Appendix 8f:
Wholesale Cost Appendices

YorkshireWater

Contents

Wholesale Cost Appendices - Overview

This collection of Appendices is to provide further evidence to support our plan on its cost robustness and cost efficiency. It consists of three sections

- **Base Cost Appendix** – This appendix describes, at a high level, the approach to building our Base Maintenance contribution to the totex plan for delivering our service to customers efficiently and a summary of the key areas of investment and pressures on the programme.
- **Enhancement Cost Appendix** – This appendix makes up the bulk of the appendices and describes in detail the costs associated with our enhancement investment. It describes the material areas of data tables WS2 and WWS2.
- **Efficiency Cost Appendix** – The final appendix summarises a number of our internal initiatives to improve our efficiency from our AMP6 levels.

Cost Overview

Table 1 - Summary of Costs (Water Resourcesand Water Network Plus)

Water Price Controls	Opex £m			Capex £m			Totex £m
	Base	Enhance-ment	Total Opex	Base	Enhance-ment	Total Capex	
Water Resources	133.0	6.5	139.5	67.1	19.8	86.9	226.4
WN+	877.9	124.8	1,002.7	538.9	313.4	852.3	1,855.0
Gs & Cs	-	-	-	-57.4	-	-57.4	-57.4
Total	1,010.9	131.3	1,142.2	548.6	333.2	881.8	2,024.0

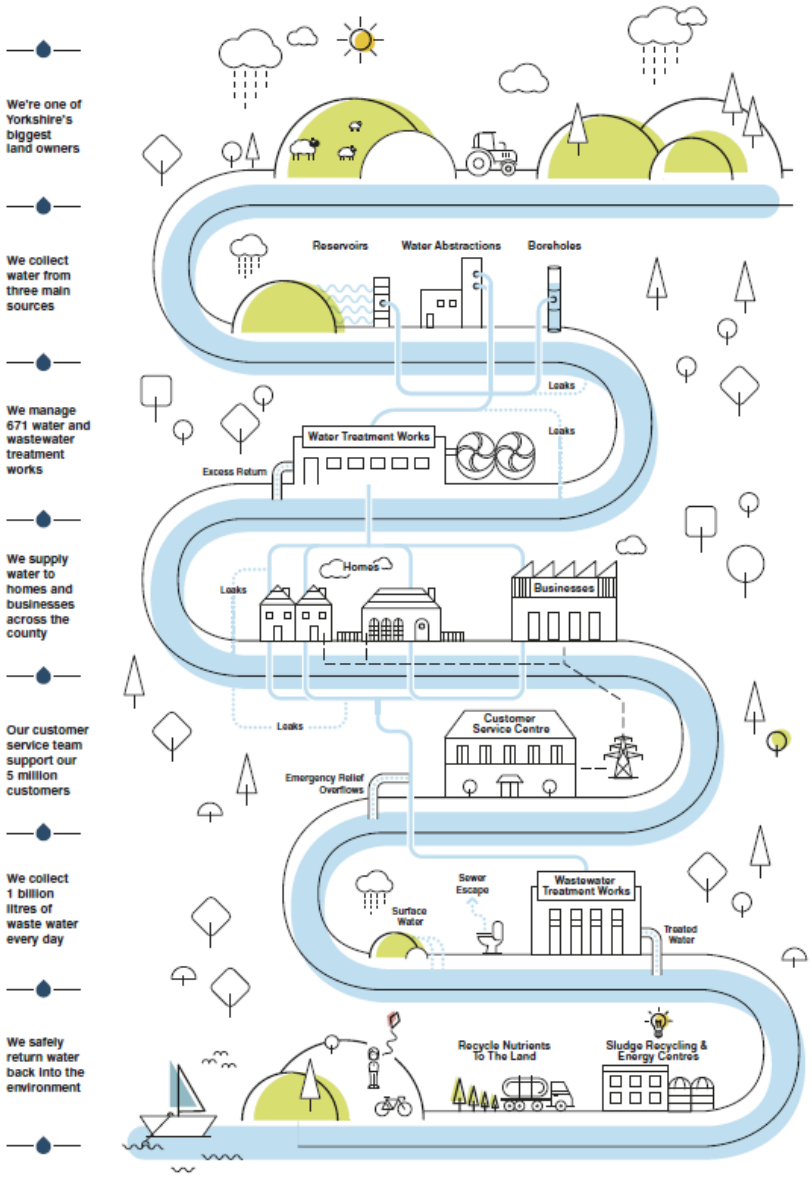
Table 2 - Summary of Costs (Wastewater Network Plus and Bioresource)

Waste Water Price Controls	Opex £m			Capex £m			Totex £m
	Base	Enhance-ment	Total Opex	Base	Enhance-ment	Total Capex	
WWN+	682.8	59.1	741.9	897.9	928.6	1,826.6	2,568.5
Bioresources	207.7	0.0	207.7	106.4	66.2	172.5	380.3
Gs & Cs	-	-	-	-56.2	-	-	-56,2
total	890.6	59.1	949.7	948.1	994.8	1,942.9	2,892.6

Base Cost Appendix

We provide water and waste water services to the people of Yorkshire. To do this we collect 1.3 billion litres of raw water from the environment every day. We use energy and chemicals to treat the water so that it is safe to drink. To get the water to where it is needed we use gravity where we can but we also have to use energy to pump it through 31,600km of pipes. We collect and treat about 1 billion litres of waste water from homes and businesses (and rainwater that goes into the 52,000km of sewers) every day as well. To do this we also use chemicals to help the treatment process and energy to run the treatment plants and pumps.

Figure 1 - A Visualisation of our Source to Sea process



To deliver our services we currently employ 3,500 people and have a large fleet of vehicles and other equipment so that we can look after all our pipes and pumping stations that deliver water and waste water services for Yorkshire.

Delivering all of the above costs money, not just the operational expenditure enabling us to carry out the activity described but also capital expenditure to ensure that the assets and infrastructure are maintained and continue to do their job.

This base cost appendix exists to summarise our approach to understanding our Totex cost requirements of maintaining our assets and delivering the service to customers and to summarise some of the key elements within the programme.

Much of this detail is described in our various parts of our Business Plan document, the aim of this Appendix is to bring it together in one place.

Decision Making Framework (DMF)

The Decision Making Framework (DMF) is an evolution of our approach to making Totex investment decisions. It is a change project across our asset management functions, and focuses on our people, processes and governance as well as our systems.

The DMF is our main tool used for ensuring that we identify the optimal programme of investment to deliver our service, performance commitment and statutory requirements. It enables us to compare thousands of solution options to identify the ones that give customers the most benefit whilst meeting financial and service constraints.

As discussed in the Decision Efficiency section of the plan, we believe that efficient decisions are ones that deliver the best benefit to customers in the long-term for the lowest cost rather than just the cheapest short term solution.

In order to assess this, the DMF is built around a new Service Measure Framework which has been developed internally and with customers to identify the key reasons that we invest. Our decision-making is based on the change in these service levels that an investment will deliver.

We start by expressing risk to service through both modelled and non-modelled approaches and identifying the size and scale of the risk and the potential interventions to address these risks.

Asset Modelling

We have developed a series of models to estimate the risk to service of asset failure and the options to mitigate.

We have models that cover

- Non-infrastructure assets (treatment works, pumping stations etc.)
- Water Network structural mains
- Wastewater Network - structural
- Wastewater Network – hydraulic
- Wastewater Network – Rising Mains

These have been developed by collecting and analysing contemporary data from our asset inventory and our SAP system to understand the factors that lead to asset failure and using this to estimate what failure will be going forward as assets age and deteriorate.

We then model the potential consequence of these failures so that they can be understood in the context of our service measure framework.

The final stage is understanding the costs associated with the models – firstly the reactive costs associated with failure of the assets and the costs of potential proactive interventions to avoid failures in the future. We generate a variety of intervention options for each asset that are passed though into our overall programme.

Project Charters

Not all of our risks can be directly modelled, Other non-asset failure related risks have been identified through a variety of investigations and through existing risk management approaches (eg. Drinking Water Safety Plans). We call risks identified through this route ‘Project Charters’.

The output of these projects is to assess non-modelled risks to service, and identify potential intervention options. The Service Measure Framework allows us to do this in a consistent method to compare modelled and non-modelled risk.

This is also the primary approach to assessing our risks to service associated with enhancement expenditure as set out in the Enhancement Cost Appendix.

Producing an efficient plan

The data collected allows us to identify the expected service impacts of failure events through time. As a result, we are able to estimate current and future service levels with and without investment.

These risks have been entered into our DMF tool as investment needs, with one or more solutions attached enabling multiple whole life cost comparison. The risks are stored within EDA (which is the software tool central to the DMF) where we also capture the relevant cost, output and activity information needed for effective asset management.

Quantifying Cost (Asset Models and Project Charters)

We estimate the costs of capital solutions to our Needs primarily using unit cost models developed within our unit cost database (UCD). These costs fully reflect our current procurement methods and the efficiencies and synergies being delivered in AMP6.

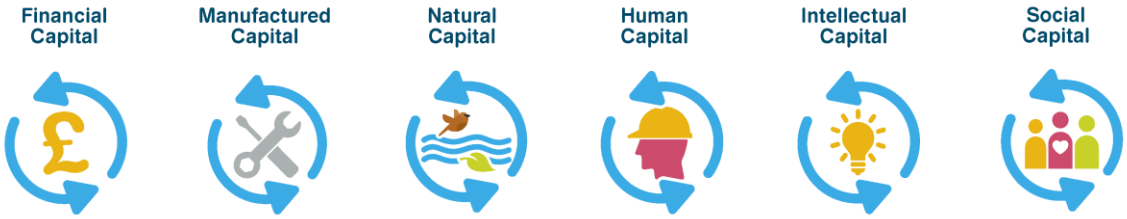
We have also considered solutions that require CAPEX, OPEX or a combination of these so that we can optioneer and test for the best balance of costs and service risk improvement during the economic modelling which follows. The costs that we have used in the economic optimisation are the CAPEX and OPEX expressed as an annualised Net Present Cost (whole life cost analysis).

Quantifying Benefit

We have enhanced our approach to understanding the benefit of our solutions – aligning our approach to a 6 capitals (see Figure 2). Rather than just valuing customer willingness to pay and financial benefits to Yorkshire Water we are now looking at the wider benefits of our investment decisions including their impact on the environment (natural capital), people (human capital) and society as a whole (social capital).

Our 6 capitals approach is described throughout our plan.

Figure 2 - The Six Capitals



We have mapped a change in each service measure to one or more of the 6 capitals and deployed specialist economic resources to obtain a monetary unit rate where there is sufficient confidence to do so. We have used traditional and innovative routes to populate these valuations only using values where we have high confidence in their provenance.

The approach helps us understand the impact of existing asset failures and the benefit we retain by fixing them, as well the ability to evaluate more creative long term, enhanced environmentally friendly solutions. We are applying this approach as a framework across our whole investment programme not just as an assessment on individual schemes.

The output is annualised benefit valuation (£) which can then be compared to our net present cost value to understand the net benefit of our intervention option.

Portfolio Modelling

The preceding steps allow each solution option to be assessed using a common currency and net benefit to be calculated over time. We have used these valuations to inform decisions.

We use our portfolio model to identify the optimal combination of solutions. We set goals and boundaries on the portfolio, such as certain service targets, or affordability constraints. Our tools allow us to visualise the outputs of multiple scenarios with varying constraints to enable our governance groups to make informed decisions on what to include in our plan.

We have run over 10,000 optimisation simulations covering our entire asset base to explore a vast range of future scenarios. This has pushed the boundaries of cloud-based computing and provided enhanced insights about our past and future. These simulations ensure our plans are resilient to future asset risk and place long-term sustainability at the heart of our investment decisions.

We know how an investment decision impacts service directly. We also know the impact of not investing money elsewhere, through holistically embracing the totex approach regionally. This ensures we are not making inefficient decisions at a programme level. We will continually challenge the outputs of the DMF, monitoring its accuracy and refining models as more data is provided.

Uncertainty analysis for cost and service ensures we can achieve our plans.

Operational Costs

Our operational costs have been informed by the output of our totex modellling within the DMF but ongoing costs enabling delivery of service have been built up by our operational and financial teams. These operational and supporting finance teams set out clear objectives and methods for their PR19 opex plans:

- Plans would calculate the additional and specific cost pressures from the company's desire to achieve ambititous targets such as 40% reduction in leakage, and achieve at least upper quartile performance in pollution, sewer flooding, water quality and supply interuptions.
- Plans would be developed in a level of bottom-up detail that would allow the entire PR19 opex budget to be uploaded to SAP (Yorkshire Water's financial system) at site and network level, incorporating and reviewing in detail all totex solutions proposed and any consequent requests for budget increases or transfers E.g. cloud solutions for IT paid annually through opex rather than the traditional capex procurement routes.
- Price Control Benchmarking would be done to understand and demonstrate comparitive efficiencies and allow teams to focus on areas that offered the most opportunity to drive further effiencies.

- Rigorous internal financial challenge processes would review all Price Review forecast for further financial and operating efficiencies, and recommend alternative strategies or targets for each area.
- Rigorous external financial challenge processes would review each price control area for further financial and operating efficiencies, and recommend alternative strategies or targets for each area.
- Plans would be in accordance with best practice Regulatory Accounting Guidelines (RAG) compliance, and would include appropriate intercompany recharging, mimicing the market, for example providing price controls such as Bio-Resources the incentive to reduce their water consumption at sites, whilst offering Water Treatment the incentive to reduce costs by reducing clean water sludges.

Site based bottom-up Operational Budgets and inclusion of cost pressures and savings

Plans have been developed so that the entire PR19 opex budget can be uploaded to SAP (Yorkshire Water's financial system) at site and network level, incorporating and reviewing in detail all totex solutions proposed and any consequent requests for budget increases or transfers. Where costs relate to non-site specific areas, these have been overlaid to price controls as general and support costs, linking them to sending cost centres and specific budgets. For example, the company's move to cloud-based IT will result in additional (and specific) operating cost recharges to those Price Controls that use this software, such as Bio-resources.

We have discussed included specific base operational cost pressures in the description of each price control below.

Price Control Benchmarking

Cost assessment comparitive data was shared with the oprational teams as part of the proces of allowing inefficiencies to be quickly targetted. Operating cost plans have been developed according to the estimated direct costs of delivering performance with indirect support costs allocated according to exisitng Regulaory Accounting Guidelines and Price Controls. These costs have then been structured by Price Controls and then compared to cost assessment data, with indivdual lines and areas analysed for comparitive efficiiency. This has been a circular process, alowing management teams to understand their efficiencies and make further challenges inernally.

Inter-price control charging and best practice Regulatory Accounting Guidelines (RAG) compliance

The plan includes appropriate intercompany recharging between Price Controls, as we want to allow internal areas the benefit of operating a market and forcing better value. For example providing price controls such as Bio-Resources the incentive to reduce their water consumption at sites, whilst offering Water Treatment the incentive to reduce costs by reducing clean water sludges. Expanding this area should further challenge support costs to reduce their costs competitively in a market environment.

Water (Water Resources and Water Network Plus)

We operate and maintain a large base of water resource, treatment and network assets. Including 47 raw water reservoirs, 45 boreholes, 48 treatment works and 31,600km of pipes to deliver reliable, safe water to our customers.

The table below summarises our expenditure in these asset groups (excluding enhancement expenditure) that we have proposed for AMP7.

Table 3 - Summary of Base Opex and Capex expenditure in WS1

	Water Resources £m	Raw Water Distribution £m	Water Treatment £m	Treated Water Distribution £m
Base - Opex	133.017	61.251	220.034	596.631
Base - Capex (infra)	45.578	1.552	0.000	192.641
Base - Capex (non-infra)	21.546	14.390	163.366	166.942
Water Base Totex	200.140	77.193	383.400	956.215

This section summarises some of the key investments and pressures on our base plan that we expect to see in AMP7. These are described in our main plan under the individual performance commitments that the investment delivers.

Our initial optimisation and costing of these plans was based on our AMP6 costs and our efficient unit rates currently being delivered. However, we identified that to deliver the levels of activity we need to achieve stretching service targets alongside a large enhancement programme whilst keeping bills affordable we will need to drive significant efficiency. This efficiency is described throughout the plan particularly in our Cost Efficiency chapter, any values given in this section are net of these efficiencies.

Our management and general expenditure is described in a section below but is apportioned based on activity and headcount across the relevant price controls and included in Table 3.

Water Resources

Water resources is a relatively small price control, but we experience greater costs than most companies due to our relatively large number of Impounding and En-route Storage Reservoirs (106). Most of the Capex expenditure in this area is to maintain the structural safety and integrity of these reservoirs which fall under the Reservoirs Act.

Table 4 - Summary of key expenditure drivers in Water Resources

Investment Area	Expenditure £m
Impounding Reservoir Safety	52
Boreholes	7

Figure 3 - A reservoir spillway in operation

Our operational spend relates to the operation, inspection and ongoing maintenance of these assets which ensure we have enough water resources to meet demand. We also open our raw water assets and surrounding land to the public for recreation so expenditure to ensure their cleanliness and safety is also found in this area.

Water Treatment

Much of this our activity in this area is described in our Water Network Plus price control document under Drinking Water Quality (CRI) and Unplanned Outage performance commitments.

Our 48 water treatment works are asset and energy intensive processes that use a variety of chemicals to provide our customers with safe, and acceptable drinking water at all times. We understand the opex requirements of our works based on their expected throughput, and the associated power and chemical usage associated with treating that volume to the regulatory standards. We are continually optimising these processes to minimise our operational expenditure.

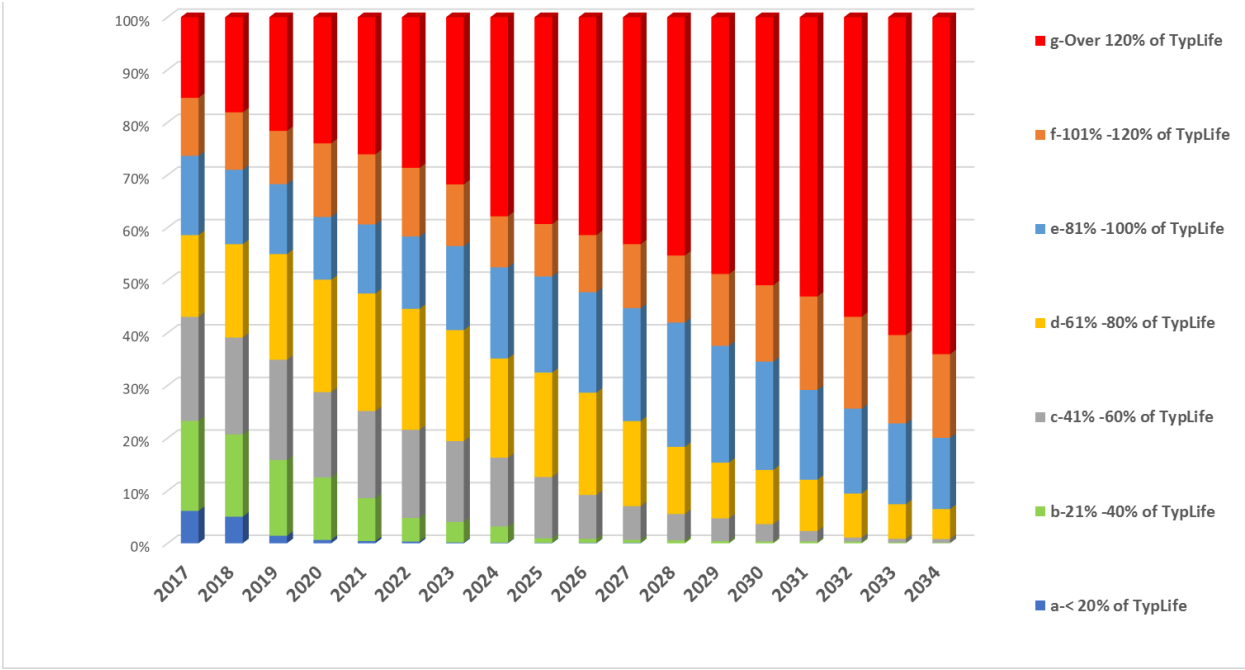
Figure 4 - Dissolved Air Flotation at Headingley WTW

We are also implementing an enhanced maintenance strategy. Which will drive service improvement through a planned, dynamic, predictive and preventative approach to the maintenance of assets based on the principles of Reliability-Centred Maintenance (RCM). To reach this position, we are working hard to achieve a truly ‘fix-on fail’ maintenance status as a baseline to work form. We will focus our attention on safety and process critical equipment which will protect our customers from outages and water quality failures.

Our capital investment is focussed on maintaining our assets to avoid service impacting failures. To optimise this investment, we have modelled our capital maintenance requirements in our Totex based non- infrastructure asset deterioration models as part of our Decision-Making Framework.

We are aware our asset base is ageing, as illustrated in Figure 5. A significant reduction in the age of the asset base would lead to a large improvement to the levels of unplanned outage we experience, however it would not be at a cost acceptable to customers. We plan to maintain capital base maintenance investment levels broadly in line with historic levels across the water treatment assets. We will offset this deterioration and drive service improvement through more pro-active maintenance of our existing assets and by strategically targeting our investment using tools such as our Resilience Dashboards and Decision-Making Framework.

Figure 5 – WTW Asset Age Profile ((% of assets at different stages of life)



The safety of our people is extremely important to us, so a material part of our capital expenditure in this area is identified to ensure our assets continue to be safe and compliant with Health & Safety regulations.

Our capital programme at WTWs has an additional pressure in AMP7 associated with our Drinking Water Quality programme. We have identified six water treatment works where significant process enhancement is required to guarantee the quality of drinking water in the face of raw water deterioration. However, alongside this enhancement

investment there is a significant element of enabling base maintenance required – this is base expenditure required to be spent earlier than predicted, to enable the enhancement schemes to deliver their compliance outputs. This has been allocated to base maintenance as per the regulatory accounting guidelines.

Table 5 - Summary of key expenditure drivers in Water Treatment

Investment Area	Specific Totex Expenditure £m
Water Treatment Capital Base Maintenance	95
Health & Safety	37

Water Distribution

Our water distribution base expenditure relates to the ability to transport 1.3bn litres of water a day through our 31,600km of water network and communications pipes, utilising 396 service reservoirs and 530 pumping stations on the way to our customers. As well as the operation and maintenance, several ancillary assets such as meters, stop taps and street furniture.

Much of this our activity in this area is described in our Water Network Plus price control document under multiple performance commitments.

Operational expenditure in this area is influenced significantly by pumping costs and our operational staff. We hope to become more efficient in this area by reducing our demand through leakage and per-capita consumption which will provide greater flexibility in our choice of water sources and reduce pumping around the region.

To maintain the improvements, we have seen in Water Quality Complaints we are anticipating an ongoing investment in flushing of the network to address manganese build-up on the inside of our pipes (c. 8m p.a.). This is an issue limited only to companies with upland water sources and is a significant cost driver in this area.

Our asset base is aging and to maintain affordable bills we are not replacing assets at the rate which they are aging – we have managed the service risk of this by improving the targeting of our interventions, our network resilience and our operational response.

However, we are aware this improvement cannot be sustained for ever in this manner and that we will need to address the underlying asset health.

We have included an uplift in expenditure in Structural mains to help support this but not to a level that we would consider sufficient to fully address asset deterioration in the long term. Our asset modelling and optimisation through our DMF has identified an optimal set of interventions that enable us to maximise our service benefit in AMP7.

We have set ourselves stretching performance commitments to be at the top end of the industry for Water Supply Interruptions and Leakage in AMP7. However, driving service improvement so quickly does come with an associated cost. We have included much of this as an enhancement – a step change in service – but there are elements that we have considered base maintenance and included as such in our plan.

The company is investing substantially in AMP6 to improve service to in these two areas, this investment is being funded by the company ensuring that customers are not exposed to the full cost of the service improvement we plan to deliver.

As part of our leakage drive down activity we have considered the capital replacement of the assets installed in AMP6 to improve leakage an additional base pressure in AMP7. We have also included the cost of maintaining an industry leading position in water supply interruptions after our initial step change as base maintenance.

Traffic Management costs are increasing in the Yorkshire Region with a further £11.6m estimated across Water & Wastewater Network Plus due to permitting expansion across Authorities and their use by Authorities. Currently only one Highway Authority of the 16 controlling the Yorkshire Region is currently operating a 100% permit across all roads and streets, with a further 10 operating a limited permitting scheme. We are forecasting all Highways Authorities to be operating permitting schemes during the next AMP and moving towards 100% permitting.

Traffic management costs and Local Authority Charges have always existed, however, there are additional costs listed below that have a significant impact on average jobs costs to the increase in out of hours working, quicker job turnaround and continuous working where required not just traffic management costs:

- Permit conditions stipulate that the traffic management on site includes “manned” lights.
- Applying for a Permit gives the Local Authorities the chance to insist on the way the work is carried out to cause the least disruption to traffic users but can result in increases to operating costs.
- It is not just the cost of the traffic management that has increased due to the Permit scheme. If Local Authorities insist on out of hours working in the Permit conditions, we can have to carry out the initial job in a specific time as well as having to backfill and reinstate the highway within a given period.
- If the job changes on site due to operational we would have to alter the Permit conditions. This would again involve an additional charge payable by the company.
- The Local Authority, as part of the Permit conditions, expect companies to continually work on Permit roads and streets and to be off site as soon as possible. This again drives additional costs and inefficiency of resource to prioritise these jobs and clear site quicker than would be expected on standard roads.

Table 6 - Summary of key base expenditure drivers in Water Distribution

Investment Area	Specific Totex Expenditure £m
Structural Mains	65
Supply Interruptions (base)	37.5
Service Reservoirs & Water Towers	30
Mains Flushing & Rehabilitation	31
Water Pumping Stations	10
Customer Meter Replacements	37
Maintaining Leakage	155

Wastewater (Wastewater Network Plus and Bioresources)

We operate and maintain a large base of sewage collection and treatment assets as well as a network of bioresources facilities and assets to enable us to transport, treat and dispose of sludge produced from these assets.

The table below summarises our expenditure in these asset groups (excluding enhancement expenditure) that we have proposed for AMP7.

Table 7 - summary of Base Opex and Capex expenditure in WWS1

Category	Sewage Collection	Sewage Treatment	Sludge Transport	Sludge Treatment	Sludge Disposal
Base - Opex	244.334	438.507	33.298	124.824	49.537
Base - Capex (infra)	290.776	2.847	0.000	0.000	0.000
Base - Capex (non-infra)	126.209	478.095	5.261	100.291	0.803
Waste Water Base Totex	661.319	919.449	38.558	225.115	50.340

This section summarises some of the key investments and pressures on our base plan that we expect to see in AMP7. These are described in our main plan under the individual performance commitments that the investment delivers.

Sewage Collection

We collect about 1 billion litres of waste water from homes and businesses (and rainwater that goes into the 52,000km of sewers) every day as well. Our Sewage Collection base expenditure relates to the operation and maintenance of this network of sewers, detention tanks, pumping stations and ancillary assets such as ironwork.

Much of this our activity in this area is described in our Wastewater Network Plus price control document under multiple performance commitments.

Operational expenditure in this area is influenced significantly by pumping costs and our operational staff. We also spend a significant amount jetting and reactively repairing sewers to ensure that we minimise our service and environmental impact.

Figure 6 - Outputs of our asset deterioration model for WW Networks

Our asset base is aging and to maintain affordable bills we are not replacing assets at the rate that they are aging – we have managed the service risk of this by improving the targeting of our interventions, our network resilience and our operational response.

However, we are aware that this improvement cannot be sustained in this manner and that we will need to address the underlying asset health.

We have included an uplift in expenditure in sewer rehabilitation to help support this but not to a level that we would consider sufficient to fully address asset deterioration in the long term. Our asset modelling and optimisation through our DMF has identified an optimal set of interventions that enable us to maximise our service benefit in the next AMP (see Figure 6).

Figure 7 - Detention Tank under construction in Goole

We have set a wide range of stretching service targets including step changes in Pollution and Internal sewer flooding and improvements in External flooding and Sewer Collapses. However, driving service improvement so quickly does come with an associated cost as activity levels increase to drive down asset failure and to maintain service at improved levels.

The company is investing substantially in AMP6 to improve service to in these two areas, this investment is being funded by the company ensuring that customers are not exposed to the full cost of the service improvement we plan to deliver.

Whilst some of this cost has been identified as enhancement expenditure (step change in service) we have included the cost of maintaining an industry upper in internal sewer flooding after our initial step change as base maintenance in the plan.

We have set out in detail our costs associated with internal sewer flooding in our Cost Adjustment Claim. This sets out the additional service impact that we experience due to the high level of cellared properties in our region and the corresponding cost impact of delivering upper quartile performance in internal sewer flooding due to this regional circumstance.

As described in the Water Network Plus Section Above the movement of local authorities to a 100% permitting approach of Traffic Management has a significant operating cost impact on us. An additional opex cost has been included in our plan.

Table 8 - Summary of key expenditure drivers in Sewage Collection

Investment Area	Specific Totex Expenditure £m
Sewer Rehabilition	238
Internal Sewer Flooding (base)	66
Sewage Pumping Station Refurbishment	36

Sewage Treatment

We treat over 1 billion litres of waste water at over 600 Sewage treatment Works every day. The base expenditure in this area is to ensure that our works achieve the right water quality before we discharge back into the environment.

Much of our activity in this area is described in our Wastewater Network Plus price control document under the discharge permit compliance performance commitment.

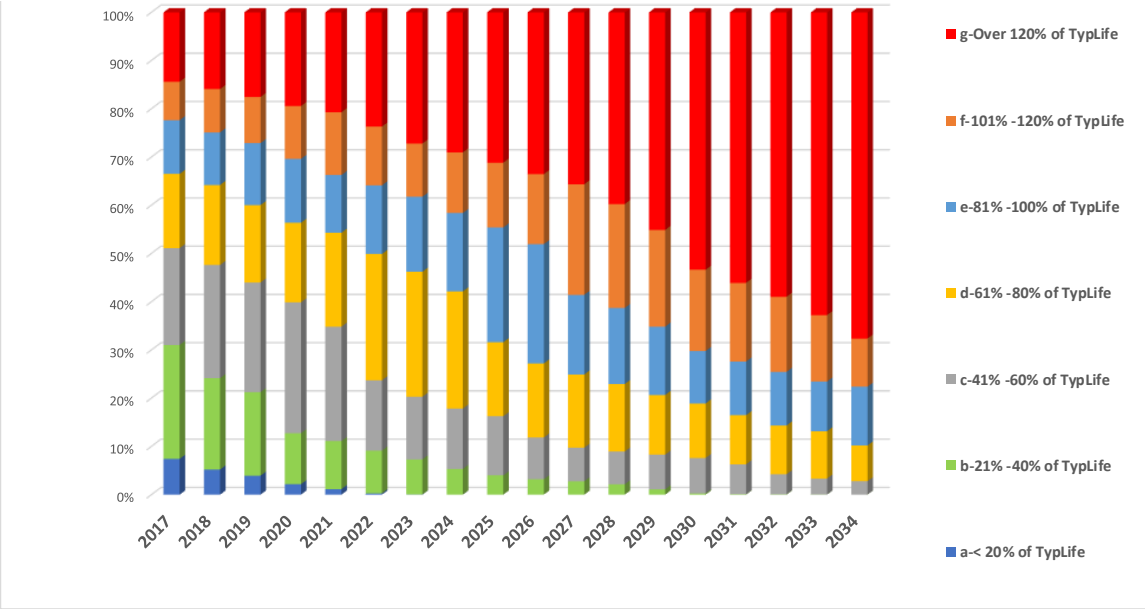
Figure 8 - Aldwarke STW

The operational expenditure is focussed on operating these treatment works. We use chemicals to help the treatment process and energy to run the processes and pumps. We understand the opex requirements of our works based on their expected throughput, and the associated power and chemical usage associated with treating volumes to the regulatory standards.

We are also implementing an enhanced maintenance strategy. Which will drive service improvement through a planned, dynamic, predictive and preventative approach to the maintenance of assets based on the principles of Reliability-Centred Maintenance (RCM). To reach this position, we are working hard to achieve a truly 'fix-on fail' maintenance status as a baseline to work form. We will focus our attention on safety and process critical equipment which will protect our customers from outages and water quality failures.

Our capital investment is focussed on maintaining our assets to avoid any service impacting failures. To optimise this investment, we have modelled our capital maintenance requirements in our Non- Infrastructure Totex Risk Model (NITRO) as part of our Decision Making Framework.

Figure 9 - STW Asset Age Profile (% of assets at different stages of life)



We are aware our asset base is ageing, as illustrated in figure 9. A significant reduction in the age of the asset base would lead to an improvement in STW compliance, however it would not be at a cost acceptable to customers. We will offset this deterioration and drive service improvement through more pro-active maintenance of our existing assets and by strategically targeting our investment using tools such as our Resilience Dashboards and Decision-Making Framework.

We have included a large uplift in Sewage Treatment Works maintenance in our base plan associated with our WINEP Enhancement programme. We have obligations through WINEP3 to invest in over 80 Sewage Treatment Works to ensure that Phosphorus standards are met at the outlet of the works and in the receiving watercourses. However, alongside this enhancement investment there is a significant element of enabling base maintenance required – this is base expenditure required to be spent earlier than predicted, to enable the enhancement schemes to deliver their compliance outputs. This has been allocated to base maintenance as per the regulatory accounting guidelines.

The safety of our people is extremely important to us so a material part of our capital expenditure in this area is identified to ensure our assets continue to be safe and compliant with Health & Safety regulations.

Table 9 - Summary of key expenditure drivers in Sewage Treatment

Investment Area	Specific Totex Expenditure £m
Sewage Treatment Works Maintenance	193
WINEP Enabling Base	158
Health & Safety	91
Sea Outfalls	5

Bioresources

Our Bioresources service in 2020 will have 14 treatment centres, 13 of which will be Anaerobic Digestion (AD) sites and 1 will be an Advanced Digestion facility.
There are a larger number of Dewatering and Thickening Facilities across the region which prepare indigenous and local sludges for transport to the treatment centres.

Figure 10 – Our Advanced Thermal Hydrolysis Plant at Esholt

Our base costs in this area are related to operating and maintaining these assets. However, we recognise the need to make significant changes to the way we deliver Bioresources, so our service is more efficient and resilient and allows us to make greater environmental contributions while reducing the cost to our customers.

In this regard we are exploring markets approach to make the most of our bioresources, utilising 3rd party solutions where beneficial. Our approach to bioresources is set out in greater detail in the Bioresources chapter of our Plan and in our Bioresources appendix.

Management & General (M&G)

Our Management and General (M&G) programme is a support function to enable business as usual operations and we view it as a critical component to supporting the continuous flow of service to our customers and maintaining the serviceability of our assets. The M&G programme is made up of several investment areas such as Information Technology, Vehicles and Plant, Land and Property and Security. The programme for AMP7 enables the business to deliver a level of service which meets our future ambitions for the environment and our customers, whilst driving efficiency through innovation.

Table 10 - Key Areas of Capex Spend in our M&G Plan

Investment Area	Capex Expenditure £m
IT Hardware	62
CRM	38
It Software	39
Telemetry	46
Vehicles & Plant	24
Security & Emergency Planning	22
Land &Property	14

Table 11 - Key Pressures on Operating Costs included in our M&G plan

Total BSG Impact	£m Opex (AMP7)
IT - cyber security costs	24.5
IT - Cloud based solutions	38.5
Increased fleet costs supporting UQ employees	3.3
Increased Additional license impact	1.7

The expenditure in our M&G programme are apportioned across our price controls on the basis of activity and/or headcount. As per regulatory accounting guidance we have allocated the investment associated with individual projects to the prime price control –

the key example here is our proposed new CRM system which has been allocated to Wastewater Network Plus on the basis that it will have the greatest number of users.

Information Technology

The largest proportion of the proposed M&G investment is within the Information Technology area, with over 50% of the TOTEX residing in this area. Technology and IT services are provided for all internal staff and external service partners where appropriate. The estate consists of approximately 6000 client devices, 2000 smartphones and 1000 servers, across 2 data centres. The IT programme also supports key systems and services such as Billing, Payroll and Work Management. Telemetry and remote intervention services are available to support all waste and clean water business processes.

In AMP6, Yorkshire Water will become the first UK utility to implement the SAP S4/HANA solution to manage several core background processes such as asset management, work management, health and safety, procurement, human resources and finance, all in a real-time and fully integrated way. By employing new and improved data and process governance tools, a sustainable step change in asset performance is anticipated, enabling new maintenance practices, significantly reducing maintenance costs and improving asset reliability, all of which will benefit our customers in the long term.

Like in previous AMP periods, we aim to invest in our IT infrastructure to ensure systems and processes can continue to enable the business to carry out its day to day operations by providing appropriate timely access to information, early warning of emerging risk to loss of service and the ability to remotely manage and intervene in the operation of its assets. This also assists the company in becoming efficient in the way services are delivered to customers. This will also be supplemented by the continued use of innovation within the IT arena, to allow staff and customers to be more efficient and to rationalise our IT estate.

Our IT is strongly integrated with and supports the business processes that the company uses to run its daily operations. Our stakeholders rely on the support and benefits that a fully responsive IT service provides to ensure that we meet our service levels and enables us to achieve the targets and challenges that we face in day to day operations. As part of understanding the efficiency of our IT operations, we have commissioned Gartner to assess the cost efficiency of the delivery of IT services in scope and the implications of the future investment levels. The key message that this review provided was that, when compared with peers across the utility sector, 7 out of the 8 technical towers examined were assessed as 'best in class' for both cost efficiency and service.

CRM system

We are therefore proposing a significant investment in our plan for a new CRM system. There are multiple drivers for change that have led to the core systems supporting our domestic customer base to need updating.

Firstly, customers expect a comprehensive self-service offering, across a full range of customer contact channels, integrated to provide a complete view of the full customer relationship. Our new CRM system will enable this and allow us to provide a personalised and proactive approach to customer service, tailoring engagements and services based on customer knowledge, and positively serving their needs before they must contact us.

The system will drive efficiency by significantly reducing levels of transaction handling facilitated through comprehensive self-service provision & transaction automation, resulting in reduced cost to serve.

Key components of the existing customer service technology infrastructure are coming to the end of their expected life and require replacement. In addition, these core systems are not fit for purpose to support different customer expectations in the future, where fast response, comprehensive self-service and proactive, personalised service must be provided.

The CRM Programme will deliver the following main capabilities:

- Comprehensive self-service delivery.
- Fully integrated customer contact channels.

- Single, consistent view across all channels of the full customer relationship with YW.
- Personalised, tailored service delivery.
- Proactive customer service delivery across all service and product areas.
- Customer transaction automation supported by 'service bots'.
- Customer control of service requests and scheduling.
- A single view of the complete customer relationship maintained dynamically.
- Comprehensive and dynamic customer information capture and management.
- Increased and detailed customer knowledge to support proactive and personalised servicing.
- A single master source of customer information, customer-centric rather than bill-centric.

IT Security

The plan is proposing a significant uplift in the level of investment for IT Security, compared to AMP6, in line with the risks that are posed here and to ensure resilience of our systems. The investment will be used to proactively defend against the threat of an electronic attack (cyber) and protect company data (both organisational and customer). The threat from an electronic attack to IT networks has grown significantly since AMP6 and acknowledged there is a significant risk to the critical areas of its operational networks. The Department for Environment, Food and Rural Affairs (DEFRA) have acknowledged this threat and, in March 17, released a paper saying their vision for 2021 was "…a secure, effective and confident water sector resilient to the ever-evolving cyber threat". As our reliance on technology grows, the impact of failure of those systems and the opportunities for those who wish to compromise those systems increases. YW's control systems are heavily reliant upon technology and therefore are increasingly becoming a more attractive target for threat actors wishing to cause harm and disruption to a country. The investment plan for AMP7 aims to mitigate the risks and address the technical defence YW needs, to proactively defend itself from an electronic attack and unauthorised access.

Telemetry

The IT programme also includes a fundamental re-engineering of the telemetry platform to allow the organisation to both take advantage of advances in data analytics, as well as implementing the requirements of initiatives such as the company's Process Safety program. This will also enable a programme of real time situational awareness,

visualising real-time asset and contextual information within the Central Control Room in a way that supports effective decision making and risk management.

Digital Workplace

Our ambition for IT is to embed a truly digital capability across the business that will connect us with each other, our customers, our suppliers, our partners and other key stakeholders. This will create greater collaboration opportunities, improve transparency and deliver a platform for participation. In the future, all our stakeholders will be able to actively participate in how we plan, design and run our business. We aim to do reduce the size of our technology landscape into fewer core systems. This means removing many old internally developed systems and replacing them with a smaller number of more modern integrated solutions. These larger solutions will become the foundation of our technology estate and will not change rapidly in the future. We also aim to be more agile in our response to changing business requirements. The pace of business change demands that the time taken to deliver niche solutions and applications must reduce. Therefore, our delivery capability needs to accelerate in certain areas and utilising modern architectural principles and taking advantage of cloud technology, will enable this to happen in a truly integrated way.

Vehicles and Plant

YW own and operate 1,515 commercial vehicles and items of mobile plant. Whole life cost determines our asset maintenance programme for vehicles and plant and the parameters for this are constantly being challenged to see if an asset life can be increased to ensure we can deliver service at the lowest whole life cost. The parameters include maintenance costs of a vehicle, physical condition and bodywork warranties, residual values, fuel economy and other running costs such as tyres, road fund licences and manufacturer's standard warranties.

The provision of a reliable fleet to mobilise our workforce will ensure that we are able to proactively maintain our assets and respond to operational incidents quickly and efficiently. This will contribute to the provision of delivering our commitments to our customers by contributing to the reduction of the number of significant incidents and minimising impact on customers when failures do occur.

Figure 11 – A YW Commercial Vehicle

In AMP7 we plan to replace 1,107 vehicles and items of mobile plant. The programme will also aim to utilise innovation in the fleet area to maximise efficiency and reduce the impact on the environment. An example of this is our current trialling of electric vehicles that we have undertaken in this AMP period, across several tactical work areas to stress test where we can maximise vehicle utilisation without compromising service and ability to service the needs of our customers in the future.

Land and Property

The operational requirement for owning and managing land around impounding reservoirs is to safeguard water quality and resources from pollutants, whether man-made (e.g. agrochemicals) or natural (e.g. colour). The way in which land is managed affects the quality and quantity of water flowing into reservoirs and the aim is to send the optimal quantity of good quality water to the Water Treatment Works to minimise the amount of chemicals and energy required to treat the water to the required standards.

Figure 12 – Rodley Nature Reserve (A YW land asset)

In addition to the operational drivers dictated by the core business, there are statutory, regulatory and Health & Safety drivers that apply to those who own land and property and who are responsible for furthering recreation and conservation activities. Our land holdings are notable for the level of statutory designations e.g. SSSI with over 75% of our land subject to one or more designations.

Since AMP5, we have maintained a strong focus on Catchment Management and our approach to managing our land has complemented this. As an example, the SSSI recovery project underway at that time was perceived to have strong synergy with Catchment Management objectives and this has enabled us to target other areas for Catchment Management investment in AMP6, secure in the knowledge that our own land is being managed in a sympathetic manner.

Our aims for the 50,000 acres of catchment land that manage are:

- Having 'fit for purpose', efficient, compliant (with statutory duties and obligations), least cost, sustainable non-specialised land and building assets.
- Ensuring land and building assets and estate, and their management practices, are exemplar
- Enhancing the enjoyment experience (and through that our customers knowledge) of the public invited onto our estate and ensure safety

Our purpose is to ensure "The right land, in the right places, managed in the right way" and to ensure the wholesale business has the land it requires now and in the future. Investment in AMP7 focuses on 5 core areas; Buildings, Infrastructure, Natural Environment, Boundaries & Fencing and Customer Engagement & Trust. The AMP7 programme has been co-created in partnership to deliver bigger, better and customer lead projects. This has also allowed partners to seek funding from National Lottery and others, by using Yorkshire Water match funding whilst undertaking its statutory duty. We also aim to ensure we engage with our stakeholders on key programmes. In AMP7 opportunities have been identified to partner and be part of local and regional initiatives that support our Performance Commitments in areas of recreation, access, conservation and community engagement on our land and waters. Partnering with Heritage Lottery bids (e.g. Sheffield and Rotherham Wildlife Trust, Pennine Prospects, Nidderdale AONB), landscape initiatives (e.g. White Rose Forest) and visitor satisfaction (e.g. East Riding Tourism Triangle) helps deliver our outcomes sooner, and with added benefits to our customers and visitors. Supporting these regional initiatives helps us influence

projects that will deliver benefits to YW in water quality, flood management, landscape management, biodiversity and recreation. Identifying key partners will help us contact our hard to reach customers, those currently not represented in our visitor surveys yet within our regional customer profile e.g. disability groups, BAME, and those with health and welfare problems.

Security

The Security & Emergency Measures Direction 1998 (SEMD), outlines the requirements for the provision of essential water supply and requires the company to maintain the protection of Critical National Infrastructure (CNI) and infrastructure asset protection to mitigate the impact of the terrorist threat, the threat of crime and safety to staff, and natural hazards.

Security protection of our assets is driven by the standard Deter, Detect, Delay, Respond approach. The level of physical protection required for general compliance has been agreed in working groups between water companies, Defra and the Centre for the Protection of National Infrastructure (CPNI). These standards are contained in a Water UK document 'Standard for Security Arrangements at Operational Assets', which specifies the equipment that should be installed, appropriate to the level of risk. Larger sites with larger potential impacts, such as CNI, require security protection measures which are approved by Government Security Advisors (GSA).

Security systems are an integral part of the day to day operation of assets and supports business functions to mitigate the risk of failure of assets and the safety of staff through the threat of terrorism, criminal activity or natural hazards. In general, increased levels of protection are a requirement, not a choice (both regulatory and to enable day to day operations).

Protective security measures implemented throughout since AMP4 are one factor in mitigating cable/metal/theft on our sites and there has been a steady reduction in incidents across the organisation. Additionally, improved security culture, coordinated activity in conjunction with police forces and the introduction of the updated Scrap Metal Dealers Act are other factors contributing to this reduction.

A large part of our proposed investment in Security is to mitigate the impact of locking systems, currently deployed on our sites. At the end of AMP 6 the current locking

systems will come to the end of its patented life. To comply with Defra Advice Notices and guidance, a new locking system within patent is recommended. In addition, a Strategic Group Audit review identified risks in the current locking system. Consequently, this expenditure is to comply with the guidance in respect to patented systems and to minimise risk of unauthorised access. Following Security Team research – which could not find a solution which met all company requirements - an independent review of requirements and research in to suitable solutions was undertaken; this confirmed that there was no suitable solution to meet all needs; but an electro-mechanical solution would meet the majority. A trail of a recommended system was undertaken during AMP 6 and will be in place on 8 sites by the end of AMP 6. This system will be rolled out to critical sites during AMP 7.

Further investment is also proposed to ensure that appropriate security standards are maintained for the business in accordance with the current threat levels and current regulatory requirements.

Enhancement Cost Appendix

This Appendix has been created to meet the OFWAT requirements defined in *'IN 18/11 June 2018 - Enhancement Expenditure: Setting expectations for well evidenced proposals and clarifying interaction with cost adjustment claims'*.

This appendix deals with cost robustness and efficiency only, the table map should be used to refer to the relevant Performance Commitment appendices to understand the associated performance, and the Cost Adjustment Claim appendices to understand the link to any cost adjustment claim.

The table below maps the relationship between the Enhancement investment tables, cost adjustment claims and Performance Commitments.

Table 12: Enhancement Spend Relationship Summary table

Cost Appendices	Cost Adjustment Claim?	Table Ref	Line Ref and Description	Performance Commitments
WINEP	No	WWS2	2 - Sludge enhancement (quality) (In part)	Length of River improved Working with Others Land Conserved and Enhanced Integrated Catchment Management
	No	WWS2	7 - WINEP / NEP ~ Flow monitoring at sewage treatment works	
	No	WWS2	9 - WINEP / NEP ~ Schemes to increase flow to full treatment	
	No	WWS2	10 - WINEP / NEP ~ Storage schemes at STWs to increase storm tank capacity	
	No	WWS2	11 - WINEP / NEP ~ Storage schemes in the network to reduce spill frequency at CSOs, etc	
	No	WWS2	12 - WINEP / NEP ~ Chemicals removal schemes	
	No	WWS2	13 - WINEP / NEP ~ Chemicals monitoring / investigations / options appraisals	
	No	WWS2	15 - WINEP / NEP ~ Groundwater schemes	
	No	WWS2	16 - WINEP / NEP ~ Investigations	

Cost Appendices	Cost Adjustment Claim?	Table Ref	Line Ref and Description	Performance Commitments
WINEP (cont.)	No	WWS2	18 - WINEP / NEP ~ Nutrients (P removal at activated sludge STWs)	Length of River improved Working with Others Land Conserved and Enhanced Integrated Catchment Management
	No	WWS2	19 - WINEP / NEP ~ Nutrients (P removal at filter bed STWs)	
	No	WWS2	20 - WINEP / NEP ~ Reduction of sanitary parameters	
	No	WWS2	22 - NEP ~ Discharge relocation	
	No	WWS2	41 - WINEP / NEP ~ No Deterioration in Sanitary Parameters	
	No	WWS2	42 - UWWTD Investigations	
	No	WS2	1 - WINEP / NEP ~ Making ecological improvements at abstractions (Habitats Directive, SSSI, NERC, BAPs)	
	No	WS2	3 - WINEP / NEP ~ Non-native invasive species	
	No	WS2	17 - WINEP / NEP ~ Drinking Water Protected Areas (schemes)	
	No	WS2	18 - WINEP / NEP ~ Water Framework Directive measures	
DWQ	No	WS2	5 -Improving taste / odour / colour	Unplanned Outage CRI
	No	WS2	6 - Meeting lead standards	
	No	WS2	13 - Investment to address raw water deterioration (THM, nitrates, Crypto, pesticides, others)	
Growth	No	WS2	11 - New developments	Discharge Permit Compliance
	No	WS2	12 - New connections element of new development (CPs, meters)	
	Yes	WWS2	25 - New development and growth	
	Yes	WWS2	26 - Growth at sewage treatment works (excluding sludge treatment)	
Domestic Meter Optants	No	WS2	21 - Metering (excluding cost of providing metering to new service connections) for meters requested by optants	NA
Leakage	No	WS2	26 - Leakage Reduction - UQ	Leakage
Interruptions to Supply	No	WS2	27 - Reduction in Interruptions to Supply - UQ	Water Supply Interruptions
Bioresource	Yes	WWS2	2 - Sludge enhancement (quality) (In part)	NA
Hull	No	WWS2	27 - Resilience	Internal Sewer Flooding

Cost Appendices	Cost Adjustment Claim?	Table Ref	Line Ref and Description	Performance Commitments
Network Escapes	Yes	WWS2	30 - Reduce flooding risk for properties	Waste Water Pollution Incidents Internal Sewer Flooding
		WWS2	37 - Pollution - UQ	
		WWS2	38 - Internal Flooding - UQ	
SEMD	No	WS2	15 - SEMD	
	No	WWS2	28 - SEMD	
First Time Sewerage	No	WWS2	1 - First time sewerage (s101A)	
Supply Demand	No	WS2	8 - Supply side enhancements to the supply/demand balance (dry year annual average conditions)	
	No	WS2	24 - Drought Management Plan	

In accordance with the guidance, we have only provided additional information for areas deemed to be material, materiality has been defined by price control using the Ofwat definition of materiality in the Cost Adjustment Claim guidance, as follows;

Table 13: Materiality Summary

Price Control	5-year Totex	Materiality %	Materiality Threshold
HHR	c.£261m	4%	(£10.4m)
Bio	c.£380m	6%	(£22.8m)
WWN+	c.£ 2,512m	1%	(£25.1m)
WN+	c.£1,797 m	1%	(£18.0m)
WR	c.£2,261m	6%	(£13.6m)

We confirm the following areas were not considered significant against the materiality threshold;

- Security and Emergency Measures Direction £0.9m
- First Time sewerage £1.0m
- Supply Demand (aligned to the Water Resource Management Plan) £2.0m

We also confirm that all expenditure classified as enhancement, has been done so in full alignment with OFWAT Regulatory Accounting Guidelines as follows;

Quality: where expenditure is required to comply with new legally enforceable quality obligations agreed with Environment Agency or Drinking Water Inspectorate to meet more exacting water quality standards.

Enhanced Service Level: where expenditure provides an identifiable, measurable and permanent step change in overall level of service to existing customers above the standard previously provided.

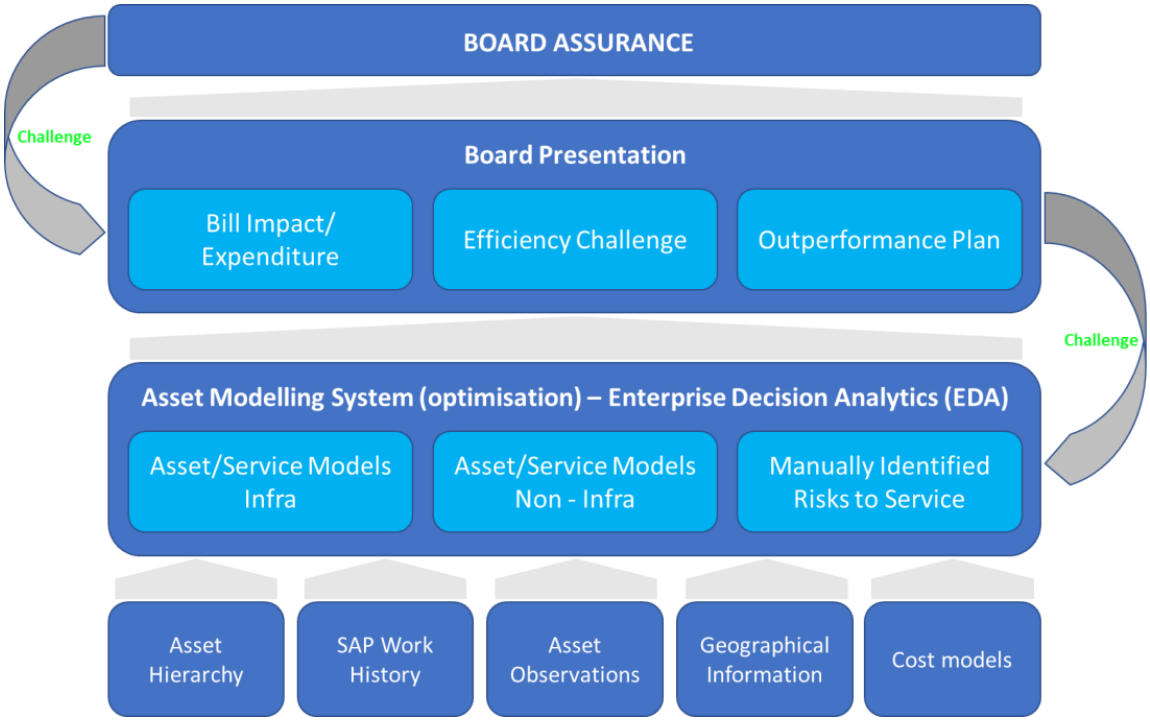
Supply/Demand Balance: where expenditure provides water and sewerage service for new customers with no net deterioration from the current level of service provided to existing customers and/or accommodate the increased use of water by existing customers at the current level of service

General

In construction of the plan we have facilitated cost robustness and efficiency in the systems and processes we have created and deployed. The processes relate to quality assurance, as well as a rigorous governance as part of our Board Assurance process, the systems relate to our cutting-edge application of the 6 capitals (including customer valuation), vast historic catalogue of company unit costs, all applied through optimisation routines aligned to Government Green Book and Spackman approaches. Full details of the system approach and relationship to our sector leading Decision Making Framework, can be found in the Decision Efficiency Section of our plan.

Pictorial demonstration of the Board Assurance is given below, the intention is to highlight the detailed nature of information presented, demonstrating the level of efficiency the company is taking with full board visibility;

Figure 13 - Board Efficiency Alignment



The remainder of this document details each area of enhancement.

WINEP (Quality)

The capital expenditure is included in the OFWAT tables WS2 and WWS2 is shown below;

Table 14: WINEP enhancement capital expenditure WS2/WWS2

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	1 - WINEP / NEP ~ Making ecological improvements at abstractions (Habitats Directive, SSSI, NERC, BAPs)	£1.608	£0.970	£1.051	£2.638	£1.858	£8.125
WS2	3 - WINEP / NEP ~ Non-native invasive species	£2.376	£1.366	£2.144	£1.471	£0.294	£7.651
WWS2	10 - WINEP / NEP ~ Storage schemes in the network to reduce	£12.561	£25.838	£23.312	£15.383	£4.637	**£81.731**
WS2	17 - WINEP / NEP ~ Drinking Water Protected Areas (schemes)	£1.696	£1.024	£7.018	£5.511	£1.988	£17.237
WS2	18 - WINEP / NEP ~ Water Framework Directive measures	£4.320	£2.995	£1.565	£0.641	£0.186	£9.707
Total		**£10.000**	**£6.355**	**£11.778**	**£10.261**	**£4.326**	**£42.720**
WWS2	13 - WINEP / NEP ~ Chemicals monitoring / investigations / options appraisals	£1.616	£0.640	£0.000	£0.000	£0.000	**£2.256**
WWS2	15 - WINEP / NEP ~ Groundwater schemes	£0.182	£0.082	£0.000	£0.000	£0.000	**£0.264**
WWS2	16 - WINEP / NEP ~ Investigations	£5.624	£1.979	£0.136	£0.139	£0.140	**£8.018**
WWS2	18 - WINEP / NEP ~ Nutrients (P removal at activated sludge STWs)	£87.843	£106.375	£83.657	£51.617	£17.893	**£347.385**
WWS2	19 - WINEP / NEP ~ Nutrients (P removal at filter bed STWs)	£60.596	£45.007	£18.464	£4.151	£0.676	**£128.894**
WWS2	20 - WINEP / NEP ~ Reduction of sanitary parameters	£1.744	£1.621	£0.586	£0.000	£0.000	**£3.951**
WWS2	22 - NEP ~ Discharge relocation	£0.000	£2.213	£2.047	£1.151	£0.274	**£5.685**
WWS2	41 - WINEP / NEP ~ No Deterioration in Sanitary Parameters	£0.000	£0.949	£1.774	£1.395	£0.472	**£4.590**
WWS2	42 - UWWTD Investigations	£9.355	£9.383	£8.311	£6.094	£2.756	**£35.899**
Total		**£222.299**	**£234.941**	**£174.926**	**£107.529**	**£38.286**	**£777.981**

The operational expenditure for these lines are as shown below;

Table 15: WINEP enhancement operational expenditure WS2/WWS2

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WWS2	2 - Sludge enhancement (quality) (In Part)	£0.000	£0.000	£0.000	£0.038	£0.038	**£0.076**
WWS2	7 - WINEP / NEP ~ Flow monitoring at sewage treatment works	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**
WWS2	9 - WINEP / NEP ~ Schemes to increase flow to full treatment	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**

WWS2	10 - WINEP / NEP ~ Storage schemes at STWs to increase storm tank capacity	£0.000	£0.000	£0.000	£0.019	£0.163	**£0.182**
WWS2	11 - WINEP / NEP ~ Storage schemes in the network to reduce spill frequency at CSOs, etc	£0.000	£0.000	£0.000	£0.000	£0.103	**£0.103**
WWS2	12 - WINEP / NEP ~ Chemicals removal schemes	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**
WWS2	13 - WINEP / NEP ~ Chemicals monitoring / investigations / options appraisals	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**
WWS2	15 - WINEP / NEP ~ Groundwater schemes	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**
WWS2	16 - WINEP / NEP ~ Investigations	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**
WWS2	18 - WINEP / NEP ~ Nutrients (P removal at activated sludge STWs)	£0.000	£0.000	£1.077	£4.479	£6.504	**£12.060**
WWS2	19 - WINEP / NEP ~ Nutrients (P removal at filter bed STWs)	£0.000	£0.000	£2.363	£8.506	£12.057	**£22.926**
WWS2	20 - WINEP / NEP ~ Reduction of sanitary parameters	£0.000	£0.000	£0.000	£0.414	£0.416	**£0.830**
WWS2	22 - NEP ~ Discharge relocation	£0.000	£0.000	£0.000	£0.000	£0.049	**£0.049**
WWS2	41 - WINEP / NEP ~ No Deterioration in Sanitary Parameters	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**
WWS2	42 - UWWTD Investigations	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**
Total		**£0.000**	**£0.000**	**£3.440**	**£13.456**	**£19.330**	**£36.226**

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	1 - WINEP / NEP ~ Making ecological improvements at abstractions (Habitats Directive, SSSI, NERC, BAPs)	£0.000	£0.000	£0.031	£0.060	£0.061	**£0.152**
WS2	3 - WINEP / NEP ~ Non-native invasive species	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**
WS2	17 - WINEP / NEP ~ Drinking Water Protected Areas (schemes)	£1.082	£1.084	£1.310	£1.332	£1.457	**£6.265**
WS2	18 - WINEP / NEP ~ Water Framework Directive measures	£0.000	£0.000	£0.016	£0.027	£0.027	**£0.070**
Total		**£1.082**	**£1.084**	**£1.357**	**£1.419**	**£1.545**	**£6.487**

Context

This expenditure is required to comply with new legally enforceable quality obligations agreed with Environment Agency to meet water quality standards specified against the sites and standards in WINEP3 as issued for Yorkshire Water. This should be read in conjunction with the WINEP Appendix which gives greater details around the WINEP development methodology.

Cost Robustness

There are ranges measures and costs associated with obligations within the WINEP. Broadly these split into 4 categories;

1. Measures to physically remove biological and chemical parameters within the effluent as it passes through the treatment process specifically around sanitary or nutrient parameters
2. Measures to measure or provide additional storage capacity both on continuous discharge sites and on line intermittent storage to stop uncontrolled spills into the environment
3. Measures to proactively intervene in the water environment to improve the biodiversity and water quality e.g. installation of fish passage on heavily modified water bodies or catchment management interventions to retain and control flow of raw water to improve water quality
4. Investigations into a wide range of environmental issues to support the need for future proactive interventions ensuring that activities are targeted and effective

The WINEP was agreed and released in 3 stages to YW; WINEP1 in March 2017, WINEP2 in September 2017 and finally WINEP3 in March 2018. Within WINEP3 we have been asked to ensure that we make allowance in our Plan for all measures with green and amber status. The number of individual measures at these status' totals 1071. Our approach to costing these measures was to develop a 'Project Charter' which categorised each group of measures into cohorts, so they could be investigated and costed in a consistent way.

A Project Charter is an internal Quality Assurance methodology that defines; the assets or service to be investigated, a project plan, a RACI and funding requirements to complete the task.

The number of cohorts is largely the same as the number of drivers and measures in the Ofwat reporting lines and the tables above. Once divided into cohorts, through the project charter we then determined a costing strategy to derive a robust, efficient cost. Where possible we use the Yorkshire Water Unit Cost Database (UCD) to cost our solutions, a large database of historic costs that we can use to forecast accurately the cost of similar assets and interventions of the same type. Some solutions are very complex and have many individual cost elements associated with them (e.g. a typical Phosphorus Chemical removal scheme) whereas others are very simple solutions and may have only 1 or 2 individual cost elements (e.g. an online storage scheme). In most

of cases, no matter what the complexity, the approach to costing is the same and utilises our UCD.

For measures that required an asset that has not been constructed by Yorkshire Water historically, clearly there will be no company unit cost model available. An example of this might be a 4th stage ultrafiltration process associated with removing trace metals under the WFD Priority Substance driver. In a small number of cases we would refer to the national UCD such as TR61 or engage our contract partner delivery community to source us a robust cost.

Investigations are an area that we don't have a suite of UCDs for as they tend to be bespoke, therefore supplier quotes are obtained, or similar pieces of work carried out historically are used for comparison and cost setting.

Many of our WINEP obligations also drive additional opex – 'opex of capex' after the year of planned completion. Similar to the UCD, we have a suite of operational cost curves for areas such as chemicals, power and sludge handling. Unlike the capital UCD, we can utilise these robust cost curves in all cases and are not reliant on external data.

System and process

We utilise an in-house process selection tool, that selects and sizes the most appropriate process for the water quality parameter proposed, and this has been used consistently across the programme of activity. All our solutions and costs go into the DMF investment planning system which to ensure consistency with the rest of the programme, scored against a service measure for benefits assessment.

Quality Assurance of Costs

We have applied several quality assurance checks throughout the process. These are summarised below;

1. Early Investigation Process Workshops – these organised workshops involved our delivery framework partners and consultants over a 2-3 day period in a workshop which was designed to give much more detail to the notional design derived through our process selection tool. Each part of the process was challenged using performance and mass balance data where possible to ensure

a robust design was derived. After the workshop the scheme was recosted once again both by YW and the Contract Partner and where there was significant discrepancy we used an expert cost consultant (Turner & Townsend) to determine the most appropriate cost. This was a time consuming and expensive process; therefore, a defined range of schemes went through the process with learning deployed to the wider programme context.

2. Every design and build solution was QA'd separately by a costing engineer (capex) and T&T (opex). This ensured a consistent challenge was applied and where common issues were found, they were rectified
3. All solutions of any type are processed through the DMF system ensuring that the most up to date UCD models, opex calculations and price base are consistent.

The table below summarises the key drivers and measures and their source of capex and opex (if applicable).

Table 16 - WINEP driver costing methodology

Driver/Measure	Capex Cost	Opex Cost
Habitats Directive, SSSI, NETRC, BAPs, Groundwater	Historic cost or expert consultant estimate	n/a
WFD - Heavily Modified Water Bodies	Historic cost or expert consultant estimate	n/a
WFD - Invasive Species	Historic cost or expert consultant estimate	n/a
Raw Water Deterioration - Catchment Management	n/a	Historic cost or consultant estimate
WFD / UWWTD Flow & Storage Drivers	Company UCD	n/a
WFD - Priority Substances investigations & No Deterioration	Company UCD	Company opex model
WFD / UWWTD - investigations	Historic cost or expert consultant estimate	
WFD / UWWTD Nutrients (P removal at activated sludge STWs)	Company UCD	Company opex model
WFD / UWWTD Nutrients (P removal at filter bed STWs)	Company UCD	Company opex model
WFD - P removal through discharge relocation	Company UCD	Company opex model
WFD - Sanitary (BOD / Ammonia) improvements	Company UCD	Company opex model
WFD - No Deterioration of sanitary parameters	Company UCD	Company opex model

A more detailed explanation of the approaches to costing this large area of investment can be found in the WINEP Appendix.

Cost Efficiency

We have applied several measures to ensure our costs are efficient and customers are protected. These measures split into 2 categories; P removal costs and all other drivers and measures.

P removal costs

There are 80 individual treatment P consents in the WINEP programme. When costing the programme, we were mindful the programme size was likely to be unprecedented and larger than anything we had delivered historically. Outputs from our P removal process selection tool, drove a cost more than an affordable plan.

We are aware through the provision of initial cost information to the Environment Agency (EA), that a view was taken that the costs associated with this programme of activity were too high. We would highlight the previous costs provided to the EA were deemed 'full cost' and not just those costs associated with enhancement investment.

We have since implemented several key efficiency measures to ensure that we challenge ourselves hard in the plan to find innovation in scope and delivery, to ensure we are comparatively efficient with our P costs compared to the industry and to protect customers. The measures taken were;

- Challenging the most appropriate delivery process and associated overhead costs
- Challenging the scope of the scheme
- Challenging the least whole life cost approach and technology selection
- Challenging the requirements for future growth

Through the challenges identified above, we believe our enhancement expenditure requirements to meet the WINEP3 Phosphorous requirements are efficient. It is these efficienct costs that are included in our plan.

All other measures

Overall efficiency reductions have been applied to all other aspects of WINEP in line with our top down efficiency approach. See cost efficiency chapter of the plan.

Over and above the business risk we have accepted, we have applied an efficiency cost reduction to the whole WINEP3 programme of £47.3m.

WINEP Unit Cost

In accordance with Ofwat guidance, we have created a unit cost for all measures under Amber for reconciliation should the WINEP programme change. This is explained in detail in our WINEP Cost Appendix.

Growth (Supply/Demand Balance)

The capital expenditure is included in the OFWAT tables WS2 and WWS2 as shown below;

Table 17: Growth enhancement capital expenditure table map

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	11 - New developments	£1.635	£2.217	£2.673	£2.209	£1.766	**£10.500**
WS2	12 - New connections element of new development (CPs, meters)	£5.930	£5.973	£6.025	£6.079	£6.134	**£30.141**
Total		**£7.565**	**£8.190**	**£8.698**	**£8.288**	**£7.900**	**£40.641**

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WWS2	25 - New development and growth	£8.037	£11.070	£8.898	£6.357	£4.354	**£38.716**
WWS2	26 - Growth at sewage treatment works (excluding sludge treatment)	£7.847	£17.046	£21.229	£15.736	£5.477	**£67.335**
Total		**£15.884**	**£28.116**	**£30.127**	**£22.093**	**£9.831**	**£106.051**

The operational expenditure included in tables WS2 and WWS2 are shown below;

Table 18: Growth enhancement operational expenditure table map

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	11 - New developments	£0.000	£0.000	£0.000	£0.000	£0.000	£0.000
WS2	12 - New connections element of new development (CPs, meters)	£0.000	£0.000	£0.000	£0.000	£0.000	£0.000
Total		**£0.000**	**£0.000**	**£0.000**	**£0.000**	**£0.000**	**£0.000**

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WWS2	25 - New development and growth	£0.000	£0.000	£0.000	£0.000	£0.100	£0.100
WWS2	26 - Growth at sewage treatment works (excluding sludge treatment)	£0.000	£0.000	£0.004	£0.066	£0.229	£0.299
Total		£0.000	£0.000	£0.004	£0.066	£0.328	£0.399

Context - Overall Growth Enhancement Expenditure

There are three key areas of growth enhancement expenditure covered in this document, they are: -

1. Clean-water network growth for new development
2. Wastewater network growth for new development
3. Wastewater treatment growth for new development and DWF driver

We have some significant localised developments within our region which will impact heavily on local wastewater treatment capacity requirements in AMP7, and significantly increase our growth investment needs relative to what would be required for more typical incremental growth. The four largest of those developments (Parlington, Green Hammerton, Catterick and York), by their scale and location, it cannot be accommodated by existing sewage treatment works and will require significant investment in new assets. The costs for these developments will have a material impact on our overall costs in the wholesale wastewater price control and as such are the subject of a specific cost adjustment claim. The efficient capex cost which we consider should be excluded from any cost comparison is £55.31m as set out in WWn8 and explained in our wastewater growth cost adjustment claim evidence pack (claim identifier YKY WWN+ 04).

We have no planned enhancement expenditure for growth within water treatment or water resources on the basis that our current supply demand position and our leakage enhancement plan for AMP7 will ensure we have sufficient headroom within our supply demand balance over the planning horizon. The expenditure associated with our enhanced leakage plan is discussed elsewhere in this document.

Regarding the Bioresources price control we will require significant additional sludge treatment capacity in AMP7 to deal with the additional volumes generated because of our WINEP3, phosphate removal programme. Based on specific feedback provided by Ofwat to our query (referenced no. 269) it was confirmed that expenditure for additional sludge treatment capacity in bioresources should be treated as a cost adjustment claim, rather than expecting it to be modelled through enhancement. We have followed that advice and set out the basis for additional investment in bio-resources capacity in our cost adjustment claim evidence pack (claim identifier YKY BR-01).

A key driver of growth enhancement expenditure is forecast future population within the region and we have used a consistent approach to estimate this impact on our water and wastewater networks and wastewater treatment investment needs.

We commissioned consultancy Edge Analytics Ltd to undertake analysis based on housing growth evidence from Local Plans to develop a plan-based, housing-led growth scenario which underpins our assessment of growth investment needs which we describe in more detail below. The growth enhancement investment uses the same plan-based projection for the period up to 2024-25, as used in our Water Resources Management Plan which was developed in line with the Environment Agency's Water Resource Planning Guidelines (WRPG).

Clean-water Network Growth Expenditure

Context

The expenditure set out in table 18 above (from business plan table WS2 Lines 11 and 12), reflects the expected capital investment required during AMP7, to meet our obligations under the Water Industry Act 1991, to connect new domestic and commercial properties to our water supply network without detriment to the service provided to properties already connected to the water main network. The figures in the table are our post efficiency estimates adjusted for real price effects.

The investment reflects the cost of new communication pipes, meters, street furniture and any new mains required to ensure that we can meet our obligations under the Act. Our approach to determining clean-water network growth expenditure for AMP7 comprises analysis of likely growth in new connections and an assessment of a representative cost, based on historic out-turn costs for similar activities.

Cost Robustness – Clean Water Network Growth

Using historic cost data (between 2005/06 and 2016/17) which was provided by our New Developments team and data on new connections in that period taken from our audited regulatory returns, we were able to derive a unit cost per new connection over that period. Over this 12 year period we connected over 173,000 additional properties to our network at an overall cost of just over £68 million (2016/17 prices) giving an average cost per connection of around £392.

Using plan-based population forecast data provided by Edge Analytics we were able to forecast the number of new properties likely to be connected each year. This analysis suggested a total of 108,000 new connections required in AMP7 or just over 21,000 per annum. We have developed specific scheme costs for some known strategic development sites within our region at Parlington, Green Hammerton and Catterick and assumed that the other development growth in networks would be delivered at the unit rates derived from our historical cost analysis. On this basis our overall investment requirement in AMP7 was assessed at £48.05 million.

The activity levels and unit costs per new connection is based on accurate historic data from the last 12 years and we consider it to be robust however we also consider there are likely to be opportunities for further efficiencies in the way we deliver these outputs in AMP7 and have further challenged our historic unit cost assessment to enable us to reduce the overall costs in our plan. Our approach to efficiency is discussed below. There is some inherent uncertainty in population growth forecasts which are subject to many external macro-economic impacts, but the methodology adopted by Edge Analytics and set out in the attached report is robust and the core estimate derived represents the appropriate balance between the upper and lower bounds of their forecasts.

Cost Efficiency – Clean Water Network Growth

Provision of new water mains and connections is a well-established part of our day to day operations, with robust and streamlined processes. These activities are generally efficiently delivered through a long-standing supply chain partner (through our Water Services Agreement contract). However, in meeting water network growth needs in AMP 7 we will review our delivery routes both through re-tendering our supply chain arrangements and utilising other options such as self-lay where this would provide savings.

On this basis we have targeted further efficiencies of around 15.5% relative to our historic unit rates leading to the reduction in overall costs for our AMP7 water networks growth programme to a total of £40.6 million.

Wastewater Network Growth Expenditure

Context

The expenditure set out in table 18 above (from business plan table WWS2 Line 25), reflects the expected capital investment required during AMP7, to meet our obligations as a Sewerage Undertaker under Planning Legislation and the Water Industry Act 1991, to provide, improve and extend the sewerage network without detriment to the service provided to properties already connected to it. The figures in the table are our post efficiency estimates adjusted for real price effects.

In AMP7 we anticipate that seven significant development projects, which will ultimately deliver around 24,000 new properties. These projects will be initiated across our region in AMP7 and will necessitate specific improvements to the sewerage infrastructure in those areas. Our approach to determining wastewater network growth expenditure for AMP7 comprised analysis and detailed costing of the infrastructure required to meet the needs of those new developments and an allowance for sewer requisitions throughout the AMP. The seven developments referred to above are: -

- Parlington – 4000 properties
- Green Hammerton - 2744 properties
- York – 13,500 properties
- Catterick – 1800 properties
- Goole – 820 properties and a 1.1 hectare school development
- West Harrogate – 722 properties
- Boroughbridge – 635 properties

As stated earlier, an element of this cost forms part of our cost adjustment claim for Growth (claim identifier YKY WWN+ 04). £19.7m of our £55.3m claim is related to Wastewater Network growth and is associated with the network reinforcement element of the York and Catterick growth schemes.

Cost Robustness – Wastewater Network Growth

Given that we had specific information on the four largest development areas in AMP7 we were able to carry out a comprehensive assessment of the infrastructure and non-infrastructure investment options to meet those development needs. Our consultants Arup were commissioned to carry out a detailed study to assess the impact on the existing asset base and develop costed solutions for the four largest developments. Their approach is described in detail below.

- Location details and data about new development sites were taken from Local Plans and Arup undertook an assessment of both foul and surface water flows from each site. The assessment has considered the impact of a new development's flows on the wider Yorkshire Water wastewater network to understand existing capacity and headroom and sought to identify efficient solutions. Gravity solutions were always favoured over pumped solutions, for long term sustainability, however several sites did require some pumped drainage.
- We provided Arup with the appropriate wastewater models for the catchments concerned and they ran multiple scenarios, to establish the critical storm event duration in terms of the worst-case flooding. Comparison of the flood volumes between the baseline and the development models were made to assess the impact of the new developments on the existing network. Allowances for any contributing areas outside the modelled area were included based on industry standard approaches.
- A range of alternative solutions were developed for each site comprising both permanent and temporary treatment options and related sewerage infrastructure with consideration given to both physical infrastructure and Integrated Water Management options (to reduce inflows from new developments). Typically, 4 or 5 detailed solutions were developed and tested for hydraulic feasibility.
- Each solution was subject to detailed costing using the Yorkshire Water Unit Cost Database (UCD), supplemented by estimates from Arup and/or suppliers data. Arup also provided the opex estimates for the proposed solutions. A 40-year whole life cost comparison was then undertaken to enable us to select the solution which met all technical requirements and provided best value for customers.

The three smaller sites by property count, Goole, West Harrogate and Boroughbridge were costed by our Developer Services team following their standard methodologies using a combination of model-based option comparison and desktop analysis, appropriate to the complexity of the scheme and the materiality of the cost.

This resulted in a total investment requirement of around £33 million in addition to which we included a further £12 million for the costs of ongoing unspecified sewer requisitions which has been derived from historic costs and activity levels.

Cost Efficiency – Wastewater Network Growth

Provision of new sewerage and connections is a well-established part of our day to day operations, with robust and streamlined processes. These activities are generally delivered through established supply chain arrangements. However, in meeting wastewater network growth needs in AMP 7 we will review our delivery routes both through re-tendering our supply chain arrangements and utilising other options such as self-lay where this would provide savings.

On this basis we anticipate being able to deliver further efficiencies of around 17% relative to our historic unit rates leading to the reduction in overall costs for our AMP7 wastewater networks growth programme to a total expenditure of £38.8 million.

An element of this cost forms part of our cost adjustment claim for Growth. This is the network reinforcement element of the York and Catterick growth schemes.

Wastewater Treatment Growth Expenditure

Context

The expenditure set out in table 18 above (from business plan table WWS2 Line 26), reflects a proportion of the expected capital investment required during AMP7, to meet our obligations as a Sewerage Undertaker under Planning Legislation and the Water Industry Act 1991, to provide, improve and extend the sewerage network and make provision for the emptying of those sewers to appropriate disposal works, without detriment to the service provided to properties already connected to our system. The figures in the table are our post efficiency estimates adjusted for real price effects.

As previously stated we anticipate that seven significant development projects will be initiated across our region during AMP7. Four of these projects form part of our cost adjustment claims for Growth (claim identifier YKY WWN+ 04). Wastewater Treatment Growth makes up £35.5m of our £55.3m claim and is related to the treatment schemes at York, Catterick, Parlington and Green Hammerton.

For the remainder of our works and catchments we have carried out a detailed assessment of the impacts of population growth (using the population and property forecasts provided by Edge Analytics previously mentioned) on dry weather flows (DWF), and local works headroom to identify where further enhancement expenditure may be required.

Cost Robustness – Wastewater Treatment Growth

To establish the investment need, we identified all our works with the relevant baseline data including current DWF and their existing DWF consents. We then applied the relevant growth forecasts for each catchment to identify those works which were predicted to fail their consent by 2025 based on those forecasts.

Initially this process identified over 20 potential treatment works where additional investment would be required, this was then subjected to a QA process where challenge was levied on whether demand side solutions were available and preferable (described later), and if an alternative view of the risk could be taken. This resulted in the removal of several sites.

In April 2018 we received updated information on the requirements for the WINEP programme which revealed that many of the potential growth sites would also have a tight P consent under the WFD driver, this lead to a few sites where an integrated scheme to meet the quality drivers and address any growth pressures were developed in the interests of efficiency.

For the four communities where we have significant developments due to commence in AMP7 (York, Catterick, Parlington and Green Hammerton) we were able to develop specific costs as described previously. For the remainder we developed initial solution and costings based on the assessed additional capacity requirements using our established process selection tool to estimate the costs for the required process extensions and refurbishment. To ensure that our initial solution was not leading to excessive cost, we commissioned our consultants, Arup, to carry out a detailed assessment of the potential for alternative demand-side, flow reduction solutions. Any sites where the demand side solution represented a lower whole life cost, for example Seamer STW, the Arup alternative solution has been adopted and therefore wastewater treatment growth requirement has been eliminated or reduced.

The total wastewater treatment enhancement investment for growth, identified on this basis is £78.66 million of which a significant proportion reflects the exceptional costs included in our wastewater growth cost adjustment claim (claim identifier YKY WWN+ 04). We consider this to be a robust estimate based on our structured approach to defining the scope of the programme.

Cost Efficiency – Wastewater Treatment Growth

As described above we have sought to minimise the scope of AMP7 enhancement investment in wastewater treatment required to meet DWF consent by implementing alternative flow reduction solutions where possible and by providing integrated solutions at sites which also require quality investment to meet WINEP / WFD obligations. We consider that we have an efficient scope to meet our forecast future DWFs.

Using our company unit cost database enables us to identify efficient solution costs, but we recognise that these are high level solutions and we would anticipate that through further optimisation and value engineering we should be able to achieve further efficiencies in delivering these schemes. We will also take advantage of the opportunities to go back to the market for capital delivery partners in AMP7 which will yield further efficiency savings through innovation and better ways of working with external organisations.

On this basis we anticipate being able to deliver further efficiencies of around 14% relative to our initial cost estimates, leading to the reduction in overall costs for our AMP7 wastewater treatment growth programme to £67.335 million (after adjustment for real price effects) which includes £35.5m of atypical investment as set out in the cost adjustment claim previously referred to.

Hull and Haltemprice (Enhanced Level of Service)

The expenditure is included in the OFWAT table model as shown below;

Table 19: Hull Enhancement expenditure table

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WWS2	27 - Resilience	£5.626	£5.665	£5.734	£5.810	£5.894	**£28.729**
Total		**£5.626**	**£5.665**	**£5.734**	**£5.810**	**£5.894**	**£28.729**

Context

We face a unique regional operating circumstance in the Hull and Haltemprice area which requires an atypically large investment now and, in the future, to manage flood risk in this part of our region. Since 2007, there has been significant investment in Hull's sewerage system to reduce the risk of flooding from the sewers. Major work has taken place at Bransholme to improve the surface water pumping capacity as well as improving the operation of the East and West Hull pumping stations, used under emergency conditions. We recognise that there will be a need for investment over subsequent AMPs in the future from AMP7.

These operating circumstances makes it different to many other cities across our region and in the UK. This means that there is a significantly high risk of flooding (outlined below). These unique geographical and historical challenges include:

- **Below sea level**: Due to its level, Hull and Haltemprice must be drained by a pumped system. Pumped outfalls are utilised at the wastewater treatment works (for treatment and storm) and emergency outfalls at East and West Hull. The majority of flow during storm is discharged through the pumping stations at Saltend WwTW. During extreme weather we operate East and West Hull pumping stations. Pumping is often required because Hull is below sea level, and at times the pumps can discharge less water when the tides are high. The remaining combined sewer network can only be relieved at seven combined sewer overflows (CSO) further up in the network, which is a small proportion compared with many cities drained via a combined sewerage system.
- **Topography**: In most cities, when it floods, water will travel overland and enter into any available drainage system (i.e. back into the system it came from or an

alternative). Because Hull is flat, when it floods, the water has nowhere to go with there being very few alternative discharge points such as watercourses. Therefore, if flooding occurs, many properties are at risk.

- **Receives inflows**: Hull and Haltemprice receive inflows from neighbouring rural areas notably from the north and west. Unlike many cities, decisions were made in the 1950s onwards to cover and direct watercourses into the sewer system due to public health concerns. This has resulted in a proportion of the storm flows in the sewer network coming from rural areas with land drainage exacerbating the flood risk.
- **Impermeable ground condition**: This prevents the ability to permeate water through infiltration systems leading to higher SuDS costs to manage and gradually release flows back to the existing drainage system. It also means during heavy rainfall; the green spaces are more likely to become saturated and increase the surface runoff. Whilst this is not unique to Hull and Haltemprice by itself, when combined with the other limitations, it means that the cost of managing surface water is increased.

Understanding flood risk in Hull

We now have a far clearer and accurate understanding of the level of flood risk to properties in Hull and Haltemprice from water escaping from the sewer system. There are over 5,000 properties at risk of flooding from a 1 in 5-year rainfall event. This is proportionally higher than our other major urban areas and therefore requires long term atypical investment to address this risk.

The sources and mechanisms are extremely complex due to the interactions of different components of the drainage network, where the water comes from and the specific local context (described above). Over the last six years, we have developed the tools to understand the risk of flooding better in the Hull and Haltemprice area. This commenced with drainage area study modelling, followed by the development of an integrated urban drainage multi-agency model that replicates 2D flooding on the surface. The result is that all the agencies responsible for flooding are clearer in terms of the different sources and mechanisms of flood risk.

The multi-agency drainage model replicates the flows that can enter into the Hull and Haltemprice sewer system. This includes the:

- Rural runoff and land drainage that enters watercourses prior to discharging into the sewerage system;
- Greenfield runoff in urban areas during larger events;
- Interaction between the below ground drainage system and above ground urban area with water on the surface.

There are nearly 157,000 properties represented in the model. It indicates the number of properties at risk of internal flooding either by escaping from or not entering into the drainage system with:

- Over 5,000 properties are at risk of flooding on a 1 in 5-year rainfall return period event
- circa 17,000 properties are at risk of flooding on a 1 in 30-year rainfall return period event
- Over 29,000 properties are at risk of flooding on a 1 in 75-year rainfall return period event

Proportionally, compared with the rest of the Yorkshire region, Hull and Haltemprice is at a far higher scale of flood risk than other urban catchments due to the nature of the flat catchment (and other circumstances outlined above) with flooding spreading out on the surface. Once the water reaches a threshold, numerous properties become at risk of flooding internally. Table 20 provides a comparison between Hull, Sheffield and Leeds, demonstrating the higher flood risk in Hull.

Table 20 - Comparative predicted model flood risk in major Yorkshire urban conurbations

Location	No. of properties predicted to flood from a 1 in 30 year rainfall event.	Sewer Length (km)	1 in 30 Year Risk/Sewer Length Ratio
Leeds	9511	3561	2.7
Sheffield	5660	2366	2.4
Hull and Haltemprice	22035	1677	13.1

Customer support

Our customers[1] have stated it is important for us to manage flooding, with 75% indicating it is an important issue to resolve, and only 2% indicating it is unimportant. Furthermore, this was the fourth most important priority to our customers, with 79% of customers indicating they want the appropriate plans and resources in place to provide sewage services in the event of extreme weather.

This latter aspect is particularly relevant to Hull and Haltemprice due to its unique nature where thousands of properties are at risk of flooding in heavy rainfall events.

In addition, Rob Light, Northern Chair for Consumer Council for Water, has stated that we can do more to help businesses and consumers protect against flooding.

In our recent discussions through workshops and focus groups with customers[2] , flooding was one of the areas considered to be important, with internal flooding recognised as the most important of all the environmental areas. These results also indicated that sewer flooding performance should improve slightly both now and in the future.

We undertook customer engagement relating to our initial view that Hull would be a cost adjustment claim. Out of all the claims tested with customers[3] , 'Reducing Flood Risk in Hull' ranked as fourth in a priority list. However, this gained an increase in levels of support when the size of investment and bill information was introduced. In the East of the region, there was significantly more support for reducing flood risk in Hull, potentially because of the impact of the 2007 summer flooding was more apparent and local to them. In general, such a regionally specific investment is likely to gain lower support levels where customers from the region as a whole are asked.

[1] Not Just Water - Strategic Direction 2018.pdf outlines the customer support to reduce flooding and its overall priorities (Pg. 26 and 58)
[2] DJS - 4926 PR19 Outcomes Debrief 11.04.18 - Extract – Customer research undertaken by DJS research on behalf of Yorkshire Water outlines the customer importance placed on internal sewer flooding
[3] The findings of the research are summarised in "Qa - Cost Adjustment Claim Research - Redacted Report"

Benefit of the enhancement

We consider that the need for this investment is clear and unavoidable, considering the overall risk to our customers and the wider community within Hull and Haltemprice. We have outlined the likely interventions to take place below within the cost robustness section, essentially taking an adaptive approach utilising sustainable drainage to manage surface water. The anticipated cost is circa £50m however, we believe through collaborative working and partnership funding, the expenditure is far lower as indicated in the cost robustness and efficiency sections (circa £28.7m).

The solutions have been tested in the multi-agency model to understand the level of benefit. Overall, and in comparison, to the alternative grey infrastructure solutions (circa £72M), for the hotspots the SuDS provide good value when considered with the number of properties being likely to flood reducing for the 1 in 5, 30 and 75-year return period. For example, for the 494 properties that will not flood on a 1 in 5-year return period, this equates to £54k/property. Because of the nature of the solutions, this creates benefits to other properties as well, reducing their likelihood of flooding from more extreme rainfall events also (i.e. 1 in 30 and 1 in 75).

In line with all investments included in our business plan we have assessed the costs and benefits of our preferred solution using our strategic investment appraisal tool (DMF). This indicates that the net benefit from completing this work (over 40 years, with similar levels of expenditure planned year on year in future AMPs) based on our Services Measure Framework is in the region of £260M.

We consider that this investment will yield significant additional benefits for customers. The primary benefit is that we will reduce the flood risk to residents and those working within Hull and Haltemprice.

In addition to the reduction in flooding benefits the following additional benefits will be delivered by our proposed approach.

- Help create a more resilient network to cope with extreme rainfall
- Help create more resilient communities
- Help deliver the living with water vision (signed up to by all stakeholders)
- Help enhance the quality of the urban space

- Help improve the health and wellbeing by increasing green infrastructure where retrofitted

We have completed a high-level assessment of the potential wider benefits to the local community using the in industry standard assessment tool, B£ST (Benefits of SuDS Tool as developed by CIRIA) to give an indicative monetary value of the benefits (beyond flood risk[4]). This focused on evaluating health, amenity, education and biodiversity. Whilst there may be wider benefits that reducing flood risk brings (e.g. enabling development, tourism). Taking a pre-cautionary approach to the number of people benefiting and recognising the uncertainty within the assumptions at this high-level stage, the estimated post confidence applied benefit value over a 40-year period range from £946K to £1.09M. Pre-confidence factors applied, the benefit value could be in the region of £14M. Both values include Education and Biodiversity, whilst the lower value considers health benefits, the upper value considers the amenity benefit.

Cost Robustness

We believe in taking an adaptive approach to managing flood risk, by using flexible solutions and implementing interventions over time as our knowledge and partnership working matures. This will enable flood risk to be reduced and avoid 'historical lock in' of solutions whilst creating wider benefits for the community.

The option identification process is fully outlined in a feasibility report for Hull and Haltemprice[5]. This work forms the basis of understanding likely locations to target solutions in AMP7, and the potential costs for these solutions. In summary the process followed was:

- Understanding the flood risk including climate change impacts
- Developing concept options to account for different sources of surface water entering the drainage network. This included identifying 6 concept options (based on the understanding of flood risk and flooding mechanisms) and understanding the performance of each option.
- Short listing of options

[4] Hull & Haltemprice Flood Alleviation Intervention Benefit Assessment.pdf outlines the benefit assessment

[5] Arup – Hull and Haltemprice Feasibility Report

- Developing short listed options into solutions and evaluating their performance. This included identifying areas to target with the blue-green infrastructure solutions and resulted in solutions in hotspot areas being created.
- Evaluation of the costs and benefits to draw conclusions and recommendations for further work.

Based upon the outlined approach and evaluation, three options were taken forward as part of the feasibility work by Arup. One of these options not discussed further here was to separate surface water and discharge to Holderness Drain due to its overall cost and relative performance[6]. This resulted in two further options being considered and summarised here:

- Full grey infrastructure approach,
- Targeted blue-green infrastructure approach (with comparative costs for a grey infrastructure alternative)

A major strategic solution has been developed and evaluated by Arup on our behalf to determine the potential investment [7] [8]. **Taking a full grey infrastructure approach** reduces the number of properties at risk of flooding for a 1in 30-year return period to less than 6000, but at a cost of £1.8bn. This involves a combination of open cut and tunnelled sewers with multiple overflow points from the existing to the new system. This solution ultimately discharges flows to the Humber Estuary. The affordability and sustainability of such a scheme may mean it is unlikely to gain the backing and agreement to progress but offers an indicative benchmark of the scale of investment potentially required in Hull and Haltemprice to significantly reduce flood risk to a level like other major urban conurbations.

Utilising a blue/green infrastructure i.e. sustainable drainage (SuDS) is our favoured approach to reduce flood risk in Hull and Haltemprice. This aligns with the vision of the partnership for Hull and Haltemprice namely 'Living with Water' (www.livingwithwater.co.uk).

[6] Arup – Hull and Haltemprice Feasibility Report summarises why this option was not taken forward
[7] Arup – Hull and Haltemprice Feasibility Report – this summarises the work undertaken to investigate a strategic grey infrastructure solution.
[8] Arup – Hull and Haltemprice Feasibility Report – includes a plan showing the new infrastructure network

A strategic assessment[9] of 47 areas across Hull and Haltemprice (Figure 14), to differing levels of detail, has been completed by Arup on our behalf. Based upon this work, four areas (shown in blue in Figure 14) have been considered in detail where SuDS interventions have been identified and costed to provide the basis of the atypical investment required in Hull over the next AMP.

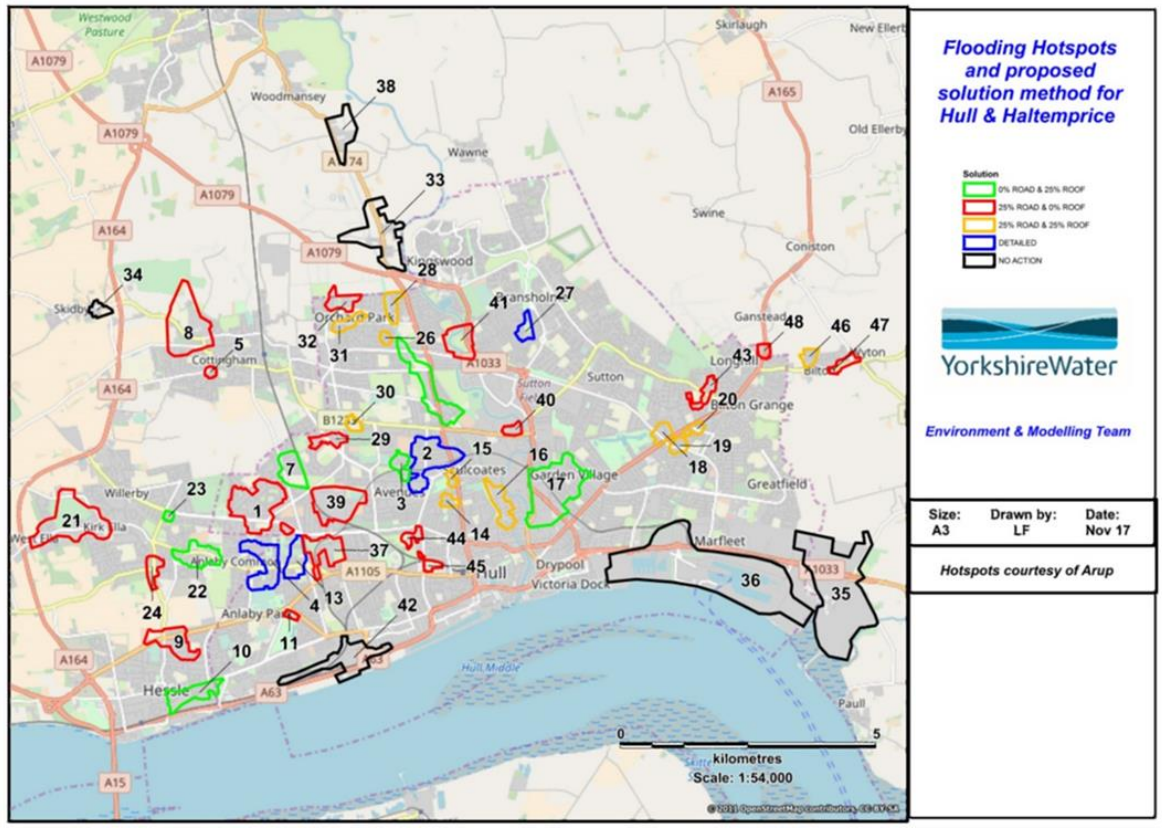
The cost for these 4 areas of implementing SuDS is £50m. This cost obviously differs to the value of the submission (£28.7m). We provide detail of why we believe our expenditure will be less than the £50m in the efficient cost section below.

A cost comparison was completed to assess the grey infrastructure alternative for each of the four hot spot areas. Allowing for an equivalent volume of storage, a unit cost was estimated using industry values, and indicated a cost of £72M.
The delivery of SuDS in the four hotspots would result in less property flooding across the whole of Hull and Haltemprice with the modelling predicting:

- 494 properties flood less on the 1 in 5-year return period
- 808 properties flood less on the 1 in 30-year return period
- 644 properties flood less on the 1 in 75-year return period

[9] Arup – Hull and Haltemprice Feasibility Report – summarises the blue/green infrastructure/SuDS conceptual solution for the four hotspot areas

Figure 14 - The 47 areas investigated, and the 4 areas considered in greater detail



At this moment in time, we anticipate that the operational maintenance of the proposed measures will fall under the most appropriate risk management authority. The measures proposed being focused on street and open space interventions (such as permeable pavement, swales, rain gardens and detention basins), and these would be best maintained by the local authority who currently owns and maintains the land. Therefore, OPEX has not been allowed for as part of this enhancement.

At this stage, with further refinement and co-working with our partners, we anticipate the locations of the solutions may change, however we are committed to achieving broadly similar levels of benefit for Hull and Haltemprice customers using the multi-agency drainage model to understand this.

Long term plan development

Our investment in Hull and Haltemprice needs to form part of a long-term delivery plan. It will see continual investment in Hull and Haltemprice over the coming years aiming to

reduce the risk of property flooding whilst increasing the resilience of the city which will in turn support growth and development.

The initial strategic evaluation for major investment is nearing completion in Hull, and subsequent development of a detailed delivery plan and wider solution development is required during AMP7 to ensure future partnership opportunities can be maximised. As part of this, £1.9m is required to support the development of the long-term plan.
The development of the plan will provide an adaptive and flexible programme of solutions that will maximise when opportunities become available. This will be fully collaborative with our partners in Hull and Haltemprice and aligned with our partners' long-term plans and strategies including housing, transportation and growth. This will sit within the partnership we have been developing, Living With Water that will engage Hull and Haltemprice's communities who we believe are an important part of the solution.

Cost Efficiency

We have been working in partnership with the Environment Agency, Hull City Council and East Riding of Yorkshire Council for several years. We have recognised the need to take a catchment approach to deliver efficient and effective solutions to manage the risk of flooding in Hull and Haltemprice, due to the widespread and connected nature of the flooding. This has resulted with an approach with a more holistic view point and collaborative journey with partners, as now created with the Living With Water partnership.

In 2016 we published Water Culture to help stimulate discussion in creating a water resilient future for Hull. Out of these discussions, the 'Living with Water Partnership' was formed, and in 2017 we held a charrette with partners, stakeholders and experts to explore an ambitious plan for the future.

Prior to the formation of the Living with Water Partnership, the 'Integrated Strategic Drainage Partnership' was working to agreed terms of reference. The newly formed Living with Water Partnership has published its purpose and vision (www.livingwithwater.co.uk) with the new terms of reference being finalised and soon to be signed off by the partnership board.

We are working with our partners throughout 2018/19 to commence a number of activities which includes SuDS retrofit pilots at both a property and a highway level, as

well as within local schools. The learning from this work will support the subsequent investment in AMP7.

The solutions we have developed to date have considered alternative grey infrastructure and SuDS approaches. The SuDS approaches are shown to be more cost effective as indicated above. The development of the SuDS solutions has followed industry best practice (CIRIA) in understanding where to retrofit solutions and provide a significant improvement in flood risk. Within those locations, appropriate selection of the types of SuDS has considered the current opportunities.

The four areas have been conceptually designed to determine a cost estimate that readily improves levels of service for our customers in that area. The costs to deliver these schemes in total (identified above as £50M) is more than enhancement expenditure for two reasons.

1. We believe there are efficiencies to be gained in how the SuDS will be delivered such as collaborating with others through partnership working. This will build on the foundation of the Living with Water Partnership.
2. There is the opportunity to work with partner funding organisations as well as wider group of non-water stakeholders in Hull to supplement the investment to make up the shortfall between the estimated cost (£50M) and submission (£28.7M).

The designs have considered what is possible to retrofit, rather than be designed to a prescribed set performance level, therefore they are different to how grey infrastructure/ conventional solutions are developed. Work undertaken by Arup on behalf of Yorkshire Water to develop the SuDS solutions intercept flow from over 21ha of impermeable area. The costs for the scheme have been developed using industry evidence for retrofitting SuDS[10].

Within the four hotspot areas, flows must be attenuated and slowly released back, which significantly increases the cost of such solutions. Due to some of the local urban constraints, permeable paving has been selected to enable the management of surface water, which as a unit cost drives the higher overall cost.

[10] Arup – Hull and Haltemprice Feasibility Report - summarises the blue/green infrastructure/SuDS conceptual solution for the four hotspot areas

The four hotspot costs have been independently validated [11]. This shows that the cost estimates are reasonable and comparable to alternative delivery experience of SuDS. Whilst a high multiplier has been applied to the direct costs, there is uncertainty in the enabling works and risk required, therefore at this stage, these are appropriate. We recognise that in comparison to other major SuDS retrofit programmes, the cost appears to be greater than average, however this is due to the unique circumstances within Hull and Haltemprice and the ability to drain surface water to an alternative source. The design of the measures though is adaptable to enable them to be connected to an alternative discharge point (i.e. watercourse) in the future and remove the flows from the network.

As part of our plan development, we will continue to explore the best options to deliver the necessary solutions, considering both the balance between recurring and non-recurring totex as they develop.

[11] Stantec – YWS PR19 Cost Adjustments - Hull Costs - Technical Note v1 – Independent review of the SuDS scheme costs for the four hot spot areas in Hull and Haltemprice

Network Escapes (Enhanced Level of Service)

The following enhancement expenditure is associated with the prevention of network escapes associated with our Internal Sewer Flooding and Pollution Performance Commitments.

- Reduced flooding risk to properties
- Pollution UQ
- Internal Sewer Flooding UQ

The expenditure is included in the OFWAT table WWS2 as shown below;

Table 21: Network Escapes Enhancement Expenditure WWS2 Capex

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WWS2	30 - Reduce flooding risk for properties	£7.596	£14.031	£11.303	£4.236	£4.274	**£41.440**
WWS2	37 - Pollution - UQ	£5.700	£4.404	£4.425	£4.435	£4.435	**£23.399**
WWS2	38 - Internal Flooding - UQ	£10.326	£0.000	£0.000	£0.000	£0.000	**£10.326**
Total		**£23.622**	**£18.435**	**£15.728**	**£8.671**	**£8.709**	**£75.165**

Table 22: Network Escapes Enhancement Expenditure WWS2 Capex Opex

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WWS2	30 - Reduce flooding risk for properties	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**
WWS2	37 - Pollution - UQ	£2.918	£3.251	£3.646	£4.002	£4.344	**£18.161**
WWS2	38 - Internal Flooding - UQ	£4.383	£0.000	£0.000	£0.000	£0.000	**£4.383**
Total		**£7.301**	**£3.251**	**£3.646**	**£4.002**	**£4.344**	**£22.544**

Context

Our big goal: *We will remove surface water from our sewers and recycle all waste water, protecting the environment from sewer flooding and pollution* [12].

Weather patterns are expected to change, and the population is expected to grow. This will put additional pressure on our sewer systems. If we do not change how we manage our network, the changes in weather and population could lead to increased investment to build greater capacity, or an unacceptable detriment in performance. The latter may lead to:

- increased risk of sewer flooding,
- increased amounts of sewage entering our rivers from combined sewer overflows,
- increased pollution resulting from network escapes.

Whilst we have maintained our performance against the internal sewer flooding and pollution performance measures during AMP6 [13], we realise that our performance can be improved further to benefit our customers and the wider environment.

To rectify this, we have set ourselves stretching targets in the area of Internal Sewer Flooding and Pollution in both the AMP6 and AMP7 periods. We are commencing this journey through reinvesting circa. £90m of outperformance money in AMP6 to improve our service, ensuring Customers are not exposed to the full cost impact of the stepped service improvement.

We have committed to achieving a 70% reduction in internal sewer flooding, reducing the number of incidents to no more than 345 by the end of 2024/25 and a 40% reduction in pollution incidents, reducing these to no more than 116 by the end of 2024/25. This reduced further through AMP7. These commitments feature in our long-term strategy namely goal 3 of our 5 big goals. Our customers have indicated the reduction and management of flooding and pollution incidents are a key priority[14].

[12] Not Just Water – Strategic Direction 2018
[13] AMP6 performance commitment defintion
[14] DJS - 4926 PR19 Outcomes Debrief 11.04.18 - Extract

Internal sewer flooding

We plan to deliver Upper Quartile service levels to our customers in AMP7 which is a significant improvement on our AMP6 service as shown in Figure 15 (based on the shadow reporting definitions for consistency). The graph shows the increase in incidents in 2017/18 (due to the number of repeats), and the step change in performance through reinvestment starting in Year 4 and 5 in AMP6 and the benefit to our customers. The number of incidents will drop from 582 in year 5 of AMP6 to 401 in the first year of AMP7, as indicated in Table 23 that shows the performance commitment for internal sewer flooding incidents.

Figure 15 - Number of internal sewer flooding incidents per year for the AMP6 and AMP7 performance commitments compared with actual performance and the UQ improvement plan (based on shadow reporting definition)

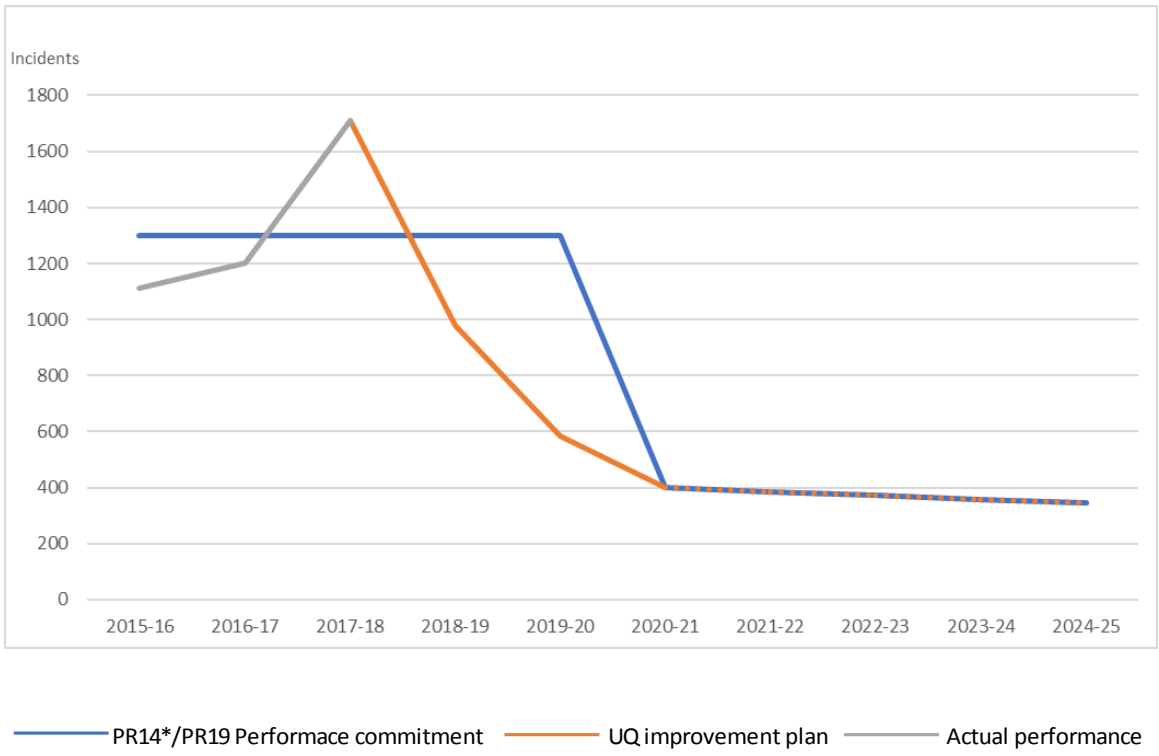


Table 23 - Our AMP7 performance commitment incident numbers for internal sewer flooding

	2020/21	2021/22	2022/23	2023/24	2024/25
Performance Commitment Target	401	386	372	358	345

Pollution

Similarly, we plan to deliver Upper Quartile service levels to our customers in AMP7 which is a significant improvement on our AMP6 service as shown in Figure 16. This highlights that with no change, our performance would be at risk of deteriorating, however through the upper quartile programme investment and continued expenditure, we will reduce the number of pollution incidents occurring significantly by the start of AMP7 and then a gradual reduction during AMP7.

Figure 16 - Number of pollution incidents per year comparing the performance commitments with actual and proposed performance changes

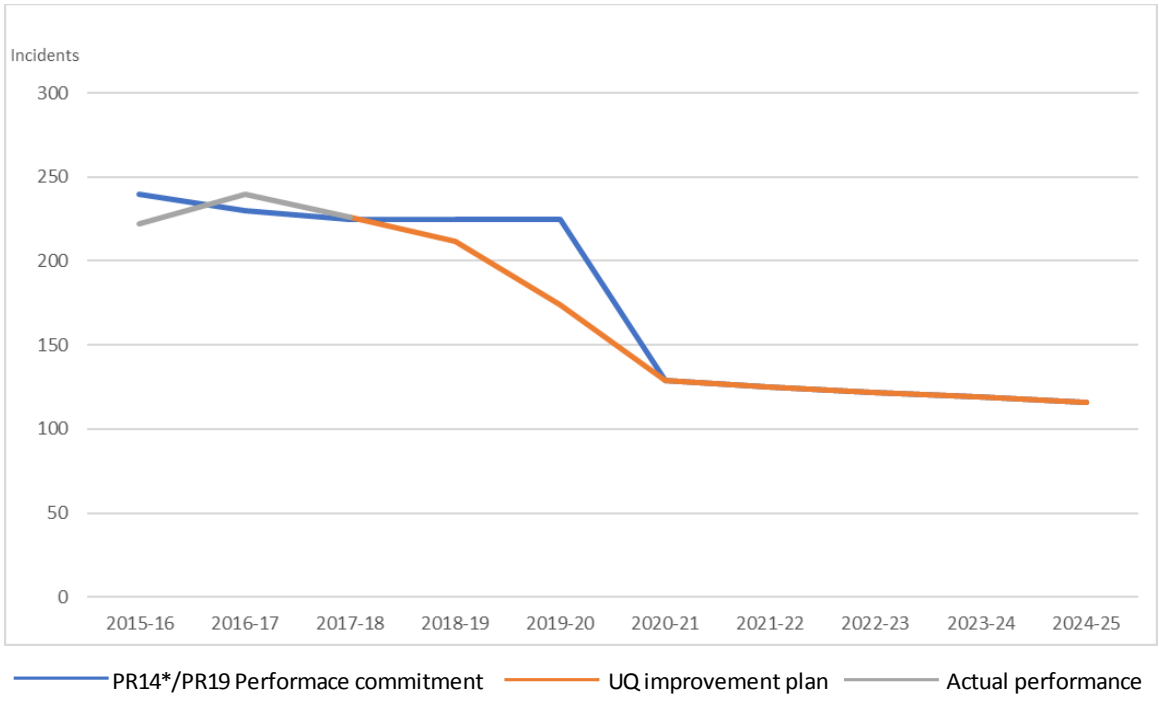


Table 24 - The AMP7 pollution incident performance commitment values

	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)
Performance Commitment Target	129	125	122	119	116

Summary of Enhancement

We have considered the following spend in AMP7 associated with Network Escapes as 'Enhancement'. This is a subset of our overall expenditure in delivering;

- Reducing hydraulic flood risk - We have identified £41.44m of capital enhancement expenditure (growth) to address hydraulic flooding issues that are predicted to materialise in AMP7. Line 30 of WWS2.
- Upper quartile Flooding - We have identified totex enhancement investment of £14.713M to enable us to drive a step change in performance to achieve upper quartile status in Internal Flooding Events by the end of year 1 of AMP7. There is a continual improvement in this service throughout the AMP to ensure that we continue to remain upper quartile. The costs associated with this further improvement level of performance are included in our plan as base maintenance but have not been added as enhancement and are populated in our programme in Years 2-5 of lines 7, 12 & 13 in WWS1.
- Upper quartile Pollution - We have identified totex enhancement investment of £41.56M to continue to improve our performance year on year in AMP7.

We have included all the spend associated with improving our Pollution performance as enhancement. Our spend reflects the diminishing return that can be expected in reducing the number of incidents, as the number becomes lower and lower. We believe we have set ourselves an extremely challenging target, which we revised downwards at a late stage in our planning following the APR 2018 industry data share. This also reflects a response to our quality regulator's (the Environment Agency) expectation of a long-term drive towards zero pollution incidents.

Cost Robustness

To develop our required expenditure for AMP7, we used our Decision Making Framework (DMF) system to select the optimal solutions to deliver the required performance. Inputs into the optimiser consisted of schemes from three sources;

manually generated schemes of new initiatives to drive upper quartile performance, outputs of predicted issues from our ongoing DAP programme and Enterprise Decision Analytics asset failure modelled solutions.

This section is divided into two parts, enhancement expenditure related to:

1. Internal Sewer Flooding; and
2. Pollution

Internal Sewer Flooding

We will have invested circa £44m in Internal Sewer Flooding (Enhancement Expenditure - Hydraulic Flooding CAPEX) in AMP6. The table below shows the PR14 FD expenditure for hydraulic flooding. Based on the hydraulic incidents occurring during this time and scheme affordability we invested less than anticipated to manage hydraulic capacity incidents. However, expenditure in years 4 and 5 increases significantly with the investment to reduce the number of other causes incidents leading to internal sewer flooding (circa £39.9m), to start to improve performance.

Table 25 – Summary of the PR14 final determination investment profile and the actual (including forecast for years 4 and 5) in AMP6.

	2015/16 (£m)	2016/17 (£m)	2017/18 (£m)	2018/19 (£m)	2019/20 (£m)
PR14 FD £m	17.853	12.636	18.808	26.505	28.96
Actual £m	5.645	7.113	10.827	33.609	28.928

Investment into internal sewer flooding is separated into the following three areas,

- The hydraulic sewer flooding programme;
- The other causes sewer flooding programme; and
- The enhanced upper quartile plan investment programme.

The table above is for hydraulic and upper quartile focusing on other causes as enhancement expenditure only. Investment to maintain the current level of flooding due to other causes sewer flooding is base maintenance and contained within the wastewater networks sewer rehabilitation programme.

Flooding from the public sewer network can be caused by a number of factors. These include blockages, damage to the sewer network, breakdown of mechanical equipment such as pumping stations, customer interference, third party activity and hydraulic overloading of the sewer network. We have a duty to deliver effective drainage to our customers.

Hydraulic flooding by its nature is dependent on external factors such as rainfall, whilst we can reduce this impact by designing our network to cope with storm events we can't cover every eventuality. Due to many factors such as excessive cost, unfeasibly large tanks and storage requirements as well as space restrictions, we are now looking to deliver solutions to these problems in more innovative ways.

During AMP5 and AMP6 we have been working to produce a Drainage Area Plan (DAP) programme, this has produced predictive flooding risks for 73 of 300 Drainage area zones (DAZ) which predominantly cover our larger urban and more problematic areas. Each of these DAPs identify our hydraulic flood risk so that we comparatively understand performance. In those areas where we have not completed DAPs we developed our DMF system using experts from AECOM and SEAMS to build a predictive hydraulic incidents model for the remaining DAZs. This used historic flooding incidents and the DAP outputs for similar DAZs to predict how these may behave in the future. We used flooding scheme costs (historical and those developed through our DAP programme) to determine scheme costs for predicted hydraulic incidents and optimised based upon need. Typically, for new properties flooding, historical costs are circa £160k i.e. one incident, often with properties flooding more frequently returning at a higher unit rate to resolve. However, before we applied further efficiencies (with a view to using SuDS), our programme costs were circa £78k per incident.

Most our internal sewer flooding incidents (over 90%) come from other causes rather than hydraulic overload of the network, the upper quartile programme is our additional activity to achieve this step change in the reduction in internal sewer flooding incidents through targeted activities to improve our performance. This means reducing the number of blockages that occur in our networks (either by preventing them forming or reducing the materials that cause blockage in the first place).

We have started initiatives in AMP6 to improve our other causes performance, these will continue in AMP7, where the learning taken from Year's 4 and 5 of AMP6 will help tune our activities. As we look to reduce the number of flooding incidents further in AMP7, it

forms part of our enhancement expenditure in Year 1 of AMP7. These different initiatives provide a flexible programme that aim to provide benefits both in the short and longer term. For example, the cleansing programme will help us reduce the likelihood of an incident occurring in the short term, in combination with our engagement programme to change behaviours over a longer time frame to keep incidents low. Our increased refurbishment programme provides a longer term solution that are less reliant on other activities or change in behaviours.

We developed this programme of initiatives to help achieve upper quartile performance by bringing several our wastewater experts together from planning and operations to identify, develop and outline interventions that would reduce internal flooding within our region. This planning focused on both improving asset health (which takes time) as well as interventions to create a shorter term benefit. We reviewed historical approaches and evaluated their overall performance to reduce internal sewer flooding. In addition, we identified new approaches, such as increasing wastewater visibility through sensors, monitoring and analytics. We identified for each initiative the level of benefit to be realised (i.e. reduction in incidents or enabling activities) and the investment required to help shape the investment programme (discussed in cost efficiency). We have taken our upper quartile programme through external audit to ratify the approach and costs.

The key initiatives we are undertaking that will continue into AMP7 include:

- Enhanced network rehabilitation programme
- Proactive Find and Fix (sewer network defect rectification)
- CCTV (an enabler for proactive sewer cleansing and sewer network defect rectification
- Engaging customers to change behaviours
- Proactive blockage predictor tool
- Proactive sewer cleansing

Our enhancement expenditure covers the first 2 initiatives, with the remaining forming important elements of our upper quartile programme of work.

Enhanced Network Rehabilitation and Maintenance Programme (£5.62m)

Network refurbishment provides a long term solution to reduce flooding incident risk forming part of our enhanced rehabilitation and maintenance programme. To date, we have targeted two areas at highest risk for structural defects that were causing incidents; Keighley and Girlington, with an increased refurbishment programme. Whilst it is too

early to truly recognise the benefit against previous year's performance, early indications are that we are seeing a significant reduction in incidents occurring (nearly doubling the time between an incident occurring since the work was completed). We will continue to monitor and review after 6/12 months to ensure that this investment has been beneficial and there is a sustained reduction in incidents and customer contacts. We are planning to continue with this programme of proactive network refurbishment in other identified high risk areas of internal flooding. We have used historical costs to derive the programme cost and likely benefit, resulting in an allowance of £200/m with an average of 10m per property, targeting circa 2000 properties where improvements are required. This accounts for the challenging circumstances found within our networks where often there is no direct access points to the sewers in and around properties where these defects are known to be.

Proactive find and fix – sewer network defect rectification (£4.25m)

Whilst we are undertaking a proactive network refurbishment in targeted areas, we know we need to identify and rectify other sewer defects throughout our network. Our other programmes of work including proactive sewer cleansing and CCTV programme that identify the defects will be proactively resolved through lining (patch and full length) and replacement in this initiative. In year 1 we estimate that 80km of sewer will be inspected and 3km rehabilitated or replaced.

Engaging customers to change behaviours

A key element of the upper quartile programme is to increase the level of customer engagement to encourage a change in behaviour through information and education. This is a cost effective way to reduce the likelihood of blockages occurring within our network, considering that most of the incidents occur in common areas, but not always at the same properties or same assets. We know this can be very successful as we saw in Bradford where through engagement we have seen a 99% reduction of flooding within an area, preventing typically over 80 flooding incidents, avoiding numerous actions on site (typically £360/jetting crew attending). This also forms part of our longer term strategy to keep the number of incidents low, therefore whist we expect this to support our reduction, we don't account for this under enhancement expenditure. This does from part of our enhancement expenditure to reduce pollution incidents as well and we discuss this work in the next section.

Pollution

During AMP6 we have maintained our pollution performance through the normal maintenance activities on our network. We have increased expenditure though to reduce the number of pollution incidents in Year 4 and Year 5 of AMP6 as indicated in Table 26. This relates to the reduction in pollution incidents and not the ongoing maintenance programme. The increased expenditure has resulted in targeted activities to improve our performance, with these activities continuing into AMP7. This includes elements of our wastewater visibility programme (installing sensors and improving analytics) whilst improving the network condition.

Table 26 – Enhancement expenditure on pollution to reduce the number of incidents per year in AMP6.

	2015/16 (£m)	2016/17 (£m)	2017/18 (£m)	2018/19 (£m)	2019/20 (£m)
PR14 FD £m	£0.000	£0.000	£0.000	£0.000	£0.000
Actual £m	£0.000	£0.000	£0.000	£18.510	£15.820

We undertook a similar approach to the upper quartile programme for flooding to develop our pollution programme of activities. We brought our experts together from wastewater planning and operations, telemetry etc to identify initiatives to reduce the likelihood of pollution. This focused across all areas of our assets including wastewater treatment works, rising mains, pumping stations and sewers. We then developed our programme based on expert knowledge and the historical understanding of performance and where improvement was required. Whist identifying improvements in how we operate and asset condition, we also identified improvements to the visibility of our network performance by increasing the number of sensors installed and developing further our analytics capability. We estimated for each initiative the level of benefit to be realised (i.e. reduction in incidents or enabling activities) and the investment required to help shape the investment programme. We have taken our upper quartile programme through external audit to ratify the approach and costs

Several activities are similar to those described to reduce other causes flooding through the upper quartile programme and builds upon our previous knowledge and historical costs of undertaking such activities. A key activity is proactively identifying and fixing defects, which also forms part of the work in years 4 and 5 of AMP6. We will focus

proactive rehabilitation where we are at highest risk of pollution incidents (through woodland, close to watercourses), as well as historical incident locations. We will undertake 60km of proactive targeted CCTV per year and resolve defects we find (focusing typically on grade 4 and 5 condition) estimated at 60 locations in Year 1, continuing this approach in the subsequent years.

We will continue our wastewater visibility programme where we are working to gain greater insight into the performance of our networks in real time. We will carry on the roll out of monitors across high risk and high consequence locations, with circa 1200 monitors to be installed in Year 1 of AMP7. This will support the step reduction in pollution incidents. We will install a further 1200 monitors in the remaining years. This will build on more than 2000 monitors installed in AMP6 year 4 and 5. This investment will enable us to build our SMART wastewater network.

A key part of our plan for year on year reduction is to tackle the “flushable challenge” and promote what should not be flushed down the toilet and sink. We will build on our existing campaign “Yorkshire Loves a Binner” and start to target communities with regular engagement to reinforce and embed the cultural and behaviour change we wish to see.

Figure 17 - Image from the “Yorkshire loves a binner” campaign

Our engagement approach includes but goes beyond targeting Primary and Secondary schools, nurseries, colleagues, hospitals looking at residential areas where blockages occur. We will deliver our engagement campaign through several methods:

- Drop in sessions,
- Social media campaigns,
- Traditional media such as TV adverts, radio promotion and newspapers.
- Rebranding of vehicles to promote waste water to our customers
- Promotion of fat traps, fab little bag and waste disposal devices
- Brand Ambassadors – Yorkshire Colleagues to be educated about this area and to participate in attended 4 visits per year to targeted areas to promote all the above.
- Customer Ambassadors – gaining support from our customers, local charities and campaign groups to support with the cause.

We have identified the priority locations for where we will target. We know this can be very successful as we saw in Bradford (discussed in the flooding section above). We will build upon our approach where we have targeted our first hotspot target area in Leeds, Huddersfield and Sheffield with over 70,000 residents engaged, for less than £10k. Early results are showing a gradual reduction in blockages, with longer term evaluation to take place along with regular repeatable engagement. The benefit of these approaches is that they will significantly reduce the likelihood of partial and full blockages forming at a lower cost than physical interventions within the sewer network.

Cost Efficiency

We are currently in the first year of delivering our upper quartile plans, therefore we anticipate bringing the learning from these activities into our enhancement expenditure at the beginning of AMP7. We have set in place feedback and analysis loops that enables us to review the effect of the activities and the level of benefit they provide. This allows us to be flexible and adaptable based on the change in performance of each activity and location.

Across the Wastewater Networks+ plan we have challenged ourselves using our AMP7 appointed partners to identify where we could improve. This involved a top-down assessment of activities and evaluation of inventive and innovative solutions that could become business as usual in AMP7 to improve efficiency. We have supplemented this with bespoke projects to contribute to applying efficiency savings. On a programme level, we have applied the broad efficiency savings this analysis identified to network escapes resulting in efficiencies in the region of 21.5% overall for our enhancement expenditure.

Internal sewer flooding through hydraulic capacity

We recognise that the activities we have historically carried out to reduce hydraulic flood risk will be less effective and affordable in the future. To address this, we will seek opportunities to work together with other stakeholders to deliver mutually beneficial solutions to shared risks.

An area of focus is the development of innovative solutions to surface water issues including embedding our surface water management strategy and promoting the implementation of Blue Green Infrastructure solutions. During AMP6 we commissioned several consultants to work with us to produce innovate ways we could improve our sewer flooding resolution. To this end we have worked with ARUP to investigate Blue Green infrastructure schemes and compare them to traditional grey infrastructure solutions. This work concluded that given the right circumstances we could save up to 62% delivering a Blue Green solution instead of a traditional storage solution.

To ratify this work and produce deliverable solutions for inclusion in the PR19 plan, we worked with our contractors Stantec, MMB & Barhale to produce Blue Green infrastructure solutions to known hydraulic flooding issues in five drainage areas across the Yorkshire region. These investigations demonstrated that not all issues were feasible to be resolved in this manner. As such our PR19 programme consists a mixture of traditional solutions and innovate Blue Green ones.

As part of our Strategic Drainage Management Plan pilots, we developed sustainable blue-green infrastructure solutions that supported a range of local drivers. These aligned with their redevelopment plans, allowing us to create headroom in our network and help those councils with their regeneration. As part of this we worked closely with Hull City Council and Sheffield City Council in the selection of locations and development of outline solutions. In Hull, we have identified how flood risk can be reduced, and will require sustained investment (as outlined in the Hull & Haltemprice section of this appendix). However, in Sheffield, the areas identified were not currently at a significant risk of sewer flooding but were identified as opportunities (during regeneration) to help manage capacity. Therefore, these areas provided little benefit to the current performance commitment, and with no fixed date provided by the councils for this regeneration to start, these schemes have been pushed back into AMP8. However, if those plans change we would seek to deliver these proactively in partnership at efficient

costs. These schemes would also benefit our surface water removed performance commitment.

Whilst the five catchment solutions demonstrated that not all Blue Green infrastructure solutions are feasible, working with City of Hull and Sheffield City Council highlighted the greater benefits of partnership solutions when planning network capacity/flood improvements. We will seek to continue and embed this approach with other local authorities within our region and drive the use of sustainable drainage.

Our DMF system used the DAP outputs, hydraulic flooding model predictions and historic problem solutions to optimise a programme that would deliver the level of service required for the performance commitment. Furthermore, we have applied efficiency recognising that the solutions we wish to promote will utilise sustainable drainage (based on the studies completed). This equates to the proposed pre-efficiency £50.7m programme, which we have achieved a £9.3m saving by planning to use the solutions described above compared to more traditional solutions. This results in a lower unit cost per incident of £64k.

Internal sewer flooding and pollution occurring due to other causes

Our work helps to avoids numerous incidents every day, therefore we are confident that increasing our activities in the right areas will see the flooding and pollution benefits, and tackle problems resulting from ‘other causes’. Managing our sewer network through targeted proactive interventions is part of our day to day operations. This applies to the proactive find and fix work and enhanced R+M which brings together components of traditional activities within robust and streamlined processes, delivered directly through ourselves and established supply chain arrangements. We have identified areas based on sound historical evidence, so have confidence this will reduce the likelihood of blockages forming and internal sewer flooding occurring at these locations.

Our increase in customer engagement provides an efficient approach to reach 1000s of customers and commence a change in behaviour regarding the disposal of FOG and solids. We recognise this will take several years to embed but contributes to the longer term reduction in incidents.

We continue to develop new approaches to target network rehabilitation. We expect our blockage predictor tool currently being developed will improve the targeting of assets for

investigation and rehabilitation. Development of our SMART Wastewater Network, with the installation of over 8000 monitors (pollution and flooding) will provide further evidence (through analysing the returned data) that a defect needs to be prioritised for rehabilitation. A three-phased approach will deliver a more integrated and efficient approach to proactively resolving network issues before they have an impact.

- **Use of data**: Maximise the use of data, starting with existing data and then seek additional data sets. Management of the wastewater network data will provide consistent understanding allowing the business to make informed choices on investment and mange activity on the network.
- **Adopt proactive approach**: We will change approach from one that is reactive to become predictive and thus proactive based on sound analytics through monitoring. This will include the use of weather patterns and their impact on sewer networks, its performance and the outcome for the environment and customers. It is equally important to link this change to education of our customers about the material they flush down the toilets and into our sewers and the effect this can have on others and the environment.
- **Monitor in real time**: Real time monitoring of the network in strategic points will reduce customer flooding and pollution incidents. We will take real time data and use it alongside predictive models to inform a proactive maintenance plan of the network to best utilise our resources

Our development of these approaches will enable us to become more efficient resolving the right problems in the right location through our enhancement expenditure whilst also supporting are other base operations as well.

Bioresource (Quality)

The capital and operational expenditure included in the OFWAT table WWS2 is shown below;

Table 27 - WINEP enhancement expenditure table map

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WWS2	2 - Sludge enhancement (quality)	£18.052	£20.092	£15.521	£9.454	£2.892	**£66.011**
Total		**£18.052**	**£20.092**	**£15.521**	**£9.454**	**£2.892**	**£66.011**

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WWS2	2 - Sludge enhancement (quality)	£0.000	£0.000	£0.000	£0.038	£0.038	£0.076
Total		**£0.000**	**£0.000**	**£0.000**	**£0.038**	**£0.038**	**£0.076**

Context

Our Bio resource expenditure in the plan is split between two purpose areas (base and enhancement.)

Our base plan ensures that we maintain our assets and treatment service through a combination of traditional and market based procurement routes taking 100% of waste water network sewage sludges always and ensuring 100% Biosolids Accreditation to Land through our Quality Agricultural Products Performance Commitment.

Our enhancement plan delivers additional asset treatment and dewatering capacity and an efficient cost to deal with the impacts of our large environment programme driven through WINEP. This approach is captured and detailed in full in the Bio Resource Cost Claim. There is also a small amount of additional investment to meet the requirements of the Medium Combustion Emissions Directive.

Included in the overall strategic business plan submission, there are 5 documents that relate specifically to the Bio Resource business plan and should be read in conjunction with this Cost Appendices. These are;

1. Bio Resource Narrative

2. Bio Resources Technical Appendix
3. Bio Resources Cost Adjustment Claim
4. Bio Resource RCV

And in addition to those, there is documentation on the Performance Commitments that link into Bio Resources.

The key components of the enhancement expenditure in Bio Resources are;

- Costs associated with growth in sludge from population increases and WINEP
- Costs associated with Regulatory Compliance

Costs associated with growth in sludge from WINEP are dealt with in the Bio Resources cost claim. We have not included any costs associated with sludge growth due to increases in population and have absorbed that as an efficiency in the plan.

The remaining expenditure is associated with regulatory compliance which is summarised as;

- 4 nr schemes to meet new compliance standards against the Medium Combustion Emissions Directive
- 1 nr scheme for Anerobic Digestion Permitting
- 1 nr scheme for Integrated Pollution Prevention Control

Cost Robustness

Our approach to costing these measures was to develop a ‘Project Charter’ which categorised each group of measures into cohorts, so they could be investigated and costed in a consistent way.

A Project Charter is an internal Quality Assurance methodology that defines; the assets or service to be investigated, a project plan, a RACI and funding requirements to complete the task.

Where possible we use the Yorkshire Water Unit Cost Database (UCD) to cost our solutions, a large database of historic costs that we can use to forecast accurately the cost of similar assets and interventions of the same type.

For measures that required an asset or an alternative intervention that has not been constructed by Yorkshire Water historically, clearly there will be no company unit cost model available. In a small number of cases we would refer to the national UCD such as TR61 or engage our contract partner delivery community to source us a robust cost.

Investigations are an area that we don't have a suite of UCDs for as they tend to be bespoke, therefore supplier quotes are obtained, or similar pieces of work carried out historically are used for comparison and cost setting.

System and process

All our solutions and costs go into the DMF investment planning system which to ensure consistency with the rest of the programme, scored against a service measure for benefits assessment.

Quality Assurance of Costs

We have applied several quality assurance checks throughout the process. All solutions of any type are processed through the DMF system ensuring that the most up to date UCD models, opex calculations and price base are consistent. The table below clarifies how costs for bio resource regulatory compliance were costed.

Table 28

Key Area of Plan	Capex cost	Opex cost
Regulatory Compliance	Company UCD / 3rd party cost	Company opex model

Cost Efficiency

No efficiency measures were specifically applied to this area of the programme. We have built a bio resource programme that moves us from lower quartile efficiency to a much improved efficiency position. There was no further need to apply efficiency measures to the regulatory compliance solutions.

Domestic Meter Optants (Supply/Demand Balance)

The expenditure is included in Ofwat table WS2 as shown below;

Table 29 - DMO enhancement expenditure table map

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	21 - Metering (excluding cost of providing metering to new service connections) for meters requested by optants	£4.525	£4.557	£4.597	£4.638	£4.680	**£22.997**
Total		**£4.525**	**£4.557**	**£4.597**	**£4.638**	**£4.680**	**£22.997**

Context

Yorkshire Water have a duty to install a meter to any domestic customer who requests one (subject to certain payable fees). Such installations are called “Domestic Meter Optants” – i.e.: it is an entirely voluntary process. We make information on the process available to customers via our website and mail literature.

Water meters have been used as a method of charging for domestic water usage on new properties since local authorities stopped assessing new or extensively altered properties on a rateable value from September 1989. This officially took effect from 31/03/1990 when Poll Tax was introduced.

Customers can opt for a measured charge, free of meter installation charges. Where customers opt, we must charge on a measured basis, except where it is impracticable (This may be because the pipework serving a property is complex or because there isn’t a suitable location.). The customer has 24 months in which to revert to an unmeasured charge if they find that metering does not suit their needs.

The government’s White Paper, published in December 2011, made no direct policy statements on the need for compulsory metering. The decision on a more ‘universal’ approach to meter installation is now very much in the hands of the individual water company. Thus, companies may now be expected to analyse whether an enhanced metering programme is appropriate to their specific circumstance.

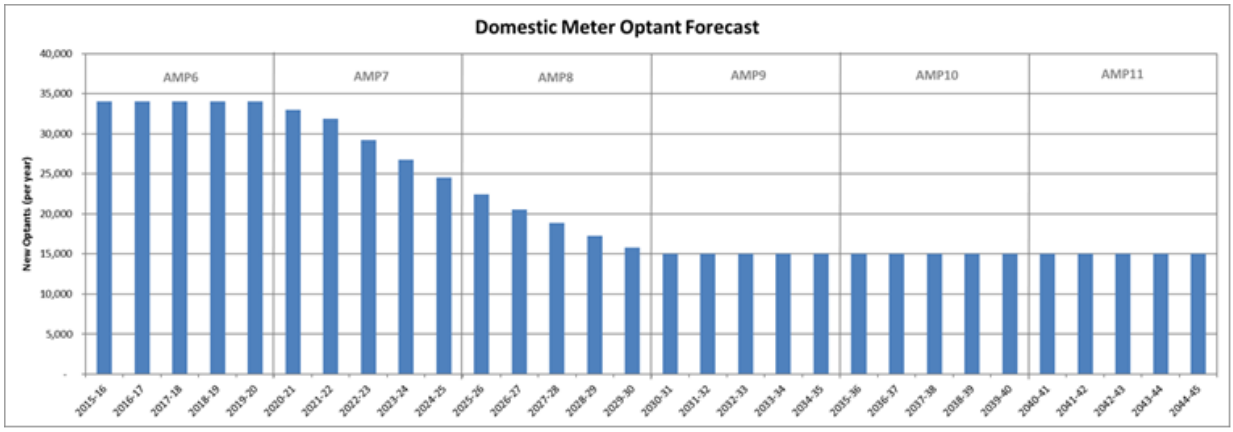
Yorkshire Water are not classed as a water-stressed region and, as a result, we feel that promoting metering to non-metered customers is not a necessity. We feel that the metering policy we have developed based on a ‘demand-led’ approach, with only

modest promotion to our customers, remains the preferred approach. Meter penetration will continue to increase, year-on-year, through DMOs and through new builds. Based upon research, our trajectory of metered growth has very much reflected the industry in general.

Cost Robustness

There is a strong correlation between the value of unmetered customers' bills and the number of meter optants each year. When unmetered bills increase, there is a corresponding increase in customers opting for a metered supply. In the last few years, increases in unmeasured bill values have been relatively small, and this has resulted in lower meter optants in these years. Historically we have promoted a metered supply to customers with affordability issues as a means of managing their water charges. In recent years, there has been a decrease in the number of such customers choosing to switch to a metered supply. Instead they elect to join one of our customer support schemes such as Water Direct, Water Support and Resolve, which help customers with low income or bill arrears manage their water charges. Currently around 50% of our household customers have a metered supply. We are forecasting an average of 34,000 optants per year from 2015/16 to 2019/20, which is the average number of optants in the previous 5 years. This is forecast to decrease gradually to 15,000 per annum by 2030/31 and remain fixed at this rate for the remainder of the planning period. This is detailed in the table below;

Figure 18: Domestic Meter Optants profile



This decline reflects the decreasing number of unmeasured households available to opt, with a financial benefit of opting.

By 2044/45 we are predicting 64% of base year unmeasured household properties will have opted to be metered. Including all new properties, which are metered as a legal standard, we are forecasting 84% household metering by 2044/45.

This scheme aims to increase the number of meter optants by an additional 25,000 above those planned in the baseline forecast. We estimate this scheme will reduce water consumption by 0.34Ml/d after a five-year implementation period. This aligns with our Water Resource Management Plan and our policy of demand management, through both reduction in customers' water use by metering and water efficiency, and through reduction in leakage on our own distribution system.

Cost Efficiency

Metering is instinctively an appropriate method of charging for water and sewerage, based on payment for use. However, metering is expensive compared to unmeasured billing and would significantly increase customers' bills through the additional cost of the meter, a replacement cost every 10 to 15 years and the ongoing operating costs of servicing a measured account. The cost of metering coupled with a policy of maintaining an element of customer choice, results in a continued policy of demand led (meter optant) household metering in Yorkshire.

We are planning on investing £22,997 on Domestic Meter Optants (DMOs) in the period of 2020-2025 which represents a reduction on the period 2015-2020. Whilst it is essential we have these provisions in our plan to facilitate customer requests for meters, the reduction represents the decreasing number of customers taking up metering as a

billing option. Whilst our overall DMO programme will reduce we still expect to see a reduction in PCC through other factors such as more targeted metering and increased water efficiency campaigns.

Efficiencies gained following projects successfully delivered in previous AMPs are now realised and streamlined, such as AMR (automated meter reading) allowing multiple meters to be read and downloaded in the time it would traditionally take to read one. Additionally, it is more efficient to install a meter internally at a property but is a balance in how efficient in reading the meters

There are various things that affect the DMO demand on an annual basis. These can be summarised as follows:

- Change of address
- Lifestyle
- Consistency
- Price increase
- Economy

The unit rates have been calculated based on the mix of job types observed over the last 13yrs, the different job types can be summarised as follows;

- Meter Installed External - 45%
- Meter Installed Internal - 55%

The different types of installations have then been applied to a schedule of rates through our Water Service Agreement Framework Contractor. This framework was procured through OJEU procedures with annual adjustments for inflation.

On this basis we are forecasting to install 145,313 meters over the AMP7 period at a unit rate 19.8% more efficient than the AMP6 forecast outturn.

Leakage (Enhanced Level of Service)

The expenditure included in the OFWAT WS2 table is shown below;

Table 30 - Leakage enhancement expenditure in WS2

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	26 - Leakage Reduction - UQ	£25.955	£26.141	£26.370	£26.605	£26.846	**£131.917**
Total		**£25.955**	**£26.141**	**£26.370**	**£26.605**	**£26.846**	**£131.917**

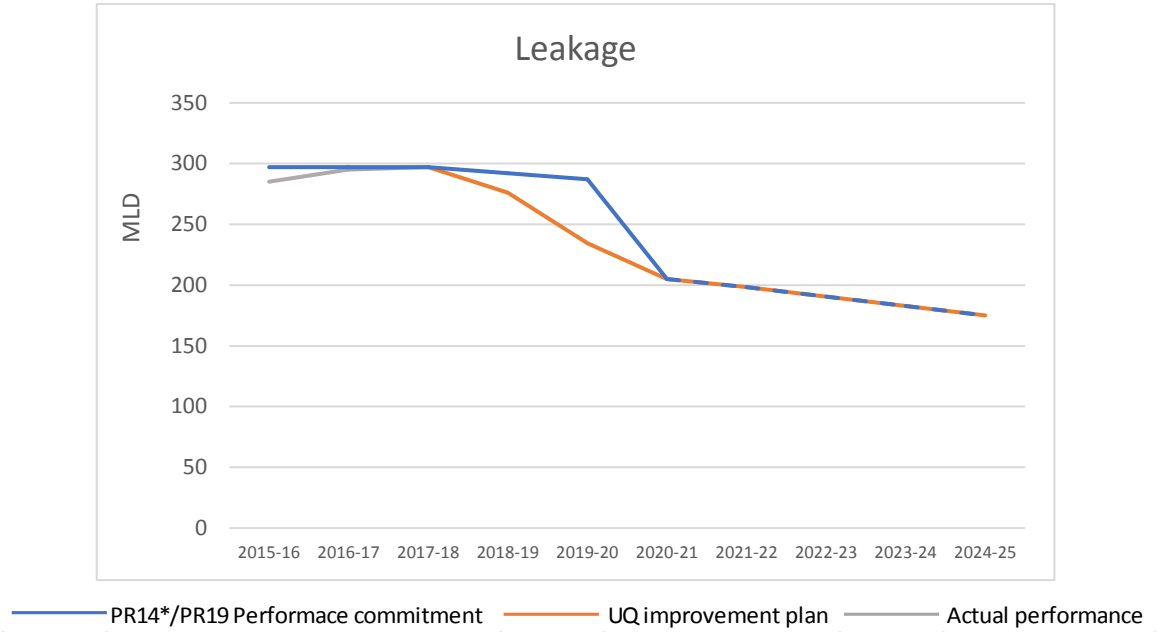
Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	26 - Leakage Reduction - UQ	£26.792	£23.887	£23.013	£22.125	£22.233	£118.050
Total		**£27.792**	**£24.887**	**£23.013**	**£22.125**	**£22.233**	**£118.050**

Context

Yorkshire Water are committed in our aim to achieve an upper quartile level of performance for leakage in AMP7. This reflects our customer priorities, as well as the wider regulatory environment. Additionally, we consider that it will deliver long-term resilience and environmental benefits.

Yorkshire Water have a 7-year plan to reduce leakage by 40% which we believe will match the upper quartile performance in the industry. In the last two years of AMP6 we will be making significant re-investment of £119m from outperformance to ensure that we end AMP6 in the best position possible with respect to leakage. This will ensure that the full cost of improving our current position to future upper quartile performance does not fall on customers in AMP7.

Figure 19 – Leakage Performance Targets AMP6 and AMP7



Our plan will secure a circa 60 Ml/d reduction in leakage over the remainder of this AMP and a further circa 66 Ml/d over the course of AMP7, by providing a new leakage management infrastructure including;

- Enhanced DMA and trunk mains monitoring
- Deployment and evaluation of new innovative technologies
- A smart networks strategy

We have included enhancement expenditure associated with leakage in every year of AMP7 as Leakage Performance commitment in AMP7 is an ongoing step change in service. We have excluded from our enhancement costs any maintenance of assets (such as meters) installed in our AMP6 step change. These are included alongside our normal base maintenance expenditure for stopping the natural rate of rise in leakage.

Cost Robustness

Our current plan comprises nine discrete workstreams, ranging from traditional ‘find and fix’ approaches to futuristic satellite based detection techniques. Our approach to

costing these workstreams was to develop a 'Project Charter' which pulled together subject matter experts and technical specialist from across the business to develop and plan in a consistent way. Our approach to delivering upper quartile leakage performance is inherently flexible and will adapt over the course of the next seven years to ensure that we maximise those activities which provide best value to customers and deliver the desired leakage outcome in an optimal manner.

As we are shifting into new levels of leakage performance, we cannot at this point determine with certainty what the optimal balance of activities and leakage management techniques will be. Therefore, we have engaged specialist leakage and programme management consultants to oversee the delivery of our programme. With their support we will be able to shape our programme to achieve an optimal output, learning quickly as we deliver our various workstreams and maximising those that are most effective.

We have subjected our approach to internal audit through Halcrow Management Sciences who concluded that our plan represented an appropriate balance of an ambitious target whilst still being deliverable under normal conditions and that the plan represented an efficient programme to achieve the proposed leakage target irrespective of whether it was fully supported by customers.

In this new UQ level of leakage, the leakage will be far more difficult to find. However, as of July 2018 we have completed some 33,000 such repairs since the start of AMP6 in April 2015, each repair contributing on average a leakage saving of 0.02 megalitres per day.

This is a well-established part of our day to day operations, with robust and streamlined processes. A long-standing repair and maintenance partner supports us through our Water Services Agreement to carry out repairs and other support activities. To ensure we maximise the opportunity for efficiency gains in delivering our leakage upper quartile plans we will go back to the market in AMP7 to retender our detection and repair contracts giving us opportunity to drive further efficiencies, innovation and better ways of working closer with external organisations.

As well as promoting more leaks for repair, we have a strong focus on performance management to ensure the fastest possible turnaround of repairs once we become aware of a leak. This came under particular focus in the leakage outbreak earlier this year during the 'beast from the east' when we created a Leakage Resolution Hub – a

focussed team and performance management approach to eliminate any barriers to completion of repair work (delivered through our Water Services Agreement contract) with a target of turning 95% of jobs round within 2 working days. This ensured that we were able to maintain supplies to all our customers when companies in other areas were experiencing significant interruptions. This performance has been sustained and will underpin the delivery of our upper quartile leakage plan.

Our Leakage Data Analytics and support teams, using the Net base leakage management system, optimally deploy our leakage technicians and engineers on the ground by calculating, analysing and targeting the correct parts of the distribution network where leakage above acceptable limits has been identified.

Our existing and newly resourced leakage teams have a robust training and progression plan to ensure our teams are can use all the available tools and techniques at their disposal, are efficient in their ways of working and provide a quality return in terms of leak detection productivity. Additionally, we will be investing significantly in data improvements and analytics including the use of machine learning and artificial intelligence to drive further improvements in the effectiveness of our targeting and overall detection productivity.

Cost Efficiency

Given our historic sustainable economic level of leakage (SELL) is higher than many of our peers (in terms of l/property/day) the cost to deliver such a step change in leakage performance will be atypically large in comparison. This is due to the speed of movement and in ensuring that future leakage can be efficiently and affordably sustained at the improved level of service for customers.

In following established industry practice and maintaining leakage at a sustainable and economic level, we have sought to ensure that our customers are not exposed to unnecessary cost, and in embracing the challenge of achieving upper quartile leakage rates, we will continue to act in our customers' interests by controlling the transitional costs of moving to that future upper quartile position.

Our upper quartile plan will radically change the way we tackle leakage within Yorkshire Water and involves the deployment and evaluation of new and innovative approaches and significantly higher investment than we have historically required to maintain our

sustainable economic level of leakage (SELL). We have therefore put in place a comprehensive programme management framework with independent governance and technical assurance so that as we deliver the programme we are able to learn and adapt to ensure we maximise those approaches which are most efficient in achieving our outcome.

Yorkshire Water will carry the remainder of those costs at our risk and will seek to find efficiency savings by driving innovation and performance through a programme management and governance framework. We are currently rolling out the first year of our plan and establishing our programme management and benefits assessment processes. We will use this process to inform a more comprehensive cost benefit analysis of our overall plan and its constituent workstreams which will also inform further customer engagement before our business plan submission in September. Through this process we will further challenge/benchmark our costs so that the total value of the cost adjustment claim can be scrutinised further to ensure robustness and efficiency of investment.

With AMP6 reinvestment and AMP7 risk we are ensuring that our customers are only exposed to just over half the total cost of our 7-year, 40% leakage reduction.
We have typically undertaken around 5,000 repairs on mains, services and fittings because of our proactive leak detection work, but we have significantly increased the rate of active leak detection as we approach the last two years of AMP6 to ensure that we provide a robust foundation to achieve upper quartile performance in AMP7. As of July 2018, we have completed some 33,000 such repairs since the start of AMP6 in April 2015, each repair contributing on average a leakage saving of 0.02 megalitres per day.

As well as promoting more leaks for repair, we have a strong focus on performance management to ensure the fastest possible turnaround of repairs once we become aware of a leak. This came under particular focus in the leakage outbreak earlier this year during the ‘beast from the east’ when we created a Leakage Resolution Hub – a focussed team and performance management approach to eliminate any barriers to completion of repair work (delivered through our Water Services Agreement contract) with a target of turning 95% of jobs round within 2 working days. This ensured that we were able to maintain supplies to all our customers when companies in other areas were experiencing significant interruptions. This performance has been sustained and will underpin the delivery of our upper quartile leakage plan.

To ensure we maximise the opportunity for efficiency gains in delivering our leakage upper quartile plans we will go back to the market in AMP7 to retender our detection and repair contracts giving us opportunity to drive further efficiencies, innovation and better ways of working closer with external organisations.

Our upper quartile plan will radically change the way we tackle leakage within Yorkshire Water and involves the deployment and evaluation of new and innovative approaches and significantly higher investment than we have historically required to maintain our sustainable economic level of leakage (SELL). We have therefore put in place a comprehensive programme management framework with independent governance and technical assurance so that as we deliver the programme we are able to learn and adapt to ensure we maximise those approaches which are most efficient in achieving our outcome.

Interruptions to Supply (Enhanced Level of Service)

The capital and operating expenditure included in the OFWAT table WS2 is shown below

Table 31 - Interruptions to Supply enhancement in WS2

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	27 - Reduction in Interruptions to Supply - UQ	£2.946	£0.000	£0.000	£0.000	£0.000	£2.946
Total		**£2.946**	**£0.000**	**£0.000**	**£0.000**	**£0.000**	**£2.946**

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	27 - Reduction in Interruptions to Supply - UQ	£5.622	£0.000	£0.000	£0.000	£0.000	**£5.622**
Total		**£5.622**	**£0.000**	**£0.000**	**£0.000**	**£0.000**	**£5.622**

Context

Between the 2010-20 period we focused our efforts on optimising our response to reactive failure and limiting the impact of planned work. In many instances it is how we respond operationally to events that will determine the overall performance on this measure.

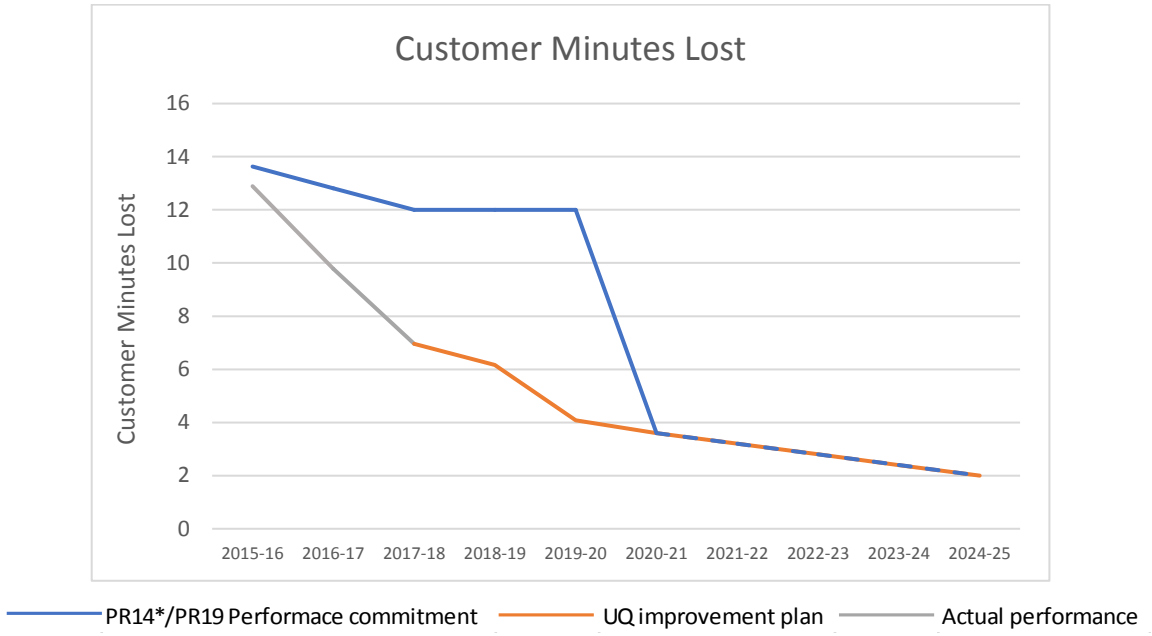
It is with this in mind that in the 2015-20 period we have undertaken a major review of significant water supply interruption incidents so that there is a more holistic (operational and capital) approach to reducing or eliminating all interruption events in size and duration. The wholistic approach is required due to our rapid response and continuous supply technologies, masking the underlying deterioration in our asset condition and performance.

Cost Robustness

With our drive for frontier or upper quartile (UQ) performance, a 6-minute internal (shadow) CML target has been introduced for Year 4 of AMP6, reducing to 4 minutes in Year 5 of AMP6, and reducing through AMP7 to 2 minutes by the end of 2024-25. This

profile is shown in the chart below The Regulatory Performance Commitment target remains 8 minutes throughout AMP6.;

Figure 20 - Performance Targets for Customer minutes



We have identified additional Totex enhancement investment of £8.771M to enable us to continue to drive a step change in performance by the end of year 1 of AMP7.

We have targeted a continual improvement in this service throughout the AMP to a final target of 2 minutes to ensure that we continue to remain at the frontier. However, the costs associated with this further improvement are included in our plan as base maintenance and are populated in our programme in Years 2-5 of lines 7, 12 & 13 in WS1.

This area of performance is a high priority for customers following our engagement work and feedback. We recognise that to continue to be an industry leader in water supply interruptions, we need to do more than just carry out traditional capital activity to maintain supplies to our customers.

Cost Efficiency

Although traditional capex projects on our network, to replace or modify our assets are important activities in maintaining supplies to customers and will continue, we need to consider other options around processes and resources, including such things as;

- Improving our Review and Reporting processes,
- Accurate Asset Records,
- Incident Response,
- Hydraulic Training for Field Operators,
- Zero Planned Interruptions to Supply above 3 Hours
- Enhanced resilience.

These initiatives will enable us to achieve our 2-minute target for what could otherwise only deliver a handful of mains reinforcement or replacement schemes to one local part of our region. This holistic approach will enhance our proactive and reactive interruptions every time we operate our network.

The transition improves the accuracy of data for our assets in the ground and following the events of an incident in terms of how we receive, collect and use the information. Real time engineering decisions and solutions for incidents 24/7, every individual operating the network trained to understand the hydraulics, risks involved and how to operate correctly, this will reduce stress on the network and therefore interruptions. There will be no planned interruptions for greater than 3 hours and will be achieved by changing our lining methodology / approach.

Due to the nature of our approach to deliver frontier performance in a cost effective manner by a combination of embracing new technology; operational excellence and optimal asset investment, it will be inherently flexible and will adapt over the course of the next seven years to ensure that we maximise those activities which provide best value to customers and deliver the desired outcome in an optimal manner.

Water Quality (Quality)

The capital and operating expenditure included in the OFWAT table WS2 is shown below

Table 32 - Drinking Water Quality enhancement in WS2

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	5 -Improving taste / odour / colour	£4.752	£4.439	£3.452	£2.276	£1.902	**£16.821**
WS2	6 - Meeting lead standards	£3.106	£2.902	£2.467	£1.384	£2.481	**£12.340**
WS3	13 - Investment to address raw water deterioration (THM, nitrates, Crypto, pesticides, others)	£13.329	£17.022	£13.643	£8.989	£7.157	**£60.140**
Total		**£21.187**	**£24.363**	**£19.562**	**£12.649**	**£11.540**	**£89.301**

Table	Line Ref	2020/21 (£m)	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	Total (£m)
WS2	5 -Improving taste / odour / colour	£0.000	£0.000	£0.000	£0.000	£0.193	**£0.193**
WS2	6 - Meeting lead standards	£0.000	£0.000	£0.000	£0.000	£0.000	**£0.000**
WS2	13 - Investment to address raw water deterioration (THM, nitrates, Crypto, pesticides, others)	£0.000	£0.000	£0.000	£0.000	£0.929	**£0.929**
Total		**£0.000**	**£0.000**	**£0.000**	**£0.000**	**£1.122**	**£1.122**

Context

As required under regulation 28(1) of the Water Supply (Water Quality) Regulations 2016 we submitted a risk assessment report to the DWI in December 2017. This report set out key risks to the quality and safety of drinking water supplied to our customers for which specific solutions were proposed for delivery in AMP7. This included addressing the regional risk due to lead supply pipes and site specific risks at several water treatments works namely: -

- Tophill Low WTW (Cryptosporidium taste and odour)
- Chellow Heights WTW (Disinfection by-products (DBPs), turbidity)
- Embsay WTW (DBPs; turbidity; manganese)
- Fixby WTW (DBPs; turbidity)

- Sladen WTW (DBPs; turbidity)
- Oldfield WTW (DBPs; turbidity)

The DWI have subsequently confirmed that they support the need for the schemes identified in our submission and intend to issue Notice under regulation 28(4) of the Water Supply (Water Quality) Regulations 2016, as amended, that requires the company to mitigate the risks and that these schemes will be transposed to formal programmes of work by DWI and their implementation and completion will be monitored, audited and closure confirmed by DWI. DWI Support is referenced in our Drinking Water Quality DWI submission Appendix.
In each case the expenditure summarised above is only the enhancement expenditure which we consider is required to deliver the necessary water quality improvements and ensure compliance with drinking water quality regulations. Where for reasons of efficiency and best value, we are electing to carry out other capital maintenance activities as part of the overall scheme at a specific site, we have removed what would have been allowed for base maintenance from the overall scheme costs, in order to ensure that there is no double counting or overlap with those costs which would be allowed within Ofwat's modelled cost baselines

We summarise below the context within which the above expenditure needs arise, full details are included in our PR19 Submission to the DWI.

Cost Robustness - Lead

Full details of our strategy for reducing the risk of lead in drinking water are set out in the document 'PR19 – Yorkshire Water's submission to DWI | Part B – Parameter specific risks & site-specific proposals' submitted to the DWI in December 2017.

As set out in that document our approach to reducing this risk over successive AMP periods has been to implement an effective plumbosolvency control programme which now covers 100% of our distribution system. This programme has entailed the reduction in background organics in distributed water; implementing optimal phosphate doses; maintaining the appropriate pH of distributed water pH whilst continuing research and development to further refine our approach.

Throughout AMP3 and AMP4 the progressive roll-out of orthophosphate dosing enabled us to meet the 25ug/l standard and enabled us to make significant progress towards the 10ug/l standard.

During AMP4 we investigated the potential for lead service pipe replacement, which whilst showing some significant benefits in terms of lead exposure presented significant challenges in terms of cost and access to customers' property. In parallel we continued a communication pipe replacement and lining programme which, whilst showing some benefit was insufficient to ensure compliance in its own right.

In order to meet the new standard in AMP5 we undertook a wider lead communication pipe replacement programme which comprised two schemes to proactively address lead communication pipe replacement in the Leeds area and another which identified and targeted high risk 'hotspots' on a regional basis. We also commissioned an extensive study to provide us with a more robust communication pipes inventory which would enable us to identify areas and customer types which were at the greatest risk of exposure to lead.

Over the past 3 AMPs we have undertaken additional sampling within our distribution system to determine the effectiveness of plumbosolvency optimisation (five times the required regulatory frequency). This has further increased our understanding of the risk across our system.

Finally, in AMP6 we have undertaken a trial in partnership with Rotherham MBC to assess the benefits and challenges of lining 1,000 lead service pipes in the East Herringthorpe area of Rotherham. The trial contributed to the development of the "Whirlwind" application technique, an in-situ lining product which provided the Industry with an alternative mitigation technique. We submitted a report on the outcome of the trial to the DWI in September 2017 and presented the findings to an Industry workshop. In AMP6 to date we have had 5 notified events for lead and we recognise that sustained activity will be required in AMP7 and beyond to address this issue.

In developing our AMP7 plan we have applied our DMA 'hot-spotting' approach together with the knowledge gained from the actual schemes implemented in AMP6, to identify the scale of the programme. We plan to address over 3,000 properties in 11 DMAs based on our hot-spotting approach. In addition, there are a number of other activities within our AMP7 lead strategy which we summarise below: -

- **Helping Hands** – analysis of data on vulnerable customers enabling us to identify those at greatest risk of exposure to lead. This approach has led to 1,200 communication pipe replacements in AMP6 and we are targeting replacement or rehabilitation of a further 1029 communication pipes (and where possible service pipes) during AMP7.
- **Education Establishments** – given the particular vulnerability of children to the effects of lead we plan a programme of renewal / rehabilitation of lead communication pipes, and where agreed, supply pipes, which will cover 205 schools and nurseries.
- **Replace on sample failure** – in line with Regulation 17(9), we will continue to replace our pipes and fittings where a sample has exceeded the 10µg/l standard. Based on past experience this should lead to the replacement of around 130 communication pipes in AMP7.
- **Customer requested** - we will fund the "free and matching" replacement of the lead communication pipe at the request of customers who have replaced all sections of lead in their supply pipe or internal plumbing system. Activity will not be specific to WSSs or DMAs but will be a region-wide programme based on customer demand, but we anticipate replacing around 530 communication pipes under this programme in AMP7.
- **Lead Trials** - to identify factors when remediating lead pipes in private rented and owner-occupied housing and further research and development into areas such as “extending the length capable of lining” and “novel approaches to lead pipe replacement.

Our AMP7 approach to lead will address specific areas of high risk, where lead exceedances have occurred, where our customers are proactively addressing the lead risk and where we plan to invest to reduce the exposure of lead to those who are most at risk. Table 33 below sets out the breakdown of the overall AMP7 capex investment for lead into the five key programme areas.

Table 33 - Breakdown of AMP7 investment to address risk from lead in drinking water

AMP7 Lead Strategy	Capex (£m)
Helping Hands	1.03
Education Establishments	0.8
Replace on sample failure	0.66
Customer requested	2.6
Hotspot DMAs	5.9
Lead Trials	1.35
Total	**12.34**

Our AMP7 strategy for dealing with the risk of lead in drinking water represents a continuation of initiatives and good practice developed during AMP6 and we have gained good understanding of the costs of delivering both the targeted activities under our helping hands, schools and DMA hot-spotting approach and the more ad-hoc activities which may arise due to customer requested or reactive response to sample failures.

We have been able to draw on scheme specific costs from similar activities to build up the costs of our programme. Over AMP6 and AMP7 we have replaced or relined over 54,000 lead service pipes to support and build our understanding around cost certainty in the removing lead from our network.
Similarly, with regard to the scale of the programme, we are able to draw on our experience and evaluation of delivering such programmes in AMP6 and earlier, to ensure that we have the appropriate scale of programme to deliver our planned AMP7 improvements and meet customer demand for proactive replacement or refurbishment.

Cost Efficiency – Lead

Our recent and extensive experience of delivering the activities which are planned within our AMP7 programme gives us confidence that we have a robust understanding of the likely costs of our AMP7 programme but we also recognise that there is scope for

efficiency relative to our historic costs which will arise through the use of the markets to ensure the most efficient delivery costs through the renewal of our supply chain arrangements and through innovation in the techniques deployed. To this end we will renew our Water Services Agreement contract in AMP7.

Also, we will achieve further efficiencies through the use of new techniques such as the “Whirlwind” in-situ lining technique and others which may emerge from AMP7 trials and research to deliver efficiencies through innovation. We will continue to monitor the effectiveness of our overall programme in mitigating the risk from lead in drinking water and continue to refine our approach as the benefits of different programmes and activities become clearer.

We assume that this combination of market impacts and innovation will enable us to achieve efficiencies of the order of 15.4% relative to AMP6 delivery costs and we have built these savings into our planned costs for AMP7.

Cost Robustness - Raw Water Deterioration

As mentioned above, there are six water treatment work sites across our operating area, which face significant water quality challenges - where deterioration in the quality of raw water means that existing treatment assets and processes will no longer able to guarantee compliance with drinking water quality regulations unless action is taken to enhance the treatment processes.

We have been proactive in addressing raw water quality risks at source through catchment management approaches and will continue to be so in AMP7, however at these six sites we consider that catchment management alone, will be insufficient to mitigate the risk to customers in the short-term. Whilst we will continue with our efforts at a catchment level we consider that some treatment based solutions cannot be avoided and our view of these risks has received explicit support from the DWI.

At five of the six sites, the primary risk is the level of dissolved organic carbon (DOC) or colour in the raw water which is leading to the production of unwanted disinfection by-products, whilst at the sixth site, Tophill Low is related to cryptosporidium. The issues at Tophill Low are described below whilst a description of the DOC issues at the other sites is provided later in this document. All of these issues are comprehensively disused in

our December 2017, PR19 Submission to the DWI a copy of which is provided in support of this submission.

Raw water quality issues arising at Tophill Low WTW

When Tophill Low was designed, the raw water quality was less challenging than today, and it was assumed that the large storage reservoirs at the site would sufficiently attenuate the risks posed by cryptosporidium and algae abstracted from the river. This premise no longer holds true due to additional nutrients and oocysts deposited in the reservoirs by wildfowl.

The sites' designation as a SSSI which precludes the use of shading or bird exclusion measures and the consequent increase in algal activity has driven the need for increased dosing of powdered carbon to control MIB and geosmin. The use of PAC compromises the existing treatment process. At the same time the trend in the number of oocysts present in the raw water is such that the existing two-stage process will no longer be able to remove them sufficiently to avoid detections in treated water.

The MIB and geosmin create water acceptability problems in terms of taste and odour whilst cryptosporidium creates public health risks. The algae can also lead to blinding of the rapid gravity filters which reduces the throughput of the site and compromises the overall resilience of our supply system for customers in the area. These risks are identified within or Drinking Water Safety Plans and confirmed by data from routine surveillance monitoring, water quality impacting events, and customer contact data.

Raw water quality issues arising at other sites

Water Supply (Water Quality) Regulations (specifically regulation 26), requires us to keep disinfection by-products (DBPs) as low as possible without compromising the effectiveness of the disinfection. We have identified five treatment works, supplying around 450,000 properties, where exceptional rates of deterioration in raw water quality are causing the levels of DOC to approach the limits of treatability for the installed processes, leading to unacceptable risk of failing to meet our obligations with regard to DBPs. These sites are: -

- Chellow Heights WTW
- Embsay WTW
- Fixby WTW

- Sladen WTW
- Oldfield WTW

If this is not addressed, the current trends in raw water deterioration are projected to lead to a risk of compliance failures by the middle of AMP8. The deterioration is driven by environmental and land use factors which are outside of management control for Yorkshire Water, and whilst we will continue to develop collaborative catchment based solutions where possible, these will not deliver outcomes in time to mitigate the risk to customers at these sites.

The exceptional nature of the deterioration in raw water quality is evidenced by research undertaken by the University of Leeds on our behalf, details of which are set out in our DWI submission. The following independent academic report provides supporting evidence of the specific regional operating circumstances within our catchments which is driving this investment need.

"Future Trends in Water Colour: the role of regional drivers" – May 2017, University of Leeds

We are committed to catchment based approaches and in situations where our analysis suggests that deterioration rates are such that failure would occur beyond AMP8, we will continue to adopt a 'catchment-intervention-only' approach within AMP7. Where we have to resort to a treatment based solution, this will still be supported by catchment management to enhance the sustainability of the solution, and limit future OPEX requirements. In developing our solutions, we have also focussed on the need to maintain compliance without reducing resilience due to the requirement to turn down flows during periods of high colour.
The raw water deterioration which is driving the need for investment has been a growing concern for a number of years. The works concerned were designed with a different raw water envelope in mind and the technologies and processes used, whilst appropriate at the time, are increasingly unable to cope with the deteriorating trend in water quality.

To date we have been able to manage the issue by limiting the output of the works to below their design capacity so that typically in the period August to October we may have to restrict the output of works such as Oldfield, Sladen and Embsay by between 19% and 34% which represents a significant reduction in the resilience of our supply system in those areas with regard to reliability and redundancy and we do not consider it

to be a sustainable solution. We have continued to invest in catchment management solutions to deliver cost effective improvements in raw water quality, including specific programmes at: -

- Upper Nidderdale and Upper Barden (Benefitting Chellow and Embsay WTWs)
- Keighley Moor (benefitting Oldfield and Sladen WTW)
- Baitings reservoir catchment as part of the Moorland 2020 plan (benefitting Fixby WTW)

However, such solutions on their own will not provide sufficient mitigation of the risk of water quality compliance failures at the five sites concerned and we have therefore sought to identify additional treatment based solutions which will provide an acceptable level of risk mitigation, which form the basis of the enhancement costs included in our plan.

Having identified the need at the six sites referred to above we have undertaken an extensive option identification and evaluation process to ensure that we can provide technically feasible and effective solutions to the water quality risks posed. We have assessed multiple options before developing detailed solution scopes for both a preferred and alternative option at each site and used a range of costing approaches to ensure that the costs derived are robust. We describe this process in more detail below.

Following an extensive risk identification process we compiled comprehensive evidence packs for each site. We assessed all sources where evidence exists of raw water deterioration and estimated the future dates when this would lead to a risk of failing drinking water quality standards, as a means of determining whether treatment, catchment management, or a combination of these provided the appropriate solution. These packs were used as a key input to a series of risk and solution identification workshops which identified around thirty potential solutions which could address those risks. These workshops involved Yorkshire Water technical experts, consultants, and our delivery partners.

The solution development workshops considered multiple potential solutions identified in terms of their feasibility; timeliness and confidence in their ability to mitigate risks and achieve water quality compliance and identified a preferred solution and an alternative primary and secondary solutions for which an outline design and schedule of components were developed. The preferred solution was then costed independently by Yorkshire Water Costing team and by one of our delivery partners using their own,

independent cost databases. This gave us confidence that our costs were robust, and the solutions would be deliverable.

In addition, we obtained an independent view of the alternative solution options generated through the workshop process from one of our consultant partners. This included costing of the best available alternative solution. Where this process suggested that the alternative option could be delivered at a lower whole life cost we reviewed our selection in the context of the risks and benefits associated with each, including long-term resilience and reduced risk to customers.

The preferred option selection considered areas such as;

- Whole life cost
- Throughput requirements
- Alternative process considerations
- Confidence of compliance and operability
- Existing site constraints

Figure 21 below illustrates the option identification and assessment approach used to select our preferred approach for addressing the raw water quality risks identified.

Figure 21 - Option Identification and Selection Process

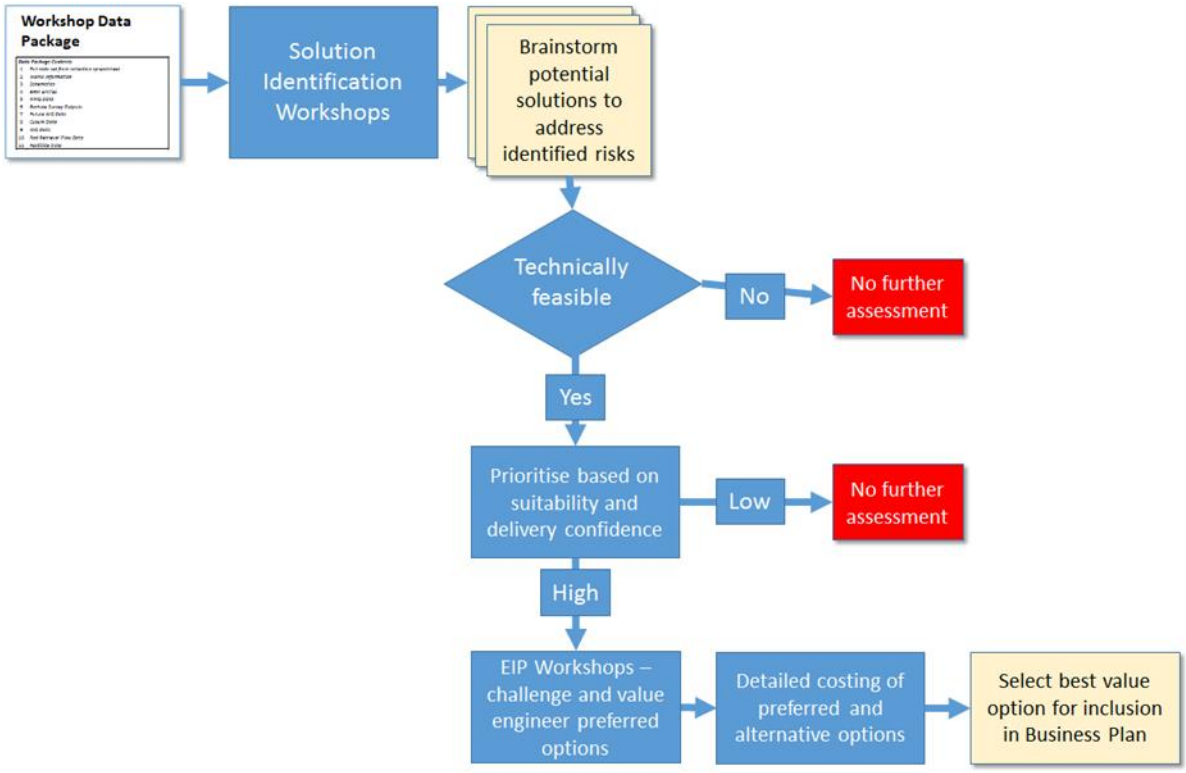


Table 35 at the end of this section summarises each of the thirty options identified and assessed through this process and highlights the main benefits and reasons for selecting our preferred option.

A more detailed assessment of the advantages and disadvantages of a range of alternative solutions is set out in a series of reports undertaken by Arup on our behalf, namely:

- “001011 Tophill Low WTW Alternatives Issue”, Arup Report, Dec 2017
- “001012 Chellow WTW Alternatives Issue”, Arup Report, Dec 2017
- “001014 Fixby WTW Alternatives Issue”, Arup Report, Dec 2017
- “001015 Embsay WTW Alternatives Issue”, Arup Report, Dec 2017
- “001017 Oldfield and Sladen WTW Alternatives Issue”, Arup Report, Dec 2017

Our process considered a range of options which carried differing degrees of risk in terms of confidence or certainty of outcome, flexibility to accommodate future challenges and cost. Cognisant of our statutory responsibilities under the Water Supply (Water Quality) Regulations and our customers’ expectations, we place significant weight on certainty of outcome with regard to drinking water quality but that does not prevent us

from considering more flexible or innovative approaches where we consider that the risk is acceptable.

Our approach to managing colour risk follows that adopted previously, a twin-track integration of treatment and catchment solutions, unless the risk is such that catchment management has the opportunity to reduce the hazard and avoid the risk becoming material.

Where our assessment of the magnitude and timing of future risk has indicated treatment, solutions are required we have identified three broad solution routes:

1. The construction of additional similar process units alongside the existing plant – essentially de-rating the process loading and bringing these back to design – an example would be the construction of additional rapid gravity filters to resolve additional particulate loads due to increased colour and coagulant entering the clarification stage, as exemplified by our approach to Fixby.
2. The construction of additional "conventional" process units, following the existing process train – an example would be the construction of a second stage of filters to allow the better separation of solids from water prior to chlorination, as exemplified by our approach to Embsay.
3. The construction of an additional "novel" process preceding or within the existing process train – an example would be the introduction of the MIEX process as pre-treatment before coagulation/clarification stage on an existing treatment plant as exemplified by our approach to Oldfield.

The use of MIEX remains a unique innovation by Yorkshire Water in the UK, although a few other companies with similar challenges are looking at ion exchange based processes for DOC removal. We have been operating processes of this type for around ten years at three sites and are currently installing a fourth.

Research conducted by Cranfield University, School of Water Sciences in 2004 (Fearing, David A. Ph.D. Thesis, Supervisor: Dr. S.A. Parsons, (2004) Process Options for the Treatment of Humic Rich Waters) indicated that MIEX was significantly more effective at reducing DOC than alternative techniques such as coagulation or GAC as summarized in table X.4 below.

Table 34 - Comparative Effectiveness of MIEX in DOC Removal

Method	Type	DOC Removal %
Coagulation	Aluminium sulphate	10-40
	Ferric Chloride	40-60
	PACl	20-40
Ion Exchange	MIEX	80
Adsorption	GAC	60-80
Ozonation / Biodegradations	O3	27
	Biodegradation	50
	O3 + Biodegradation	75

The high effectiveness of MIEX gives us confidence that it can mitigate the imminent risk of THM failures at the three sites where we propose to adopt it as our preferred solution in AMP7. Whilst other options such as PAC may appear to offer potential unit cost savings relative to MIEX, they would have potentially significant negative impacts on downstream processes which were not designed with this input in mind, creating sludge volume issues, and increases in coagulant demand and impinging on clarifier performance.

In our DWI submission, 'YKS-PR19-DWI- Part B', we set out a number of advantages of MIEX when compared with conventional treatment solutions, not least of which is that MIEX alleviates the stress on existing downstream components of the process train, enhancing rather than compromising their useful asset lives.

Where conventional process for DOC removal would increases the solids, load passing forward onto the existing process units MIEX will reduce it.

Where DOC can lead to a weak floc structure, very susceptible to shear forces present within subsequent clarification and filtration processes, resulting in high clarified and filtered turbidity; MIEX by removal of specific DOC fractions results in a stronger more shear resistant floc.

MIEX selectively removes fractions of DOC in the mid to low molecular weight category and is very effective at removing the lower molecular weight organics known to be

difficult to remove by coagulation. The low molecular weight fraction, that coagulation does not target, is thought to be significant precursor for THM formation. Furthermore, some parameters of MIEX treatment are capable of significant modulation, which allows the degree of treatment to be matched to the raw water risk (DOC/colour). In particular, the ratio of flow through / to bypass flow - can be varied, and the regeneration rate of the resin adjusted. This allows for a very flexible enhancement to treatment and reduces the cost and environmental impact when intensive treatment is not required.

In comparing MIEX with alternative processes, we have taken account of the marked differences in confidence and effectiveness, which is of the utmost importance when it comes to the provision of safe and wholesome drinking water.

Based on the process and key considerations described above we consider that we have developed robust solutions with a fully developed scope which will deliver the required risk reduction and that this scope has duly been robustly costed with those costs independently cross checked and validated.

Cost Efficiency – Raw Water Deterioration

As described above we have undertaken a robust risk assessment and optioneering process to ensure that the scope of solution proposed is appropriate to the need identified and the costs are robust. The workshops considered application of the company cost modelling approach, as well as site specific engineering considerations through our framework consultants.

We have commissioned independent consultants to explore the scope for delivery efficiencies in AMP7 through the programming and supply chain delivery mechanisms, as a result we have applied a 5.4% efficiency to the raw water quality enhancement programme and reduced the costs in our plan accordingly.

The enhancement costs included in our plan, represent in our view, an efficient cost for delivering the most appropriate solution taking account of technical feasibility; risk to customers and long-term value.

Table 35 - Summary of Option Evaluation and Selection Process

Site	Options identified through YWS / Partner workshops or subsequently during Arup review	Feasibility - Is it technically feasible to implement this option at this site	Effectiveness - level of confidence that this option fully mitigates risk	Delivery - confidence option can be delivered in time to maintain compliance	Taken forward for detailed costing?	Preferred Solution	Is solution lowest whole life cost?	Reason for selection or rejection of alternative options
Tophill-01	DAF plant and RGF refurbishment plus inter-stage ozone with GAC adsorption and contact tank	Yes	High	High	Yes	Yes	No	Provides a high level of confidence in effectiveness and deliverability of technical solution which is essential for such a critical site.
Tophill-02	Install dedicated PAC contact tank to increase contact time and improve efficiency of PAC. UV treatment. Contact tank. Wash-water recovery upgrade	Yes	Medium	High	Yes	No	Yes	Uncertainty around the technical effectiveness of the solution compared to GAC with ozone
Tophill-03	Direct river abstraction by-passing bankside reservoirs. Pre-sedimentation tank / lamella for gross solids settlement. UV disinfection (for Crypto) RGF upgrade.	Yes	Medium	High	No	No	-	Reduced resilience due to removal of bankside storage increases Crypto risk – hence need for UV disinfection. Loss of bankside storage capacity (pollution protection and poor river water Q).
Tophill-04	Cover Reservoirs with Solar panels to block out light to algae. RGF upgrade	Uncertain	Low	Low	No	No	-	Not certain this would be technically feasible
Tophill-05	Control algae in reservoir (barley straw, ultrasonics). To reduce algae to manageable levels by existing DAF and PAC.	Yes	Medium	High	No	No	-	High opex costs for barley straw. Ultrasonics can be very specific/may allow other algae to bloom.
Tophill-06	Catchment solution	Yes	Medium	Low	No	No	-	Longer term strategy, not viable in short term.

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Tophill-07	Raw water source optimisation / abstraction utilising West Beck	Uncertain	Medium	Medium	No	No	-	Uncertainty on abstraction capacity / quality of West Beck. Requires time for review
Chellow-01	100Ml/d MIEX or alternative ion exchange plant; Refurbish PAC; chemical dosing and run to waste	Yes	High	High	Yes	Yes	No	Only option which provides required level of confidence in effectiveness and timeliness of solution to mitigate risks to compliance. Proven at existing YWS sites Albert / Graincliffe
Chellow-02	GAC (conventional without ozone)	Yes	High	High	Yes	No	Yes	Installing 22 large GAC absorbers on a highly congested site is logistically challenging and carries risk on a highly critical site. GAC bed life when used for colour removal is short, compounded by the inability to use ozone upstream on Mn contactors.
Chellow-03	GAC (Carbo plus)	Yes	Low	Medium	No	No	-	Technology untested in UK. May increase solids load on Mn contactors from carryover. Complex and inflexible for flow variation. Was considered and rejected at a similar YWS site at Irton.
Chellow-04	New PAC storage and dosing plant (existing non-functional)	Yes	High	High	No	No	-	Capacity is limited to maximum dose that can be applied due to carry through to RGF, (heavy blanket, increases in coagulant demand). Inefficient as applied at front end.
Chellow-05	Change of coagulant to ferric.	No	Low	Low	No	No	-	Higher sludge production with adverse impact on sludge treatment process.

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Chellow-06	Split raw water sources and treat separately (different coagulants)	No	Low	Low	No	No	-	Major pipework civils costs. Large variability in individual flows. Different chemical streams required. Major civil construction
Fixby-01	DAF refurbishment plus additional RGFs	Yes	High	High	Yes	Yes	Yes	Most practical and highest confidence option. Lowest WLC compared with catchment management alone but catchment management alone wouldn't deliver in time.
Fixby-02	MIEX or alternative ion exchange, plus DAF upgrade and additional RGF	Yes	High	High	Yes	No	No	Unnecessary - raw water DOC/Colour does not merit MIEX at this point - whilst it can be treated cost effectively with improved conventional coagulation.
Fixby-03	Catchment management	Yes	Medium	Low	No	No	-	Long and uncertain time for effectiveness to be assessed.
Fixby-04	Change raw water blend	No	Low	Low	No	No	-	Raw water resources do not allow flexibility to choose appropriate blending volumes - would limit resilience and output
Fixby-05	Nano filtration for removal of colour	Yes	Medium	Low	No	No	-	Untested in YW. Suitable for smaller outputs only - likely to be high energy costs.
Embsay-01	Manganese contactors; new contact tank and run to waste	Yes	High	High	Yes	Yes	Yes	Proven effectiveness at many other Pennine sites.
Embsay-02	MIEX or alternative ion exchange	Yes	High	High	Yes	No	No	High capex and opex compared to Mn contactors. Does not remove Mn.

Table 35 - Summary of Option Evaluation and Selection Process

Site	Options identified through YWS / Partner workshops or subsequently during Arup review	**Feasibility** - Is it technically feasible to implement this option at this site	**Effectiveness** - level of confidence that this option fully mitigates risk	**Delivery** - confidence option can be delivered in time to maintain compliance	Taken forward for detailed costing?	Preferred Solution	Is solution lowest whole life cost?	Reason for selection or rejection of alternative options
Embsay-03	GAC after RGF	Yes	Low	High	No	No	-	Requires de-chlorination /re-chlorination if immediately after RGF. Counterintuitive to place after chlorine dosing stage. THM's already formed. GAC capacity for THM low. Short carbon life of 9 months, high opex.
Embsay-04	GAC and manganese contactor	No	High	Low	No	No	-	Overly complex and capex intensive option. Mn contactors and relocation of chlorination downstream of RGF have same effect. Short carbon life of 9 months, high opex. High land take and Capex.
Embsay-05	PAC (upstream of clarifiers) and manganese contactors	Yes	Medium	High	No	No	-	Permanent dosing of PAC creates sludge volume issues, is an explosive risk and difficult to handle and dose effectively. Difficult to operate seasonally. Risk to clarifier performance
Embsay-06	Catchment management	Yes	Medium	Low	Yes	No	-	Long term solution. Included in WINEP for peatland restoration, but timescale for improvements to stabilise DOC likely to be 10-20years; progress alongside all engineered options to secure sustainability of solution and reduce future OPEX/carbon.
Embsay-07	Nano filtration for removal of colour	Yes	Medium	Low	No	No	-	Untested in YW. Untested in YWS and trialling is not within the current timeframes. High opex cost and risk (membrane life, flux). Suitable for smaller outputs only.

Table 35 - Summary of Option Evaluation and Selection Process

Site	Options identified through YWS / Partner workshops or subsequently during Arup review	**Feasibility** - Is it technically feasible to implement this option at this site	**Effectiveness** - level of confidence that this option fully mitigates risk	**Delivery** - confidence option can be delivered in time to maintain compliance	Taken forward for detailed costing?	Preferred Solution	Is solution lowest whole life cost?	Reason for selection or rejection of alternative options
Sladen-Oldfield-01	**Sladen** - MIEX or alternative ion exchange; **Oldfield** - MIEX or alternative ion exchange; 3 stages rebuild and enhanced Run to Waste	Yes	High	High	Yes	Yes	No	Higher resilience than alternatives and avoids extensive civils / pipework costs associated with combined option
Sladen-Oldfield-02	Close Sladen Valley WTW and build a new 24Ml/d works at the Oldfield site plus 12 Ml/d MIEX Plant	Yes	High	High	Yes	No	Yes	Replacing Sladen and Oldfield with a single combined works would represent a reduction in system resilience which would require significant network reinforcement to mitigate, if these costs are considered they would outweigh the benefits of combining the works.
Sladen-Oldfield-03	Catchment management	Yes	Medium	Low	Yes	No	-	Long term solution. Included in WINEP for peatland restoration, but timescale for improvements to stabilise DOC likely to be 10-20years; progress alongside all engineered options to secure sustainability of solution and reduce future OPEX/carbon.
Sladen-Oldfield-04	Close Oldfield WTW and expand Sladen Valley WTW (DAF and RGF/Mn Contactors) by 12Ml/d and installation of a 24 Ml/d MIEX plant pre-treatment.	Yes	High	High	No	No	-	Complex as relies on a hydro turbine to recover power from transfer of water to and from Sladen. Planning and PR issues at Sladen. Risks and complications of transfer of raw and treated water. MIEX+DAF expensive opex and Capex combination.

Table 35 - Summary of Option Evaluation and Selection Process

Site	Options identified through YWS / Partner workshops or subsequently during Arup review	**Feasibility** - Is it technically feasible to implement this option at this site	**Effectiveness** - level of confidence that this option fully mitigates risk	**Delivery** - confidence option can be delivered in time to maintain compliance	Taken forward for detailed costing?	Preferred Solution	Is solution lowest whole life cost?	Reason for selection or rejection of alternative options
Sladen-Oldfield-05	Close Sladen Valley WTW, retain and refurbish the existing Oldfield works and install a new additional 14.5 Ml/d plant capacity at Oldfield WTW	No	Low	High	No	No	-	Condition of existing Oldfield clarifiers is considered beyond repair and carries too high risk. Risks and complications of transfer of raw and treated water. Sladen Valley still has significant asset life.

Cost Efficiency Initiatives Appendix

Introduction

We continually strive to deliver an efficient and effective service to our Customers, both in the planning, and in the delivery of our activities and enabling expenditure programme. This has been the case in construction of the expenditure programme supporting the PR19 submission, where we have fully engaged with our Board in identifying the challenges we face and the level of risk we are willing to accept. The level of efficiency identified requires transformational change, this has been acknowledged and plans are already being developed to ensure we are in a good position for commencing the AMP7 period.

Through the Board assurance process, we have identified £873m of efficiencies on our initially assessed plans which we have deducted from our expenditure requirements in our submitted tables. The efficiency levels are shown in the App 24a, but a quantification of the Totex efficiency challenge we have set ourselves is shown by price control in the table below;

Table 36 - Totex savings by price control

Water Resources	Water Network Plus	Waste Water Network Plus	Bioresources	Household Retail
£18	£308m	£403m	£114m	£30m

Through working with experts in the business and consultants working in an advisory capacity, the following broad themes were identified;

1. Asset Management
2. Service Delivery

Each of these themes are explained briefly below to give an indication of the type of activity we will be undertaking in the AMP7 period to deliver the efficiency. We believe this level of efficiency coupled with performance commitment targets, clearly demonstrates the level of ‘stretch’ to which we are committed, in deliver excellent service to Customers.

Asset Management

We have already put in place foundations to enhance our strategic planning capability, to both rationalise and optimise our asset base in the AMP6 period, one example of this

is the investment made in our Decision Making Framework (DMF). This includes people, process, systems, governance and is detailed further in the Decision Efficiency chapter of the plan. This facilitates continued maturity and integration of the risk based planning approach developed at Yorkshire Water over the last 15yrs

The following headings highlight the types of activity we will be undertaking in the AMP7 period to deliver the transformational efficiencies identified.

Smart Networks

Our SMART Clean Water Network will improve the efficiency, longevity, and reliability of our clean water network assets through enhanced measurement, data collection, data management and analytics. This holistic approach to the management of the asset life cycle will enable us to have visibility of how the network is performing and provide the insight to choose when to intervene before it impacts our customers and enable us to move from reactive to proactive water network management.

The SMART network will enable us to deliver our Water Network Strategy and enhance our operational performance by focusing upon;

- Asset Reliability
- Leakage
- Water Quality
- Interruptions to supply
- Resilience

The SMART network will provide the support for us to make optimised TOTEX decisions with an evidence base that can prioritise activities to manage risk and outperform regulatory compliance as well as providing insight and visibility to support decision makers to respond swiftly through pre-emptive, proactive and reactive operational and capital interventions.

We will undertake a ‘source to tap’ optimisation review of the water distribution network system across the Yorkshire water region. The objective for this review is to drive down infrastructure failure and leakage. This will involve benchmarking and prioritising the worst performing water supply zones through the interrogation of GIS data, online telemetry pressure and flow data and existing hydraulic models. Energy maps will be created to illustrate how energy was being wasted across the network and where the largest gains in terms of driving investment in order to enhance pressure management and reduce energy consumption. This source to tap review will take a holistic view of

the entire water network from the water treatment works down to distribution mains, and identify opportunities to drive down pressure, leakage and infrastructure failure rates across the entire Yorkshire region.

The benefits of network optimisation are wide spread. Indicatively, they include the potential to reduce pipeline asset failure by up to 14% for every 10% reduction in pressure. This is not only due to the reduction in total pressure within the asset, but the network also benefits from a reduction in daily variation in pressure which is experienced in many systems due to peak demand or older time modulation controlled pressure management valves. Developments in enhanced closed system controllers at management valves and pumping stations also promotes wide scale calm networks reducing asset failure through the smoothing out of network pressure fluctuations.
On top of the benefits of burst and leakage reduction, we expect the holistic review of energy and pressure loss across a whole system to identify a number of energy optimisation schemes, leading to opex efficiency.

Deliver Innovative Integrated Catchment Solutions

Maximising insights from existing unstructured multiple data sources and using data analytics will form a key part of our enhanced approach to holistic catchment understanding. This is building experience obtained through our strategic partner in other parts of the world e.g. Atlanta. This involves overlaying multiple unconnected data sources to enable a different visualisation of the catchments and create the connectivity of previously unconnected data sets.
Building on previous success of working with others, we intend to drive this concept further in the AMP7 period, this may include such things as;

- Mains Rehab programme to be shared with Gas, Broadband and Electricity providers to synergise delivery programme
- Partnering with local authorities (LAs) to firstly educate the LAs and planners of the importance of such things as SuDS, WSUD, FOGs, Energy efficiency and metering.
- Using the planning process as the vehicle to further re-iterate and if possible make mandatory the requirements (particularly for new builds) to install water efficiency and water run-off measures.

Commercially Aligned Arrangements

Commercial Engineering challenges all aspects of projects and programmes to ensure they deliver the maximum benefits. We plan to enhance the innovation our supply chain can bring both from trials within our company, but also knowledge from other sectors worldwide. Examples include;
rolling out vacuum excavation techniques, enhanced use of modular building systems and offsite production and more innovative exploration in to sewer lining systems.

We will also ensure full deployment of the Totex hierarchy whereby maximum efficiency is gained at the planning stage, rather than dependency on outperformance upon award of contract. Our Strategic Planning Partner is already appointed on a long term contract ensuring a strong partnership in deliver an efficient quality service to our Customers. Support services underpin all activities we undertake as a business and form a substantial part of both our workforce and operational spend. A full review will be undertaken of how we can rationalise such areas as suppliers, licencing, automation and process improvement.

Service Delivery

Bioresources

We will be undertaking a full review of our Bio-resource service delivery function. This will include developing further the market testing activity we have already undertaken, moving in to detailed design and implementation of the market defined solutions for identified activities. Implementation of alternative strategies for this function may include trialling full autonomy for procurement of supporting service.

Our approach to Bioresources Efficiency is described in detail in our Bioresources Price Control Chapter and our Bioresources Cost Appendix.

Maintenance Planning

Enhancing our asset condition based monitoring programme will be an area of focus, to ensure we are maximising the available life of our assets. This will involve a review of our maintenance plans, progressing proactive maintenance to reduce critical asset failures, ensure asset availability and a reduction in the volume of reactive jobs. As well

as delivering efficiency, this will facilitate a more resilient asset base and supports our Health & Safety improvement plan.

maintenance savings have been identified, following the clearance of all job backlog clearance before 2020. The principle of this project is that by proactively maintaining assets and adding telemetry we can almost eliminate reactive repair (asset outage). This strategy has been rolled out at Hull STW and is due to be expanded this year to 4 further sites. This policy is designed to support 100% asset availability and at the same time drive a long-term reduction in reactive maintenance spend in exchange for accepted up front planned maintenance costs.

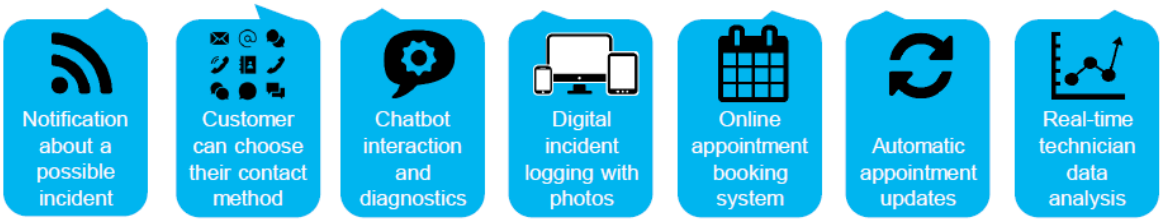
Customers

Customers are our number one priority, and we currently have multiple channels of contact, dominated through telephone and supported through website and social channels. Our research shows customers are increasingly comfortable with the use of digital channels for information and transactions. We intend to deliver an enhanced modern and personalised Customer service experience through

- Knowing our customers, with the support of real time data
- Increasing the use of digital channels and platforms
- Responding quickly to Customer needs

Our aim is to deliver a stepped change in Customer service ensuring inclusivity, affordability and choice for all our Customers. Areas of focus are illustrated below;

Figure 22 – Our Customer Areas of Focus



Our approach to Customer service will differentiate us through research activity to understand our customers lifestyles and preferences, enabling provision of timely personalised service.

Water & Waste Water Service

We are focussed on getting closer to our Customers and ensuring we both proactively, and reduce the time taken to respond to events as they occur. A review will be undertaken on the levels of resource dedicated to undertaking proactive work and reducing sewer escapes, we are also currently reviewing the contractual arrangement to understand if the service delivery can be enhanced through insourcing the currently outsourced resource provision.

: The key initiates include introducing lean initiatives to identify and eradicate inefficient processes, and a digital transformation to reduce human and manual intervention. The consultant's review found the customer journey convoluted with multiple touch points, drop offs and extended resolution times. Digital tools were not being fully exploited to interact with and track customers. The opportunities to revolutionise customer service by the end of AMP7 included the following strategies:

- Make YW a customer-centric organisation by fitting into the world of the customer, rather than making the customer adhere to YW's approach
- Meet YW's 5 Big Goals, particularly those involving the customer, including understanding customer needs and providing a personalised service
- Manage the customer, not the performance measure
- Streamline processes to make the organisation leaner
- Transform the organisation's use of digital tools to interact with customers
- Increase resilience with a 24/7 Service Delivery Centre.
- Improve the SIM score which deteriorated at the start of 2018, and act as a bridge to better and more efficient upper-quartile performance when C-MEX is introduced

Digital Innovation

As well as innovating our digital capability and service offering to Customers, we will also be driving digital innovation in to the way we operate our assets. Taking the concept of Water Resource Allocation Planning (WRAP) and enhancing its digital planning capability, then applying this concept to waste water, will allow us to create greater connectivity of our asset base. This will be facilitated through sensors and enhanced use of data analytics.

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