for stakeholders	Very likely.	15%
	Catchment resilience	Will the option impact on flood risk (fluvial, groundwater or surface run-off), area of wetland or riparian habitants and river water quality? Will the option provide a more resilient and flexible water supply for the environment and public and private abstractions?	Negative impact	Largely in line with current process	Positive impact	
	Land usage, access, amenity and engagement	Will the option impact on recreational value of local green spaces, and provide educational opportunities to the local community? Will the option provide environmental volunteering opportunities to the local community?	Negative social impact.	No social impact	Option will create new opportunities	
Providing Green Solutions	Net Zero	Proven	Significant impact	Moderate impact	Minimal Impact	5%
	Environmental Impact	Will the option impact typical environmental receptors such as ecology, built heritage, noise, potential pollution events	Significant impact	Moderate impacts	Minimal/positive impacts	
	Carbon Capture	Does the solution have a carbon sequestration potential (tree-planting, riparian buffer zones, hedgerows, peatland restoration)	No sequestration	Some sequestration	Significant sequestration	
	Natural Capital	Will the option impact the extent and condition of natural assets/stocks (e.g. water, air, soil, biodiversity) and therefore ecosystem services?	Significant NC impacts	Moderate NC impacts	Minimal/positive NC impacts	
	Biodiversity Impact	Will the option provide Biodiversity Net Gain (using the DEFRA metric)?	No Net Gain (onsite, offsite, credits)	Some BNG % with preference for onsite	Meets minimum BNG of 10% with preference for onsite	

Technically Feasibility	Technology Development Status	What is the maturity of the technology	Trial Stage, further investigation required.	Additional installations may be required.	Well proven solution	10%
	Construction/Buildability	What level of confidence is there that the scheme can safely and feasibly be constructed?	Multiple constraints and significant hazards in the construction phase that cannot be properly mitigated. Potential unknowns that could halt the project.	Elements of unmitigated risk at construction and potential project risks that could increase the scope.	The scheme has been designed with a high level of confidence around the constructability of the solution.	
	H&S in Operation	Would the option require an on-going level of management and maintenance? Are there H&S implications towards ongoing operability?	Solution creates unsafe working conditions for operators	Safe with untypical controls in place such as increased confined entry procedures, specialist rescue team required etc	Safe working conditions with typical safe working procedures in place	
Deliverability	Client Acceptability	Operational Experience of technology within SSW	Unfavoured technology or operational practice by client. Technology is unproven in client organisation	Some adaptation would be required for the client	Typical technology or operating practice for the client	10%
	Resourcing	Is the labour/resource available to manage and maintain this option?	No resource available for the option	Possible	Highly likely, resources are readily available	
	Complexity	Could the option be delivered without the need for extensive feasibility studies, trials, investigations or infrastructure modifications?	High complexity	Moderate complexity	Largely in line with current process	
Cost	Opex	What is the relative scale of the change in operational expenditure anticipated with the option?	Increase in Opex	Relatively similar Opex	Reduction in Opex	10%
	Capex	What is the relative scale of Capex expenditure anticipated with the option?	High Capex	Moderate Capex	Low Capex	

Solutions Criteria	Sub Criteria	Description	Score 1-5	Comments
Ability to meet project drivers and regulatory compliance.	Regulatory Complexity	How complex will this option be to regulate as a solution? (e.g. will there be a complex licence/permit).	4	under pressure tee's line stops and bypass. Existing main 10bar
	Problem Resolution	Will the option address the obligation identified? How much certainty is there that the option will deliver the benefits required?	5	
	Existing asset performance during Construction	How do existing operations maintain performance during construction phase.	4	18" CI will stay in commission using upt's and line stops once 400mm is commissioned.
	Failure Risk	Is the option resilient to a range of future external factors/pressures, such as water quality, climate change and political and legislative changes?	5	Very Resilient
Provide a long term solution to SSW	Business Acceptability	Is the option acceptable to all stakeholders?	5	Preference to lay a support main across private land
	Catchment resilience	Will the option impact on flood risk (fluvial, groundwater or surface run-off), area of wetland or riparian habitants and river water quality? Will the option provide a more resilient and flexible water supply for the environment and public and private abstractions?	3	No impact
	Land usage, access, amenity and engagement	Will the option impact on recreational value of local green spaces, and provide educational opportunities to the local community? Will the option provide environmental volunteering opportunities to the local community?	3	Minimal impact
Providing Green Solutions	Net Zero	Will the option impact on GHG emissions during construction (embodied emissions) and/or operation (operational emissions), i.e. new assets vs maintenance, energy costs change in land-use.	3	
	Environmental Impact	Will the option impact typical environmental receptors such as ecology, built heritage, noise	3	Private land disturbance
	Carbon Capture	Does the solution have a carbon sequestration potential (tree-planting, riparian buffer zones, hedgerows, peatland restoration)	3	Possibility across private land
	Natural Capital	Will the option impact the extent and condition of natural assets/stocks (e.g. water, air, soil, biodiversity) and therefore ecosystem services?	3	
	Biodiversity Impact	Will the option provide Biodiversity Net Gain (using the DEFRA metric)?	2	New 770m of water main

Solutions Criteria	Sub Criteria	Description	Score 1-5	Comments
Technically Feasibility	Technology Development Status	What is the maturity of the technology	5	Well established
	Construction /Buildability	What level of confidence is there that the scheme can safely and feasibly be constructed?	5	
	H&S in Operation	Would the option require an on-going level of management and maintenance? Are there H&S implications towards ongoing operability?	3	New water main is in Private land. Some fittings would be in the highway and could be difficult to operate.
Deliverability	Client Acceptability	Operational Experience of technology within SSW	5	
	Resourcing	Is the labour/resource available to manage and maintain this option?	5	
	Complexity	Could the option be delivered without the need for extensive feasibility studies, trials, investigations or infrastructure modifications?	3	Land entry details would be required.
Cost	Opex	What is the relative scale of the change in operational expenditure anticipated with the option?		
	Capex	What is the relative scale of Capex expenditure anticipated with the option?		

7.2.4 Aqua Cost Estimation Template example

An example of a cost estimation template used in our Phase 2 detailed cost estimation process.

PR24 Business Plan Estimate
CAPEX Costing
Cookley WTW - Enhancement (UV) Option : 2050-AQUA-NINF-PST-009a-CS50-Q-0255

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Direct Works (Assets and Site Specifics)

Item	Process	Process Group	Asset Type	New / Replace / Repair / Refurbishment	Asset	Nr	YS	Ys Driver	Total	Scope
1.01	Treatment Works	Disinfection	Ultra-Violet Disinfection	New	Ultra-Violet Disinfection (Ml/d)	1	18	Ml/d	£ 560,726	Cookley WTW new D/S 18Ml/d medium pressure UV treatment process
1.02	Assembly	Civil Items	Building	New	All concrete slabs (m3)	1	9	m3	£ 13,364	Slab for the high pressure UV treatment plant
1.03	Treatment Works	Disinfection	Contact Tank	New	Contact Tank (Ml)	1	0.3	Ml	£ 599,612	New 0.3Ml Contact tank
1.04	Assembly	Mechanical Items	Valve	New	Valve, Hand Isolating Valve => 350 - 600mm (mm)	8	500	mm	£ 38,783	Isolation Valves
1.05	Treatment Works	Interprocess Pipewor	Interprocess Pipework	New	Interprocess Pipework (mm dia)	150	500	mm	£ 160,976	Interconnecting pipework between new UV plant and Pumps
1.06	Assembly	Electrical Items	General	New	General - LV Cabling with Ducts and Draw	1	100	m	£ 28,648	LV cabling to new UV Plant
1.07	Assembly	ICA Items	General	New	Site Cabling - ICA Cabling with ducts, draw	1	100	m	£ 23,793	ICA Cabling to new UV Plant
1.08	Assembly	ICA Items	General	New	General - Fibre Optic ICA Cabling (m)	1	100	m	£ 17,417	Fibre Optic Cabling to new UV Plant
1.09	Treatment Works	Buildings	Kiosks	New	Kiosks M3	1	180	m3	£ 86,433	New kiosk to house UV Plant 10m x 6m x 3m high
1.10	**SITE SPECIFICS**									
1.11	Site Specifics	Site Specifics	Control & Monitoring (Inc	Enhance - Part	Motor Control Centre (MCC) (kW)	1	150	kW	£ 179,350.74	MCC upgrade incorporating new UV plant
1.12	Site Specifics	Site Specifics	Demolition	Demolish	DEMOLITION - TANKS - M3	1	300	m3	£ 24,174.00	Demolish existing Contact tank
1.13	Site Specifics	Site Specifics	Site Roads + Hardstanding	New	New Site Roads - Concrete (m2)	1	200	m2	£ 32,658.00	New access to UV building - allow 4m wide road x 50m long
1.14										
1.15										
1.16										
1.17										
1.18										
1.18										

Construction Indirect Costs

Item	Cost Heading			Total	Additional Comments
2.10	General Items - Contractor's Project Management, Supervison, Accommodation, Contractor's risk, Design, Surveys and investigations etc.	Water Non-infrastructure	**56.93%**	£1,005,316	Applied to total of Direct works costs
2.20	Contractor's Fee		**7.50%**	£207,844	Applied to total of Direct works costs and General Items

Project Overheads

Item	Cost Heading		Total	Additional Comments
3.10	South Staffs On Costs and Corporate Overheads	**14.00%**	£417,073	Applied to the total of Direct works Costs and Indirect Costs

Project Risk Allowance

Item	Cost Heading		Total	Additional Comments
4.10	Project Risk Allowance for unknown scope and site unknowns	**15.00%**	£509,425	Applied to overall costed Project

Project Cost	£3,905,592.22

7.2.5 Aqua Feasibility Report summary outputs

aquaconsultants
water · environment · energy

2050 Solutions Development Team

NINF-PST-029a

Morden Grange Nitrate Removal

Feasibility Report

South Staffs Water

Document control

Version	Status	Originator	Checker	Approved	Date
1.0	Issued for Client Review	K. Parmar J. Osbourne	J. Hodgkinson C. Waterworth	M. McNamara	June 2023

Confidentiality Statement

This document, in part and in its entirety contains confidential information. It should not be shown to or shared with other parties without consent from South Staffordshire Water PLC.

Table of contents

List of tables and figures

Project introduction

This feasibility study supports the longlist report 2050-AQUA-NINF-PST-029a-LSC-P-0183 - LSC Morden Grange Nitrate Removal as part of PR24.

This report aligns to the published guidance from both OFWAT and the Environment Agency (EA) on the development of water companies' environmental quality programmes for AMP8 and the PR24 price review.

To produce an effective and succinct document we have summarised and/or referenced other supporting evidence. This feasibility report exists as the audit trail of evidence used and decisions taken, including any sensitivity analysis, which forms the basis of the PR24 submission.

This feasibility report outlines the solution development, from scheme scoping, longlisting, shortlisting, and selecting preferred options, including costing and mitigation of risk. It details the process at which the options were produced, considering Systems Thinking; Adaptive Planning and aligned to the OFWAT criteria.

The basis of calculation for the shortlisted options and links to the supporting documents can be found in the

7.2.5.1 Summary

This document is to be read in conjunction with the corresponding Problem Needs Statement (embedded document in Appendix A).

The description of the scheme is:

- NINF-PST-029a - Water Quality. Nitrate concentration within the raw water (3 no. borehole sourced) has been trending upwards overall. A solution is required to ensure the elevated nitrates are adequately lowered to acceptable concentrations from the raw water before distribution.

The outline primary drivers for the scheme are:

Table 1: Project drivers from project needs statement.

#	Six capitals	Value model driver	Relevant?	Comments

1	Social Capital	Water Quality Compliance. Unplanned outages.	• ✓	Rising level of Nitrates.
2	Human Capital		• ☐	
3	Manufactured Capital	Water Supply Interruption	• ✓	Resilience risk, site currently not meeting abstraction license.
4	Financial Capital	Water Quality Compliance	•	
5	Natural Capital		• ☐	
6	Intellectual Capital		• ☐	

This project is an enhancement case as Morden Grange requires investment in AMP8 as to mitigate the risks identified of water quality compliance, unplanned outages, and water supply interruption. Based on historical and current data (1987-present, shown graphically in Figure 1), Nitrate concentrations have risen from ~30 to 45+ mg/L. With site investigation and communication with SSW staff, it is perceived within 2025-2030, the site will frequently breach internal nitrate trip limits at the station, resulting in loss of production.

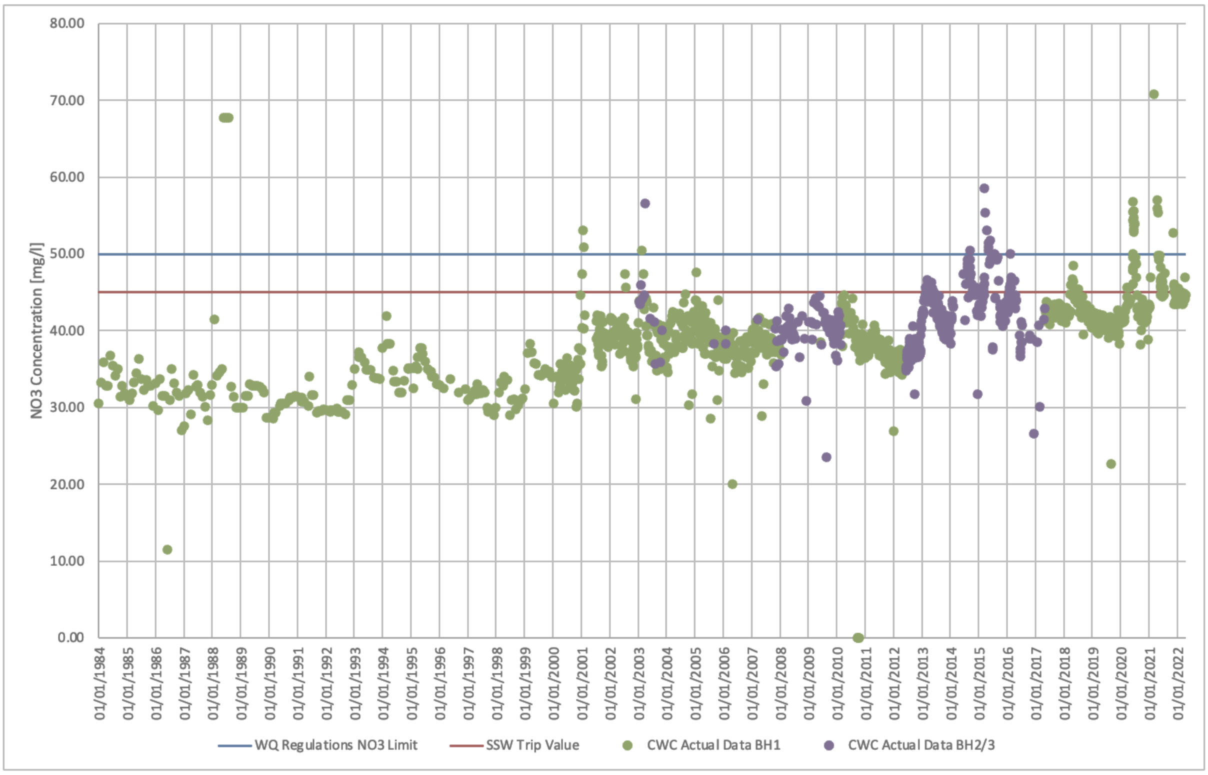

Figure 1: Raw water Nitrate Concentrations

A series of options were developed against these drivers following the process shown in Figure 2. Following an initial start-up meeting (in many cases held as part of the Initial Preferred Solution work), a series of longlisted options were developed, furthermore a Multiple Criteria Assessment (MCA) was completed for the long list options. The longlist options and MCA were presented at the longlist workshop with SSW to identify the shortlist options which were to be further developed for Risk and Value review.

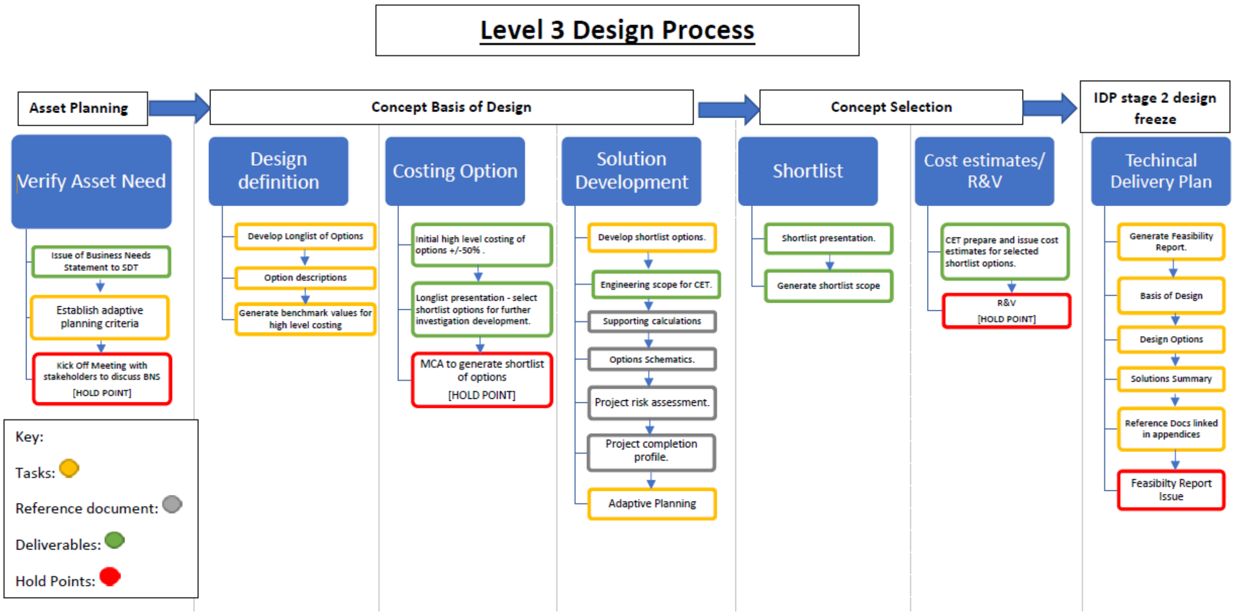

Figure 2: SDT process flow.

A full breakdown of this process can be found in the Quality Management / Design Execution Plan for the project (embedded document in Appendix A).

7.2.5.2 Longlisting

The scheme start up and initial preferred solution meeting was carried out as a workshop with key stakeholders, where drivers, site conditions, identified options and the initial preferred solution were discussed (meeting video link in Appendix A).

Table 2: Stakeholders at the scheme workshop.

Aqua attendees	SSW attendees
Justin Hodgkinson (Facilitator/Technical Lead)	Stuart Jones (Water Quality)
Terry Anderson (Cost Estimating Team)	Robert Boswell (Head of Production)
Jeremy Osborne (Asset Planning)	
Robert Chin (Technical Lead)	

Minutes and actions of the workshop were recorded within IPS Minutes (embedded document in Appendix A).

The identified options were investigated, scoped, and provided with +/-50% cost estimates. The outputs were issued to SSW in a Long List Presentation (LLP). Table 3 lists and describes the long list options, its score and whether the option was progressed to shortlisting. A full breakdown of the longlist options can be found in the link to the LLP (embedded document in Appendix A).

Table 3: Summary of longlist options.

Option	Type of option	Brief description of option and comments	MCA score	Progressed to shortlisting?
0	**Do nothing.** *Manage demand and operation or use of the existing asset or service*	Assumes base maintenance on Morden Grange is carried out. Wholesome water production will continue to be limited due to no treatment process nitrate removal.	2.96	☐

Option	Type of option	Brief description of option and comments	MCA score	Progressed to shortlisting?
1	Option 1 *Manage existing asset or service*	Geohydrology study + borehole assessment. Monitor the nitrates of all boreholes to assess blending potential to lower nitrates.	3.41	✓
2	Option 2 *Enhance/upgrade the existing asset or service*	New dedicated inline process unit for nitrate removal.	3.71	✓
3	Option 3 *Enhance/upgrade the existing asset or service*	New side stream process unit for nitrate removal.	3.58	☐
4	Option 4 *Enhance/upgrade the existing asset or service*	Network blending. Opportunity for blending supply with Affinity water. Existing network connection approx. 2.8km away.	3.84	✓

A multiple criteria assessment (MCA) of the options was carried out to assist in the selection of the shortlisted options. A screenshot of the final scoring is shown in Figure 3. Detailed scoring, with accompanying comments, can be found in the MCA excel spreadsheet (embedded document in Appendix A).

Scheme ID	Option Nr		Ability to meet project drivers and regulatory compliance.				Provide a long term solution to SSW			Providing Green solutions				
			Regulatory Complexity	Problem Resolution	Exisitng Asset performance during construction	Failure Risk	Business Acceptability	Catchment resilience	Access, amenity and engagement	Net Zero	Environmental impact	Carbon Capture	Natural Capital	Bioiversity Impact
		Option Description/ Weight	0.35				0.20			0.10				
PST-029a	0	Do nothing	3.00	1.00	3.00	1.00	1.00	3.00	3.00	5.00	5.00	1.00	5.00	1.00
PST-029a	1	BH Studies Relining	3.00	2.00	3.00	1.00	3.00	3.00	3.00	5.00	5.00	1.00	5.00	1.00
PST-029a	2	Full Stream IeX	2.00	5.00	3.00	5.00	5.00	3.00	3.00	3.00	2.00	2.00	5.00	1.00
PST-029a	3	Partial IeX	2.00	4.00	3.00	4.00	5.00	3.00	3.00	3.00	2.00	2.00	5.00	1.00
PST-029a	4	Network Blending	3.00	2.00	4.00	3.00	5.00	4.00	3.00	5.00	5.00	1.00	5.00	1.00

Scheme ID	Option Nr		Technically Feasibility			Deliverability			Cost		Total Weighted Score	Ranking	Selected For Shortlist Solution
			Technology Development Status	Construction/ Buildability	H&S in Operation	Client Acceptability	Resourcing	Complexity	Capex	Opex			
		Option Description/ Weight	0.15			0.10			0.10				
PST-029a	0	Do nothing	3.00	3.00	3.00	5.00	5.00	5.00	5.00	5.00	2.96	5	
PST-029a	1	BH Studies Relining	5.00	5.00	5.00	5.00	5.00	3.00	5.00	5.00	3.41	4	Y
PST-029a	2	Full Stream IeX	5.00	5.00	5.00	5.00	4.00	3.00	2.00	3.00	3.71	2	Y
PST-029a	3	Partial IeX	5.00	5.00	5.00	5.00	4.00	3.00	3.00	3.00	3.58	3	N
PST-029a	4	Network Blending	5.00	5.00	5.00	5.00	3.00	4.00	5.00	5.00	3.84	1	Y

Figure 3: Screenshot of MCA summary. Green cells indicate high score and red low.

After SSW stakeholder review of the LLP and MCA it was agreed that options 1, 2 & 4 would be taken forward to shortlisting. The overview table below provides an overview of each options scoring performance with regards to the criteria, commentary is also included where applicable.

Table 4: Overview of options scoring against criteria, including commentary.

Option	Taken forward?	Well scored criteria	Poorly scored criteria	Comments
Option 0: Do nothing	No	• Deliverability. • Cost.	• Ability to meet project drivers and regulatory compliance. • Technical feasibility. • Deliverability.	-
Option 1: BG studies relining	Yes	• Technical feasibility. • Cost.	• Potential to provide a long-term solution to SSW.	-
Option 2: Full stream Ion exchange process	Yes	• Ability to meet project drivers and regulatory compliance. • Provide a long-term solution to SSW.	• Cost. • Providing green solutions.	-
Option 3: Partial Ion exchange process	No	• Technical feasibility. • Provide a long-term solution to SSW.	• Providing green solutions.	Full stream option to be taken forward with bypass included.
Option 4: Network blending	Yes	• Technical feasibility. • Cost. • Ability to meet project drivers and regulatory compliance.	• Ability to meet project drivers and regulatory compliance, based on WQ from Affinity.	-

7.2.5.3 Shortlisting

Following the MCA Longlist Review, South Staffs selected a number of options to be progressed to shortlist, where a more in-depth engineering solution was developed and priced to a more accurate +/-30% estimate, following the procedure established in the Quality Management Plan (embedded document in Appendix A).

The following options were shortlisted:

- Option 1: Geohydrology study & borehole assessment.
- Option 2: New dedicated inline Ion Exchange process unit for nitrate removal.
- Option 4: Network blending.

Option 1: Geohydrology study & borehole assessment

Option description

Boreholes 2 & 3 are in the process of being recommissioned (anticipated to be online in Summer 2023). The historical data indicates that all boreholes draw from a similar aquifer, so the benefit of potentially blending these to reduce nitrates is medium to low.

However, the proposed option constitutes the following:

- Online monitoring of nitrates from all BHs to assess blending potential of the Bhs to lower nitrates.
- A geohydrological study to assess whether the BH pumps can be raised/lowered to potentially lower nitrate concentrations, and any significant nitrate contributors within the catchment.
- BH casings assessment and potential relining, again to potentially lower nitrate concentrations.

A schematic for this option is illustrated in Figure 4 (embedded document in Appendix A). Table 5 and Table 6 provides the advantages and disadvantages of the chosen solution and its suitability on meeting the primary driver, and adaptive planning considerations respectively.

Option 1

Monitor the nitrates of all BH to assess blending potential to lower nitrates. Furthermore, the solution proposes two additional studies/assessments:

- A geohydrological study to assess whether the BH pumps can be raised/lowered.
- BH casings assessment and potential relining/refurbishment.

Key

- Potential Relining/ Refurbishment
- N – Online Nitrate Monitor

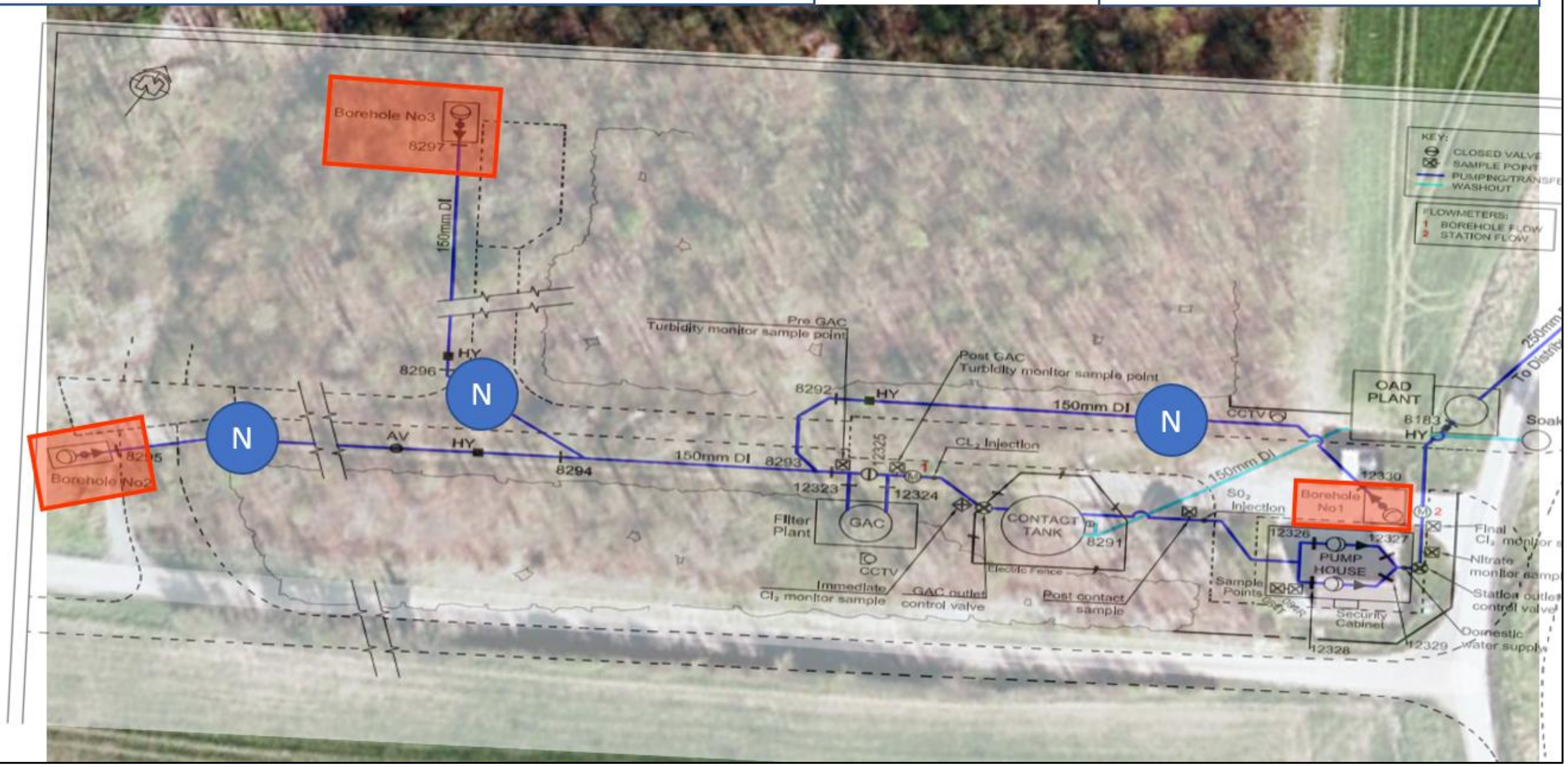

Figure 4: Option 1 schematic.

Table 5: Option 1 advantages and disadvantages.

Advantages	Disadvantages
Potentially, a combination of blending waters from the three BHs, altering operating depth/linings of the BH, and a catchment assessment could lower the nitrate concentration. Utilising existing assets, to potentially meet the driver.	Limited to no certainty of success prior to implementation. If not successful, then driver is not met, and further options will need to be implemented.
Significant lower CAPEX and OPEX cost when comparing all three proposed options.	-

Table 6: Adaptive planning considerations.

Category	Description
General Site Requirements	Demand management (shutdowns) will need to be implemented whilst BH investigations and remediations are implemented. Process investigations less likely to impact typical operation.
Climate Change	Considered but no issues for future use.
Regulatory Shifts	PCV limit for nitrate may reduce further in future. If Option 1 solution met driver initially but not future regulation requirements, Option 2/3 may need to be considered to meet requirements.
Demand	If successful, Option 1 will improve overall supply and water quality.
Technology	Latest technologies in borehole investigations and refurbishments to be used.
Unique Regional Factors	Conditions and variables unique to the South Staffordshire have been taken onto consideration.

Basis of calculations

The following source information, calculations and approach were used to build the case for investment for Option 1.

Table 7: Option 1 data sources used.

Data Set	Data provider	Data-date	System or data source	Comments
PR24 Zonal Studies Master	SSW	2023	PR24 Zonal Studies Master.pptx	Preliminary planning.
PPS 911 (MG)	SSW	2022	PPS 911 (MG) January 2022 draft.docx	Includes high level site layout used for planning.
Sample Data	SSW	2022	Raw Nitrate trending 2022 update.xlsm	Data indicating increasing trend of nitrates from source water.

This more investigation orientated option focussed on reducing the nitrates at source and was based on SSW solutions proposed based on their experience in managing other BH schemes with high nitrates.

- Bore hole investigations.
  - SSW indicated that the casings have potentially failed on the Boreholes.
  - SSW indicated varying levels of success in reducing nitrates by varying operating depths of pumps.
- Catchment assessment
  - Identify potential nitrate contributors within catchment and assess viability of reduction.
- Online monitoring to assess success of Option 1, and potential blending.

This option is envisaged as the first of a phased approach. If this option does not meet the drivers, the options in the paragraphs below are to be considered.

Risk & opportunities

The Copperleaf investment manager software quantified the following current baseline risks, against which the solution for Option 1 was designed to mitigate.

Table 8: Copperleaf baseline risks against Option 1.

Value Measure	Value (£)	Value Model Name	Category
Water Quality Cost - Private	10,507,748	Water Quality Compliance (CRI)	Risk
Water Quality Cost - Societal	15,011,069	Water Quality Compliance (CRI)	Risk
Water Quality Cost - WTP	7,858	Water Quality Compliance (CRI)	Risk
Water Supply Interruptions - Private	1,310,628	Water Supply Interruptions	Risk
Water Supply Interruptions - Societal	178,560	Water Supply Interruptions	Risk
Water Supply Interruptions WTP	2,464	Water Supply Interruptions	Risk
Unplanned Outage - Private	89,600	Unplanned Outage	Risk
Sum Total Risk	**27,107,927**	-	Risk

A concept design risk assessment (DRA) was carried out against the option. Full details can be found within the DRA spreadsheet (embedded document in Appendix A).

The significant/residual risks for this option are presented below:

Table 9: Option 1 significant residual risks.

Risk ref.	Delivery risk	Justification	Mitigation measures
SRR1	Construction vehicle access	Access will be required for investigation vehicles	Access to existing site is already in place - to be surveyed for ability to manage construction vehicles.

Risk ref.	Delivery risk	Justification	Mitigation measures
SRR2	Shut down impacts	BH shut down during investigations can limit supply.	Investigations to take place only once BH 2&3 back online to limit supply interruptions.
SRR3	Water Quality	Investigations and relining do not reduce nitrate concentrations.	Will need to progress to options presented below.

Cost estimations

High level feasibility design for all options is compliant with relevant SSW standards; specifications and standard solutions are considered to be applicable for +/-30% cost estimating, up to a standards date of April 2022 (+/- 30 CET embedded document in Appendix A).

All costs are listed in the PR24 price base of 2022/23. The 30-year asset review period costing for this projected had to be calculated manually by SDT from CET output rather than being provided automatically.

An R&V session was carried out on to quantify the risk against the project and for entry into Copperleaf. For more detail view the R&V spreadsheet (embedded document in Appendix A).

Table 10: Option 1 cost assessment.

Category	Cost (£k)				
CAPEX Delivery Cost	1015				
Change in Annual OPEX Cost	1.457				
Project Cost Profile*	Year 1	Year 2	Year 3	Year 4	Year 5
	1015				
Project Start Year (where available)	25-Apr				

Whole Life Cost	26,068,761
Benefit to Cost Ratio	26.09

* 1st *year represents the commencement of the scheme i.e., detailed investigation and not Year 1 of the AMP.*

The project start has been modelled as April 2025 to reflect what has been modelled in Copperleaf.

Option 2: New dedicated inline process unit for nitrate removal

Option description

Ion Exchange is the preferred nitrate removal technology for Morden Grange, due to the required efficacy of removal based on raw water quality and likelihood of the site being unmanned for significant periods. Furthermore, Ion exchange is used at other SSW sites for nitrate removal so there is institutional knowledge of the systems, and there are several reg 31 approved vendors.

This option involves:

- A 2.85 Ml/day Ion-exchange (IeX) process unit to be incorporated within the existing process.
- System to include of secure kiosk, blind tank for wash collection with tanker collection point that will be tankered on a weekly basis.
-

A schematic for this option is illustrated in Figure 5 (embedded document in Appendix A). Table 11 and Table 12 provides the advantages and disadvantages of the chosen solution and its suitability on meeting the primary driver, and adaptive planning considerations respectively.

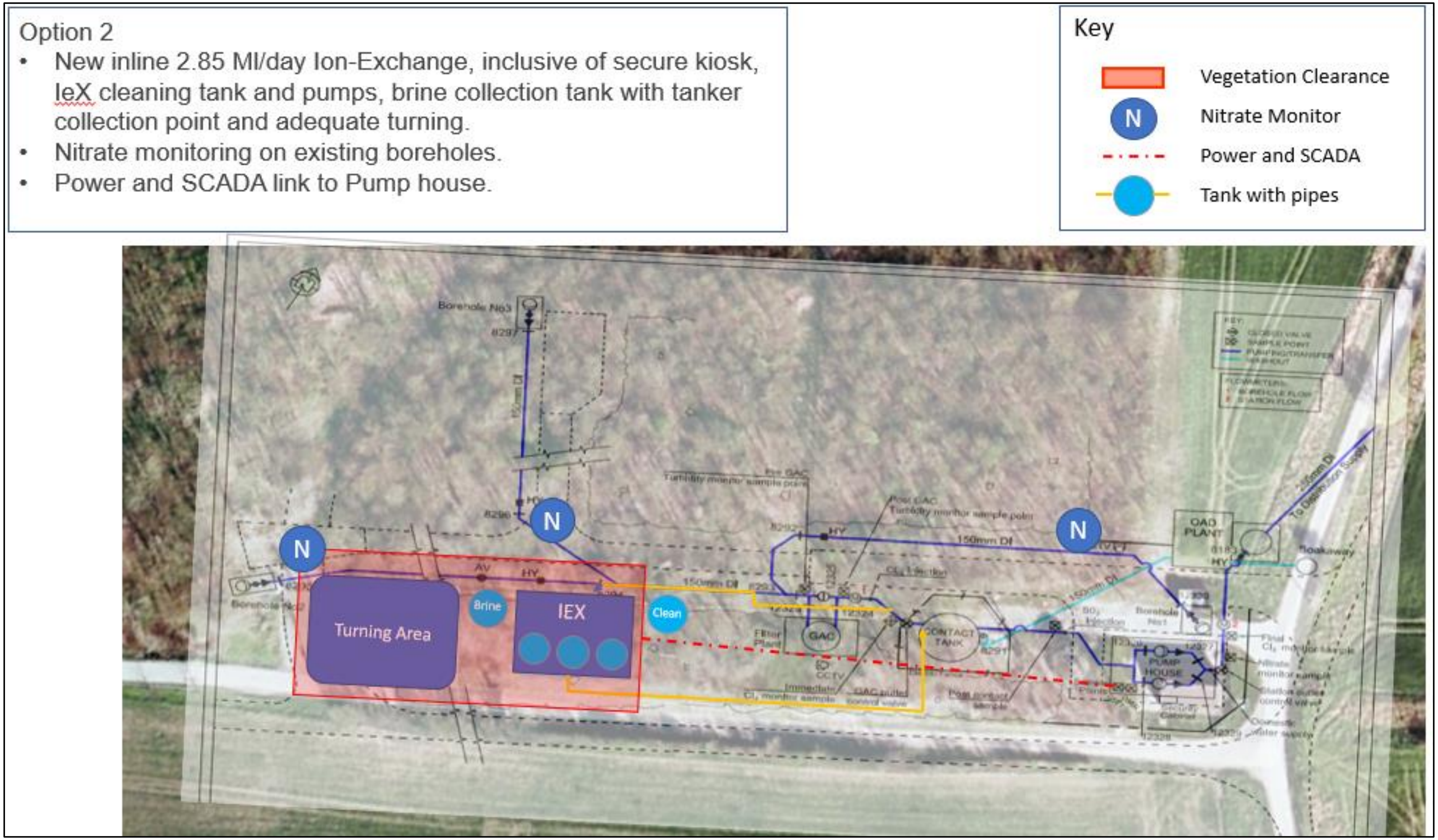

Figure 5: Option 2 schematic.

Table 11: Option 2 advantages and disadvantages.

Advantages	Disadvantages
Ion-exchange systems for nitrate removal are an established technology with high removal efficacy. Will meet the driver.	Option will add a new waste (brine stream) that will need to be disposed of.
There is sufficient space on site to accommodate new infrastructure and tie-ins are readily accessible.	A more CAPEX and OPEX intensive solution. OPEX costs include increased power consumption, chemical (salt) and brine disposal (likely tinkered to disposal site).
-	Existing power supply may be insufficient to meet new demands (not likely as increase in power will likely be nominal).

Table 12: Option 2 adaptive planning considerations.

Category	Description
General Site Requirements	Sufficient space to include the proposed solution near the anticipated tie-in point. Sufficient road access for a tanker to enter, withdraw, turn, and exit site. Sufficient power to meet increased needs to be established.
Climate Change	Constant tinkering of brine solution not ideal, alternatives to be explored at detailed design.
Regulatory Shifts	Most resilient option if regulation nitrate concentrations decrease.
Demand	Option will improve supply and quality to end users.
Technology	Latest ion exchange technology to be utilised.
Unique Regional Factors	Conditions and variables unique to the South Staffordshire have been taken onto consideration. SSW familiarity with ion exchange for nitrate removal beneficial.

Basis of calculations

The following approach and calculations were used to build the case for investment for Option 2.

Table 13: Option 2 data sources used.

Data Set	Data provider	Data-date	System or data source	Comments
PR24 Zonal Studies Master	SSW	2023	PR24 Zonal Studies Master.pptx	Preliminary planning.
PPS 911 (MG)	SSW	2022	PPS 911 (MG) January 2022 draft.docx	Includes high level site layout used for planning.
Sample Data	SSW	2022	Raw Nitrate trending 2022 update.xlsm	Data indicating increasing trend of nitrates from source water.

As described above this option (and option 4 below) is recommended to be considered if Option 1 does not meet the drivers, as part of the phased approach to minimise unnecessary capital expenditure.
This option was selected as it aims to improve both the source water and add a full treatment process that is guaranteed to meet the driver, and further future proofing the solution.

- Bore hole investigations (high potential that these could have been completed as part of Option 1)
    - SSW indicated that the casings have potentially failed on the Boreholes.
    - SSW indicated varying levels of success in reducing nitrates by varying operating depths of pumps.
- Treatment process.
    - Include an ion exchange plant capable of treating peak flow to remove nitrates with a high efficacy.

Risk & opportunities

The Copperleaf investment manager software quantified the following current baseline risks, against which the solution for Option 2 was designed to mitigate.

Table 14: Copperleaf baseline risks against Option 2.

Value Measure	Value (£)	Value Model Name	Category

Water Supply Interruptions WTP	194	Water Supply Interruptions	Risk
Water Supply Interruptions - Societal	14,081	Water Supply Interruptions	Risk
Water Supply Interruptions - Private	103,356	Water Supply Interruptions	Risk
Water Quality Cost - WTP	8,731	Water Quality Compliance (CRI)	Risk
Water Quality Cost - Societal	16,678,965	Water Quality Compliance (CRI)	Risk
Water Quality Cost - Private	11,675,276	Water Quality Compliance (CRI)	Risk
Unplanned Outage - Private	109,154	Unplanned Outage	Risk
Sum Total Risk	**28,589,758**	-	**Risk**

A concept design risk assessment (DRA) was carried out against the option. Full details can be found within the DRA spreadsheet (embedded document in Appendix A).

The significant residual risks for this option are presented below:

Table 15: Option 2 significant residual risks.

Risk ref.	Delivery risk	Justification	Mitigation measures
SRR1	Seasonal habitat removal	Vegetation removal required on existing site.	Ecology survey to be carried out prior to any vegetation removal. Investigations included in scope.
SRR2	Presence of third-party utilities, electric, gas, telecoms etc.	Existing site with potential for buried utilities.	Utility survey, CAT, GPRS and Genny to be done. Investigations included in scope.

Risk ref.	Delivery risk	Justification	Mitigation measures
SRR3	Construction vehicle access	Access will be required for construction and install.	Access to existing site is already in place - to be surveyed for ability to manage construction vehicles.
SRR4	Ground conditions	Ground conditions largely unknown, other than existing assets are on the site ground.	Survey to be carried out of ground conditions. Investigations included in scope.
SRR5	Shut down impacts	Shutdown during tie-in.	Planning, preparation, and stakeholder engagement to ensure no/minimal disruptions to consumer.
SRR6	Reliance on existing assets (isolation valves, pipework etc.)	New systems to be tied into existing infrastructure (mechanical pipework, electrical supply, SCADA etc)	Conditional assessment of all potential interfaces at appropriate design stages. Investigations included in scope.
SRR7	Constrained space on site	Constrained space.	Proposed option has a relatively low footprint, and desktop studies indicate sufficient space. Full survey to confirm appropriate location. Investigations included in scope.
SRR8	Electrical capacity	Additional power for IeX (increased head for losses through cartridges) may exceed existing capacity.	Site power capacity to be assessed and compared to load schedules generated at early design stages. Implement upgrades timeously if required. Investigations included in scope.
SRR9	Ground water/proximity to watercourse	New brine waste stream	Complaint storage and disposal
SRR10	High pressure system	Pressures may nominally exceed current operation.	Full hydraulics assessment as early as possible within the design phase, update accordingly.

Risk ref.	Delivery risk	Justification	Mitigation measures
SRR11	Waste Stream	New brine stream from IeX cleansing.	Commence early investigations to discharge waste stream (sewer, collection and transport, soakaway etc.). Obtain required licences/consents ASAP.
SRR12	Plant Hydraulics	Unknown whether IeX system can be incorporated within existing scheme without the need for booster pumps, or BH pump upgrade.	Full hydraulics assessment as early as possible within the design phase, update accordingly.
SRR13	Water Quality	Extensive raw water quality data will be required to enable an optimal design	Only nitrate concentrations available. Full suite of analytes required for complete design. Collect historical data and start sapling regime if any gaps are found.

Cost estimations

High level feasibility design for all options is compliant with relevant SSW standards; specifications and standard solutions are considered to be applicable for +/-30% cost estimating, up to a standards date of April 2022 (+/- 30 CET link embedded document in Appendix A).

All costs are listed in the PR24 price base of 2022/23. The 30-year asset review period costing for this projected had to be calculated manually by SDT from CET output rather than being provided automatically.

An R&V session was carried out on to quantify the risk against the project and for entry into Copperleaf. For more detail view the R&V spreadsheet (embedded document in Appendix A).

Table 16: Option 2 cost assessment.

Category	Cost (£k)
CAPEX Delivery Cost	13874
Change in Annual OPEX Cost	403,7

Project Cost Profile*	Year 1	Year 2	Year 3	Year 4	Year 5
	4,440	9,434			
Project Start Year (where available)	25-Apr				
Whole Life Cost	10,072				
Benefit to Cost Ratio	1.54				

* 1st *year represents the commencement of the scheme i.e., detailed investigation and not Year 1 of the AMP.*

The project start has been modelled as April 2025 to reflect what has been modelled in Copperleaf.

Option 4: Network blending

Option description

This option involves:

- Blending water supply with a supply from Affinity water.
- Replacing and existing 2.8km long 3" main with a 6" main.

A schematic for this option is illustrated in Figure 6 (embedded document in Appendix A) Table 17 and Table 18 provides the advantages and disadvantages of the chosen solution and its suitability on meeting the primary driver, and adaptive planning considerations respectively.

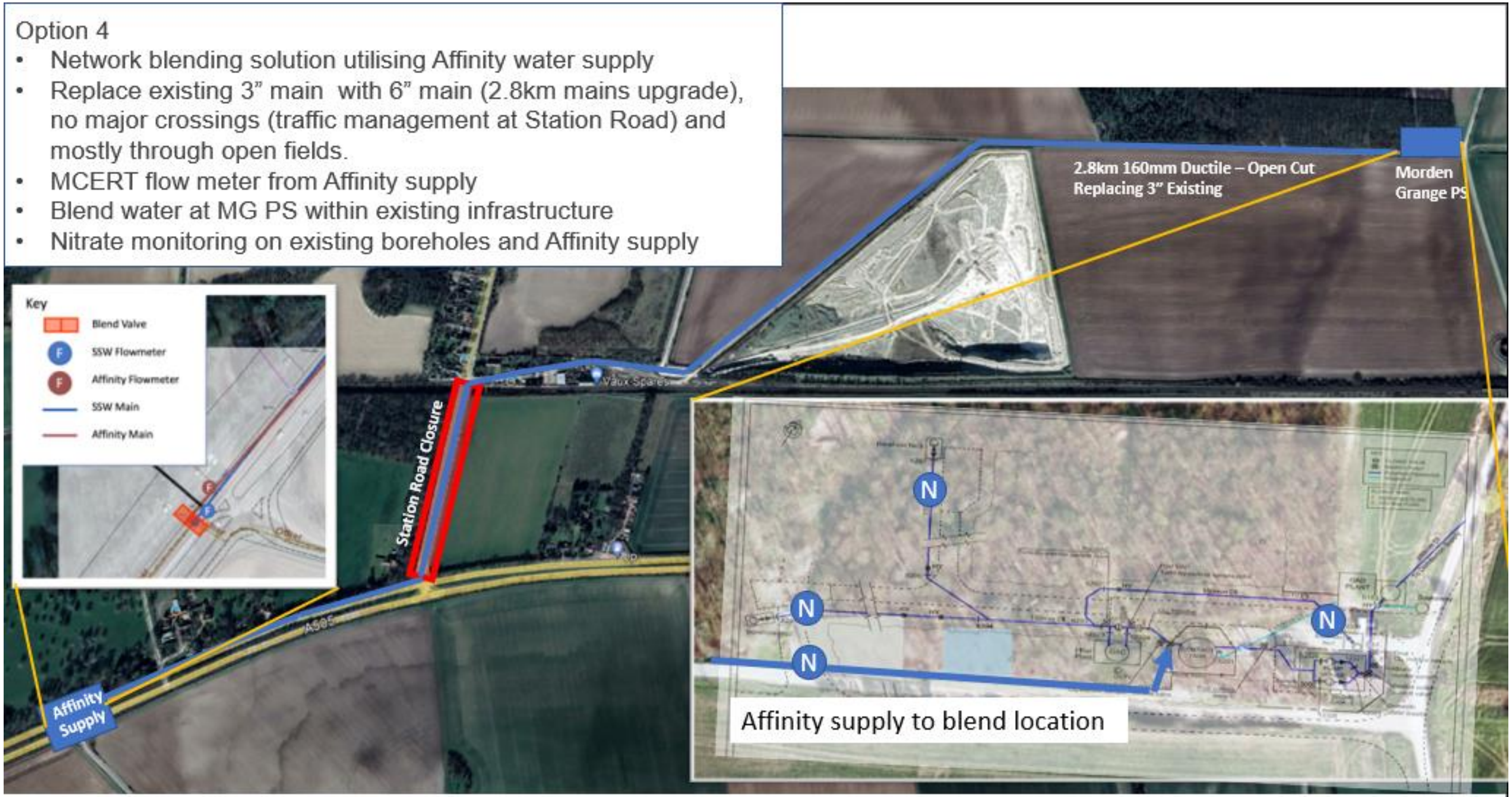

Figure 6: Option 4 schematic.

Table 17: Option 4 advantages and disadvantages.

Advantages	Disadvantages
Meets driver if there is adequate supply of low nitrate concentration water.	Complexity due to involvement with Affinity Water. Supply and quality, can be mitigated with SLA.
Lower CAPEX and OPEX than dedicated treatment process.	-
Replacing an existing small diameter main, mitigating common risks with new pipelines.	-

Table 18: Option 4 adaptive planning considerations.

Category	Description
General Site Requirements	Existing main to be replaced with a new main that is not significantly larger. Should be a simple pipe laying project.
Climate Change	Considered but no issues for future use.
Regulatory Shifts	Risk of cross company supply, but nothing that can't be mitigated with service level agreement.
Demand	If successful option will improve supply and quality to end users. However, Affinity may have to reduce supply, due to their own demands, which could compromise supply and WQ. But again, service level agreement.
Technology	MCERT flow meters for accurate tracking of cross-company supply.
Unique Regional Factors	Conditions and variables unique to the South Staffordshire have been taken onto consideration.

Basis of calculations

The following approach and calculations were used to build the case for investment for Option 4.

Table 19: Option 4 data sources used.

Data Set	Data provider	Data-date	System or data source	Comments
PR24 Zonal Studies Master	SSW	2023	PR24 Zonal Studies Master.pptx	Preliminary planning.
PPS 911 (MG)	SSW	2022	PPS 911 (MG) January 2022 draft.docx	Includes high level site layout used for planning.
Sample Data	SSW	2022	Raw Nitrate trending 2022 update.xlsm	Data indicating increasing trend of nitrates from source water.
SSW Blend Proposal	SSW	2022	GIS Morden Grange blend.docx	-

As described above this option (and option 2 above) is recommended to be considered if Option 1 does not meet the drivers, as part of the phased approach to minimise unnecessary capital expenditure.

This option was selected as SSW have previously investigated the feasibility of blending water with and other water company (Affinity) who have a water main close to the Morden Grange site. The highlighted concerns that will need to be established are:

- Quantity of supply. Is there sufficient water from Affinity to provide an adequate blend.
- Quality of supply. Is the supplied water suitable to blend, not just in terms of nitrates but other analytes such as chlorine residual, THM pre-cursors etc.

Risk & opportunities

The Copperleaf investment manager software quantified the following current baseline risks, against which the solution for Option 4 was designed to mitigate.

Table 20: Copperleaf baseline risks against Option 4.

Value Measure	Value (£)	Value Model Name	Category
Water Supply Interruptions WTP	1,377	Water Supply Interruptions	Risk
Water Supply Interruptions - Societal	99,783	Water Supply Interruptions	Risk
Water Supply Interruptions - Private	732,410	Water Supply Interruptions	Risk
Water Quality Cost - WTP	4,366	Water Quality Compliance (CRI)	Risk
Water Quality Cost - Societal	8,339,483	Water Quality Compliance (CRI)	Risk
Water Quality Cost - Private	5,837,638	Water Quality Compliance (CRI)	Risk
Unplanned Outage - Private	83,734	Unplanned Outage	Risk
Sum Total Risk	**15,098,790**	-	Risk

A concept design risk assessment (DRA) was carried out against the option. Full details can be found within the DRA spreadsheet (embedded document in Appendix A).

The significant residual risks for this option are presented below:

Table 21: Option 4 significant residual risks.

Risk ref.	Delivery risk	Justification	Mitigation measures
SRR1	Presence of third-party utilities, electric, gas, telecoms etc.	Potential for third party utilities buried alongside/close to new 160mm main.	Utility survey, CAT, GPRS and Genny to be done. Investigations included in scope.

Risk ref.	Delivery risk	Justification	Mitigation measures
SRR2	Construction vehicle access	-	Access to existing site is already in place - to be surveyed for ability to manage construction vehicles.
SRR3	Ground conditions	Ground conditions largely unknown along main length.	Trial holes included in scope costing.
SRR4	Equipment obsolescence	Decommission and potentially remove existing 3" main	Assess best option whether to decommission and remove, or cap, or incorporate as low flow resilience.
SRR5	Plant Hydraulics	Unknown whether Affinity water can meet supply required for adequate blend.	Full hydraulics assessment as early as possible within the design phase, update accordingly.
SRR6	Water Quality	Unknown whether Affinity water is low in nitrates to make blend viable, or whether there are other analytes of concern.	Commence raw water sampling of Affinity water, if required over and above existing sampling historical data.

Cost estimations

High level feasibility design for all options is compliant with relevant SSW standards; specifications and standard solutions are considered to be applicable for +/-30% cost estimating, up to a standards date of April 2022 (+/- 30 CET link embedded document in Appendix A).

All costs are listed in the PR24 price base of 2022/23. The 30-year asset review period costing for this projected had to be calculated manually by SDT from CET output rather than being provided automatically.

An R&V session was carried out on to quantify the risk against the project and for entry into Copperleaf. For more detail view the R&V spreadsheet (embedded document in Appendix A).

Table 22: Option 4 cost assessment.

Category	Cost (£k)				
CAPEX Delivery Cost	1,178				
Change in Annual OPEX Cost	-				
Project Cost Profile*	Year 1	Year 2	Year 3	Year 4	Year 5
	427	751			
Project Start Year (where available)	25-Apr				
Whole Life Cost	13,921				
Benefit to Cost Ratio	12.82				

* 1st *year represents the commencement of the scheme i.e., detailed investigation and not Year 1 of the AMP.*

The project start has been modelled as April 2025 to reflect what has been modelled in Copperleaf.

Summary

The baseline risk for the project that has been entered into Copperleaf is summarised below (this table sums all the value models used against the scheme including private, societal and willingness to pay measures).

Table 23: Baseline risk description from Copperleaf.

Copperleaf Ref	Identified risk models
Option 1 - BH studies + relining	• Water Quality • Water Supply Interruptions • Unplanned Outage
Option 2 – Nitrate treatment plant	• Water Quality • Water Supply Interruptions • Unplanned Outage
Option 4 - Network Nitrate blend scheme	• Water Quality • Water Supply Interruptions • Unplanned Outage

This is compared to the cost estimates of the different options where the proposed solutions mitigate the risks to give a Net Present Value and Benefit/Cost Ratio to measure the options.

Table 24: Summary of shortlisted options benefit to cost analysis.

Option no.	AMP8 delivery costs (£) *	Change in annual OPEX cost (£)	Investment Costs (£)	Investment benefits (£)	Net present value (£)	Benefit to cost ratio
Option 1	449,196	1,457	1,039,167	27,107,927	26,068,761	26.09
Option 2	13,874,160	403,691	18,518,053	28,589,758	10,071,705	1.54
Option 4	1,177,704	0	1,177,704	15,098,790	13,921,087	12.82

**Value includes 15% contingency value*

Recommended solution

The recommended solution based on the outputs of the R&V modelling is that Option 1 - Borehole and catchment investigations.

This proposed solution has the advantage of optimising existing infrastructure to meet the drivers.

The key residual risk is that the investigations and optimisations/refurbishments option is not meeting the driver, hence it is recommended that a phased approach of the options is implemented.

1. Option 1 (the highest cost benefit ratio)
    a. Assess success of meeting driver.
    b. If successful, hold.
    c. If regulations change in future, reassess, and potentially progress to remaining options.
    d. While Option 1 is being implemented it is recommended that the supply and water quality from Affinity water is established and a draft service level agreement to ensure Option 4 can be implemented.
2. If Option 1 is not successful it is recommended that Option 4 (the second highest cost benefit ratio is implemented), provided that the water supply and quality is suitable and sustainable to meet the project driver.
3. Finally, if Option 4 is not viable, implement Option 2 (the lowest cost benefit ratio) as it will meet the driver.
4. Residual risks: the key residual risk to meet the Morden Grange nitrate driver will be planning and implementation of the phased approach. There is no certainty that Option 1 will meet the driver, but if it does will have significant benefits. Option 4 requires some groundwork to establish its viability, if it is viable, it will be the preferred option if Option 1 does not meet the drivers.