Appendix:
YKY29_Water Quality Improvements Enhancement Case

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YorkshireWater

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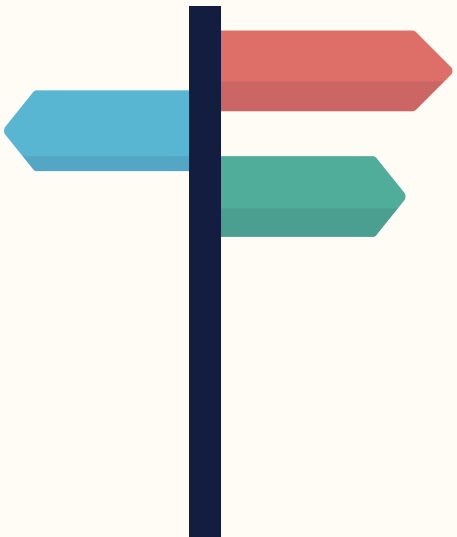
More detail on this subject can be found in **Chapter 8 Part 2: What our plan will deliver**



Contents

Enhancement Case for DWI Schemes: Delivering Long-Term Drinking Water Quality

Glossary

AMP	Asset Management Plan
CNI	Critical National Infrastructure
CPNI	Centre for the Protection of National Infrastructure
CSF	Catchment Sensitive Farming
Defra	Department for Environment, Food & Rural Affairs
DMA	Distribution Management Area
DOC	Dissolved Organic Carbon
DWSP	Drinking Water Safety Plans
EA	Environment Agency
LTDS	Long Term Delivery Strategy
PODDS	Prediction of Discolouration in Distribution Systems
T&O	Taste & Odour
Turbity	Cloudy, opaque, or thick with suspended matter
WINEP	Water Industry National Environment Programme
WRMP	Water Resource Management Plan
WSSRS	Water Supply Systems Resilience Strategy
WSZ	Water Supply Zones
WTW	Water Treatment Works
SEMD	Security and Emergency Measures Direction
NIS	Network & Information Security Directive

Summary

Yorkshire Water are seeking £94.7m in enhancement funding to address water quality risks in AMP8. This funding is split across water treatment and water networks.

Water Treatment

All the proposed water treatment based schemes are required against a backdrop of deteriorating raw water quality supplying the sites identified and are required to ensure Yorkshire Water is able to continue to supply clean, safe drinking water to customers in AMP8 and beyond. The deterioration ranges from increases in algal load impacting taste and odour for customers, to increases in rates of bacteriological detections and the level of nitrate water sources. Detailed analysis and investigations have been undertaken to understand the time to impact for a range of potential risks, and those selected are either already impacting service and water quality in AMP7, or have a high likelihood of impacting before the end of AMP8. Several schemes that were under investigation for AMP8 investment have been deferred as part of this process, as it became clear the impact is not likely to be experienced until AMP9 or 10. These risks will continue to be monitored and if required, included in subsequent Price Reviews in line with our LTDS and our long-term statement on Drinking Water Quality.

None of the specific risks included have previously been subject to enhancement funding. Identified risks were passed to our Strategic Planning Partner for investigation to understand solution options and select a preferred solution. This process was iterative, with emerging risks being added throughout AMP7 (e.g. Inbirchworth) and solutions modified in response to shifting drivers and customer need. The preferred solutions were chosen on the back of a cost benefit assessment, which ensure the risk is suitably reduced or removed at the most efficient costs. Solutions will be developed further as part of this ongoing process, in a continuation of the drive to ensure best value for customers, while addressing the risk.

Water Networks

Our schemes relating directly to the water network focus on reducing the taste, odour and aesthetic impacts of water source and network changes to customers, and reducing lead supplies where PCV failures are found or an establishment is deemed high priority I.e. schools and vulnerable customers.

When increased flow through a trunk main is necessary (such as due to increased demand or source water changes), or unacceptable discolouration risk is identified, trunk mains have typically been taken out of service to undergo invasive cleaning. Although this may achieve good results in terms of risk reduction, the process is disruptive, requires specialist teams and tools, and discolouration risk may be increased elsewhere as network settings are altered to re-allocate demand, and ultimately the cost is usually high. Building on successful work in other Water Supply Zones (WSZ) in AMP7, we are proposing a programme of trunk main conditioning in 16 WSZs. Small increases in flows will allow discolouration material to be removed and the main conditioned to accept higher flows in future. This is a low-cost alternative to mains renewal or relining and the WSZs selected have not been subject to enhancement funding.

In order to reduce customers exposure to lead, we are proposing a combination of solutions. These include addressing lead risk at schools, customers on our Priority Services Register (PSR) and domestic dwellings in concentrated areas that have a risk of lead exposure. This is alongside replacement of lead pipes because of regulatory sample failures and where customers are replacing their own lead pipework. None of the areas proposed have been subject to previous Enhancement funding.

1 Water Quality Improvements Enhancement Case

Our customers assess the provision of clean and safe drinking water as their highest priority. Enhancement funding is required for maintaining healthy drinking water assets, networks, and innovation in the short, medium and long term. While our legislative obligations dictate most of our investment in some form, many of these regulations exist to protect the quality, consistency, safety, and sustainability of the supply of water we provide to our customers.

This enhancement case is aligned to our Long-Term Statement on Drinking Water Quality, Lead Strategy and the Appendix A & B DWI submission documents provided to the Drinking Water Inspectorate (DWI) in January and March 2023 (copies of these can be found in the Annexes section at the bottom of this document). The primary purpose of this enhancement investment is to maintain high quality drinking water, taking action to mitigate risks that are forecast to impact in the 2025-30 period.

1.1 Driver:

Drinking Water Inspectorate supported interventions.

1.1.1 Requested Investment:

Table 1.1: Proposed AMP8 Expenditure for Water Quality Improvements

	£m	Table Line Ref.
Enhancement Expenditure Capex	90.928	CW3.91, CW3.97, CW3.106, CW3.109
Enhancement Expenditure Opex	3.755	CW3.92, CW3.98, CW3.107, CW3.110
Base Expenditure Capex	6.909	CW2.15, 16
DPC value	0.000	
Total	**101.592**	

1.1.2 Associated Reporting lines in Data Table

Table 1.2: CW3 Reporting Lines

Line Number	Line description
CW3.91	Improvements to taste, odour and colour (grey solutions); enhancement capex
CW3.92	Improvements to taste, odour and colour (grey solutions); enhancement opex
CW3.93	Improvements to taste, odour and colour (grey solutions); enhancement totex
CW3.97	Addressing raw water quality deterioration (grey solutions); enhancement capex
CW3.98	Addressing raw water quality deterioration (grey solutions); enhancement opex
CW3.99	Addressing raw water quality deterioration (grey solutions); ; enhancement totex

CW3.106	Lead communication pipes replaced or relined; enhancement capex
CW3.107	Lead communication pipes replaced or relined; enhancement opex
CW3.108	Lead communication pipes replaced or relined; enhancement totex
CW3.109	External lead supply pipes replaced or relined; enhancement capex
CW3.110	External lead supply pipes replaced or relined; enhancement opex
CW3.111	External lead supply pipes replaced or relined; enhancement totex

1.2 High Level Driver description:

We propose enhancement expenditure across three drivers for water quality improvement in AMP8:

Table 1.3: Driver Descriptions

Driver	Description	AMP8 solutions
Improvements to taste / colour / odour	We are improving the acceptability through new ways to manage our network, rather than there being a health risk for our customers. It's described in the WHO guidelines (p.237) and the DWI guidance that when customers report water with unacceptable colour, odour or taste, levels of iron and manganese, the pipes are often the culprits, along with treatment of water containing elevated levels of certain species of algae.	**Mains conditioning** targeting manganese and iron sediment in network assets. **Ingbirchworth WTW** – treatments including ozone and PAC, supported by reservoir improvements
Addressing raw water quality deterioration	Our processes for addressing water quality risk are being affected by changing weather and environmental patterns, our long-term risk planning takes account of how this could affect water quality and the availability of sources. The DWI's Guidelines for Drinking-water Quality' (Fourth edition) states that: "failure or a likelihood of failure to supply wholesome water because of a deterioration in raw water quality (such as nitrate, pesticides, turbidity, THMs (and precursors), colour, Cryptosporidium and other pathogens) should be identified through raw water monitoring and the DWSPs and Risk Assessment Reports (RARs) for every water treatment works and its associated supply system." Deterioration refers to a "measured change in raw water quality over time, or demonstrable unmitigated volatility in quality changes brought about by changes within the catchment, most frequently arising from diffuse pollution."	**Doncaster Boreholes** – nitrate blending and chemical disinfection **Haisthorpe Boreholes** – Nitrate removal **East Ness WTW** – controlled cryptosporidium disinfection & filtration upgrades
Meeting lead standards	We are removing lead pipes from the water network. Lead has wide-ranging health impacts. Lead in the body is distributed to the brain, liver, kidney and bones. It is stored in the teeth and bones, where it accumulates over time. Lead in bone is released into blood during pregnancy and becomes a source of exposure to the developing fetus. It therefore poses particular dangers for children and pregnant women.	**Lead** communication pipe and supply pipe renewal in high-risk areas, especially in education establishments

1.3 Need

1.3.1 Interaction with base and previous price reviews

None of the specific risks at the identified WTWs sites have been addressed through previous enhancement funding. They are all new risks, in light of deteriorating raw water quality. We confirm this enhancement case does not duplicate base funding.

Although the majority of the funding is enhancement, funding new asset types and interventions, we expect a small element of base funded improvements will be included in solutions where this is efficient to do so. This will be identified through optioneering and confirmed at outline design, once the solution is confirmed.

In addition, the solutions developed as part of our optioneering process included like for like replacement of existing in the total solution costs. As part of our 'enhancement to base' assessment these have been removed from the total enhancement cost tables and are instead included in the base tables. The total of £6.91m base maintenance is included in the table below.

Table 1.4: Base Maintenance Costs

Scheme name	Base Maintenance Capex Cost (£m)
Ingbirchworth WTW	0.90
Doncaster Boreholes	3.02
Haisthorpe Boreholes	0.64
East Ness WTW	2.36
Total	**6.91**

1.3.2 Long-Term Delivery Strategy Alignment

The Long-Term Delivery Strategy (LTDS) has been influential in directing this submission. The LTDS is a new requirement for this pricing period, and an integral, mandatory part of Yorkshire Water's PR24 plan. The long view to 2050 is adaptable, with pathways that can be modified in pursuit of long-term aims. So, this work is not simply part of a five-year plan, but rooted in the future ambitions of Yorkshire Water, its customers and stakeholders.

The strategic planning frameworks Water Resource Management Plan (WRMP), Drainage and Wastewater Management Plan (DWMP) and Water Industry National Environment Plan (WINEP) will feed into the LTDS. It is chiefly concerned with future enhancement investment, and the coming price period and future DWI water quality submission components will be included. The LTDS will also include future risks for the next three pricing periods.

As part of the LTDS process subject matter experts used the long term raw water forecasts to estimate the required water quality enhancement expenditure required to 2050. For more information navigate to sections 3.5.2 and 4.4.1.3 of our LTDS, link below.

Read more about this at
Long Term Delivery Strategy

1.3.3 Customer support

We engage with our customers on an ongoing basis, but at regular intervals we carry out specific research to inform our future plans. Across June and July 2022, we completed a research programme called 'Valuing Water' to inform our PR24 plans. This research provides a comprehensive assessment of the views of Yorkshire Water's customers and stakeholders. It

identifies the main priorities that they would like to see the company focus on, alongside detailed explanation of why these things matter, and why other aspects are considered to be of less importance. The research highlights that customers consider that the highest priority for YW remains 'providing a continuous supply of water that is safe to drink', with 75% of customers surveyed choosing this service area as the number one priority This was supported by the research carried out on behalf of Ofwat and CCWater which found, out of 24 performance commitment areas, 'do not drink notices' and 'taste, smell and appearance' both fell within the highest grouping of priority for customers. Read more about this in our Customer Research Appendix.

In testing our WRMP draft plan with customers we have learned that most customers will prioritise areas that have the most personal impact on them day-to-day. There is an underlying concern amongst customers about water becoming scarcer and the impact we all have on the planet. We develop our future plans knowing that provision of a continuous supply of water that is safe to drink is the highest priority for our customers.

We engage with more than our customers; our stakeholders have significant involvement in achieving this target. With regards to our stakeholder engagement, the source water for our water treatment works comes from the environment, hence it is important to maintain strong relationships with multiple stakeholders. An example of engagement in this area would be the series of initiatives to return moorland to their natural state. We have engaged with landowners, Natural England, and Environment Agency to take steps to retain more rainwater in upland catchments – this prevents the stripping of organic matter out of soils resulting in raw water which is less coloured and requires less chemicals to make it acceptable to drink. In addition, we work with the farming community to reduce or optimise the use of pesticides, supporting the production of food and reducing health risk to the consumer of drinking water.

We tested the acceptability of our PR24 business plan, independently (outside of Ofwat guidelines). In this study we put forward to customers our improvement target for water quality, our plan was supported by the vast majority of customers, 79% of customers found our plan to be acceptable overall including this target. We also showcased this enhancement case (packaged with cyber and security) in the acceptability and affordability testing we undertook following Ofwat guidelines, in this testing 78% of customers found our plan to be acceptable.

More detail on our wider customer engagement can be found in
Chapter 6: Customer and Stakeholder Engagement

1.3.4 Factors outside of management control

Drivers for these schemes (improving taste, odour and colour and deterioration in raw water quality) are outside of management control. Risks arising due to existing asset condition/failure and maintenance are to be addressed via Base funding. However, funding being sought as part of this Enhancement case is to address changes to raw water quality that require additional management of raw water resources and/or additional treatment processes.

1.3.5 Alignment with our other strategies

We have not duplicated any funding requests across the various strategies and drivers that support our AMP8 business plan investment. Please refer to our other enhancement cases for our proposed investments under our other strategies, where those are the primary driver.
We have considered how this enhancement case enables us to protect and enhance drinking water quality, but while being cognisant of the context in our work programmes for our WRMP, and other regulatory obligations, such as meeting the requirements of the Security and Emergency Measures Direction (SEMD) and Network and Information Security regulations (NIS).

Read more about this at
Supply-Demand Enhancement Case

We highlight the relevance of our WINEP and our Water Supply Systems (WSS) Resilience Strategies below.

1.3.5.1 Water Industry National Environment Programme (WINEP)

Our proposed WINEP programme was submitted to the Environment Agency (EA) in two phases, in November 2022 and January 2023. Some of the interventions within our plan have a primary focus on the protection and enhancement of raw water quality, and therefore have relevance to the DWI submission. These are summarised below:

- Upland Drinking Water Protected areas – 30 restoration actions, benefitting 19 WTWs.
- Lowland Drinking Water Protected areas – 6 no deterioration actions, benefitting 6 WTWs.
- One investigation action assessing the benefits of weather station data on providing early warning / guidance on the application of agro-chemicals.
- 26 actions under Water Framework Groundwater drivers, benefitting 8 WTWs.

Read more about this at
WINEP Enhancement Case

1.3.5.2 Water Supply Systems Resilience Strategy

The resilience investment planned in the Chellow Water Supply System of c.£133.5m does not overlap with the schemes proposed in this Water Quality enhancement case.

Read more about this at
Water Resilience Enhancement Case

The interventions proposed through the water quality programme and the strategic planning frameworks represent only part of our overall plan for water quality in the coming price period. Base maintenance activity will target other areas of performance such as Water Treatment Works coliforms and throughput, asset replacement and refurbishment.

1.4 Direct Procurement for Customers (DPC)

We do not propose to address any of this case via a DPC approach. For information on the process followed and the cases that were ultimately judged as suitable for DPC please see section 6.3 in the Introduction to Enhancement Cases appendix.

Read more about this at
Introduction to Enhancement Cases

1.5 Methodology

The optimal approach to addressing WQ risk and enhancement need is to identify existing and emergent risks and create a hierarchy of interventions. Our well-established Drinking Water Safety Planning (DWSP) methodology is critical to identifying specific hazards and risks that we consider have the potential to result in deterioration of drinking water quality or acceptability across different time frames. This approach was utilised to identify WQ risks likely to impact in AMP8. These risks were then investigated in more detail by YW and our Strategic Planning Partner to confirm the impact, likelihood and time to impact. Once confirmed, unacceptable risks forecast to manifest in AMP8 or early AMP9 were taken forward and possible solutions were identified and ranked.

We are committed to catchment management and a catchment-first approach. Water catchments are our primary treatment system, and we are developing strong and active partnerships with land users, rivers trusts and regulators, to protect our catchments for the future. Tenants and private landowners follow regulations to reduce water and air pollution, e.g. Farming Rules for Water Regulation (regulated by the EA), and also covered by Catchment Sensitive Farming (CSF).

Compared to engineered treatment solutions, catchment management has a number of benefits.

- Reduced energy and carbon emissions.
- Reduced costs for customers.
- Long-term sustainability benefits as water issues are dealt with at the root, rather than at symptom level.
- Environmental benefits, ranging from improved biodiversity and river and bathing water quality, carbon capture and flood risk.
- Benefits for the farming community.

As per our LTDS, green, catchment based solutions are explored first as these are generally more cost efficient with a lower carbon footprint. Grey, treatment solutions are only sought where the catchment based approach is not forecast to deliver suitable improvements within the required timeframe. Furthermore, once identified, risks are investigated in collaboration with our Strategic Planning Partner to ensure any opportunities for additional totex efficiency and innovation across the whole life of the asset are identified and considered as part of the solution. An example of this approach is the Haisthorpe WTW Nitrate Removal Scheme. The notional solution included installing a nitrate removal plant at the treatment works to treat full site flows, to mitigate increasing raw water nitrate concentrations. However, further investigation revealed that adding nitrate removal to the two raw water sources with the highest nitrate concentrations would deliver the water quality improvements required at the most efficient cost for the customer.

When catchment solutions are unsuitable, treatment interventions are often necessary.

1.5.1.1 Approach to risk mitigation

The risks requiring planned interventions are summarised in the table below. These interventions seek to strengthen and improve the layers of protection. Our mitigation strategies can be effective across the source to tap system but will take a ‘catchment first’ approach where effective to do so.

Table 1.5: Summary of Risks Requiring Intervention in AMP8 and AMP9

	Reservoir	River	Groundwater	Production	Storage	Distribution	Consumer
1	Colour / UV Light abs @254			Trihalomethanes	Trihalomethanes	Trihalomethanes	
2	Algae			Taste and Odour	Taste and Odour	Taste and Odour	
3			Total Coliforms	Total Coliforms	Total Coliforms		
4			E.Coli (faecal coliforms)	E.Coli (faecal coliforms)	E.Coli (faecal coliforms)		
5			Clostridia perfringens				
6			Nitrate				
7						Lead	Lead
8						Iron Total and discolouration	

Source: Yorkshire Water’s Long-term Statement on Drinking Water Quality, January 2023.

With risks identified, we worked on the best options to mitigate them. The following were taken into consideration:

- **Time to impact**
  This influences both the timing and type of intervention selected. Evidence must show that mitigation is required in the next five-year period. The type of mitigation will be influenced by the time to impact. For example, Yorkshire Water can deploy its ‘catchment first’ approach, where time to impact is beyond five years. If time to impact is more immediate, a treatment-based intervention would be required.

- **Connectivity with other programmes of work**
  Our strategies took into account the work being done by other planning frameworks and business plan components, such as the WRMP and WINEP.

- **The speed of performance improvement**

Removal of lead from the water supply network is a long-term approach, for example, and the speed at which lead removal is delivered is a choice which influences the costs associated with delivery.

- **The full range of options**
  Solutions could involve a catchment, a treatment, or a combined solution. Technology choices for treatment solutions must be considered. Operational risk mitigation, such as throughput reduction, could be appropriate in certain situations.

- **New and emergent risks such as PFAS**
  These must be monitored and considered for appropriate intervention. Although these have not triggered the need for medium-term intervention currently, they will continue to be monitored and responded to accordingly.

2 Improving taste/colour/odour – Mains Conditioning

Trunk mains are typically conditioned to a handle a particular level of flow. An increase in flow can cause a mobilisation of sediment, which deposits on the inside of the water main, often resulting in discoloured water. Manganese tends to cause discolouration, and unlined cast iron networks can cause iron deposits in customers' pipes. Water with unusual discoloration, odour or taste is not usually a risk to public health, but it causes concern to customers, who report it when it occurs. Acceptability levels are described in the WHO guidelines[1] (p.237) and the DWI guidance.[2]

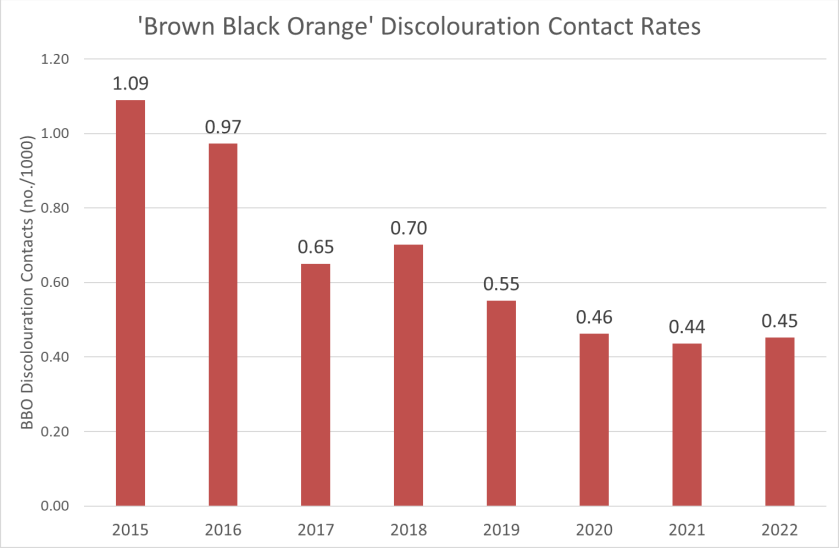
2.1 Need

2.1.1 Need for managing discolouration

Issues with taste, colour and odour are usually detected and reported by customers at low levels, and they tend to be caused by sediment in the water.

Yorkshire Water has made a lot of progress in addressing this issue over the last 20 years. We have significantly reduced the levels of turbidity, iron and manganese leaving water treatment works. In addition, we have implemented mains rehabilitation across 16 WSZs in recent years: 10 in WSZs spread across the region, and a further 6 specifically in Sheffield. We have also used enhancement funding to undertake substantial mains rehabilitation activity as part of the Section 19 programme of work. This has successfully driven down both numbers of customer contacts and levels of metals non-compliance, shown in the figure below.

Figure 2.1: Historical Customer Contacts for Water Discolouration



Source: Yorkshire Water internal analysis

Our customers still contact us about discolouration, so levels remain unacceptable to some, however the number of contacts received has generally reduced year on year, due to our Distribution Management Areas (DMAs) flushing. The flushing programme will continue into the

[1] WHO guidelines

[2] "Water that is aesthetically unacceptable will undermine the confidence of consumers, will lead to complaints and, more importantly, could lead to the use of water from sources that are less safe. To a large extent, consumers have no means of judging the safety of their drinking-water themselves, but their attitude towards their drinking water supply and their drinking-water suppliers will be affected... Guideline values have not been established for constituents influencing water quality that have no direct link to adverse health impacts."

coming price period and beyond, but we want to build on the trunk mains conditioning work done in the 2020-25 period, as we feel this will provide another cost-effective way to reduce the number of contacts we receive from customers about discolouration.

2.2 Best option for customers

2.2.1 Our trunk mains conditioning

While previous investment in manganese filters at water treatment works, coupled with large-scale flushing of DMAs, has helped to reduce the risk of discolouration, the trunk main system has received considerably less focused intervention.

Managing sediment is often a reactive process, however our trunk mains conditioning method allows us to apply 'in-service cleaning' by proactively managing incremental increases in flow. With no specialist tools required, and the ability to be integrated as part of a standard and regular maintenance procedure involving no service disruption, discolouration material can be removed and the main conditioned to accept higher flows at little cost.

Yorkshire Water's innovative conditioning process involves gradually ramping the water in the pipes up to higher flow volumes so a debris event has less impact. It's a kind of 'controlled flushing', allowing pipes to accept higher flows and removing sediment, over time, in undetectable amounts.

Building on the learning from previous price periods has allowed us to bring in several changes. We trialled our new process in 2015-20 (AMP6) and rolled it out to 16 Water Supply Zones throughout 2020-25 (AMP7) through an agreed programme of work with the DWI. During the 2020-25 price period, we developed a process to assess trunk main-related risk and began to implement mains conditioning solutions based on the Prediction of Discolouration in Distribution Systems (PODDS) philosophy. (Note: the trunk mains are structurally sound; only the sediment requires treating.)

Interim results show an improvement and monitoring is still ongoing. Our work for AMP8 will reduce the chance of a large-scale one-off incidents, as well as lowering the amount of sediment transferred from our trunk main system into the DMAs, where any future changes in flow (mainly from a mains pipe burst) could result in negative impacts on customers.

We have also adapted our treatment process to safeguard water quality. For example, source risks will be addressed through the design of water treatment works. All but one river or reservoir-fed site will incorporate three stages of treatment by the beginning of the 2025-30 period.

2.2.2 Alternative solutions

To date, we have used typical DMA flushing and our trunk mains conditioning (in AMP7) to address the discolouration issue. The main alternative to these would be to completely renew the mains – this would be prohibitively expensive.

We began an intensive, systematic DMA flushing programme in 2014 which has delivered further benefits to customers and compliance. On average, we have been flushing about 25% of the network every year. Although the principle of flushing is not particularly innovative and has probably been taking place for 50 years, our new approach is an innovative development as it allows risk-based targeting of flushing activity and an improved level of automation.

Calculating sediment depth from a scientific end-to-end process allows us to model, and then make risk-based predictions about which DMAs are likely to cause discolouration should there be a change in flow patterns. We can then base our DMA flushing programme on risk of discolouration (depth of sediment) rather than responding reactively to customer contacts. This has helped drive our discolouration performance to lower levels, at a more efficient cost.

2.2.3 Zone selection for trunk mains conditioning

Our discolouration contact data from 2020 to November 2022 has been used to rank and identify target zones. We developed scenarios for delivering this programme of work based upon different numbers of WSZs being delivered within AMP8 and beyond. The chosen scenario of 16 WSZ was based upon >150 contacts per WSZ from the observation period, and then included Keighley 2004 WSZ, due to the automation work we have completed as a result of the

dry summer of 2022. A further three WSZs that have performed relatively poorly had fewer contacts than the worst performing zones but allowed a balanced approach to work across the region, improving deliverability of the interventions and ensuring that all areas of Yorkshire get a similar benefit.

We designed our programme to increase the population that would see improvement from circa 929,000 customers in AMP7, to around 1.21million customers in AMP8. Table 2.1 shows the shortlist of proposed sites. The green WSZs represent a proposed list for AMP9.

A further programme of trunk main conditioning is provisionally planned for AMP9 of a similar scale. DMA flushing activity will continue, but post trunk main conditioning, material that can cause discolouration entering the DMA should reduce, reducing the reseeding rate in DMAs and reducing the flushing frequency.

Table 2.1 Short list of proposed sites for mains conditioning (orange, grey and blue is proposed AMP8 programme)

AMP8	Name	Eng Area	Reportable event	Exc	2015	2016	2017	2018	2019	2020	2021	Average
Y	Shipley 2019 WSZ	West	25	235	0.31	0.68	0.52	0.69	0.51	0.27	0.37	0.48
Y	Hull Bransholme 2019 WSZ	East	15	227	2.19	1.94	0.92	1.40	1.43	0.93	0.60	1.34
Y	Barnsley Grid - Grimethorpe 2019 WSZ	South		212	0.61	0.73	0.53	0.70	0.42	0.99	0.44	0.63
Y	Bradford City North 2019 WSZ	West	101	208	0.42	0.47	0.23	0.38	0.13	1.20	0.54	0.48
Y	Colne Valley 2019 WSZ	West		201	1.00	0.80	0.79	1.20	0.59	0.65	0.51	0.79
Y	Wakefield City North 2019 WSZ	South		195	1.23	0.99	1.48	0.66	1.01	0.56	0.61	0.93
Y	Roils Head 2004 WSZ	West		190	1.29	1.05	0.60	0.80	0.55	0.63	0.91	0.83
Y	Wakefield City South Sam 2019 WSZ	South		165	0.74	0.98	0.81	0.59	0.61	0.46	0.89	0.73
Y	Pontefract 2019 WSZ	North		164	1.08	1.32	0.63	0.78	0.74	0.49	0.46	0.79
Y	Brighouse 2004 WSZ	West		162	1.50	0.92	1.00	0.98	0.89	0.56	0.67	0.93
Y	Carcroft 2019 WSZ	North		155	1.33	0.54	0.48	1.39	0.35	0.87	0.44	0.77
Y	Leeds HL Harewood and Shadwell 2019 WSZ	North	13	153	0.52	0.72	0.51	0.46	0.54	0.60	0.46	0.54
N	Skipton/ Craven 2015 WSZ	West		137	0.81	1.45	0.49	0.58	0.73	0.87	0.55	0.78
Y	Market Weighton 2019 WSZ	East		134	0.67	0.83	0.51	0.41	0.65	0.99	0.48	0.65
Y	Keighley 2004 WSZ	West		130	0.46	2.06	0.46	0.35	0.41	0.47	0.34	0.65
N	Huddersfield 2019 WSZ	West		121	0.65	0.88	0.56	1.06	0.61	0.35	0.68	0.69
N	Denholme and Queensbury 2019 WSZ	West		119	0.47	0.69	0.55	0.54	0.40	0.33	0.35	0.48
Y	Fulwood 2019 WSZ	South		117	1.37	1.32	1.06	1.09	0.42	0.46	0.35	0.87
Y	Beverley 2019 WSZ	East		116	1.69	1.37	0.72	0.52	0.34	0.53	0.17	0.76
N	Graincliffe 2004 WSZ	West		116	0.90	0.79	0.73	0.68	0.49	0.78	0.45	0.69
N	Barnsley Grid - Wombwell 2019 WSZ	South		114	0.51	0.59	0.61	0.42	0.26	0.35	0.26	0.43
N	Tadcaster and Wetherby 2019 WSZ	North	28	111	0.90	0.51	0.55	0.62	0.40	1.30	0.49	0.68
N	Batley 2019 WSZ	West		111	0.48	0.67	0.52	0.47	0.33	0.24	0.47	0.45
N	Dewsbury 2017 WSZ	West		110	0.75	0.76	0.59	0.49	0.45	0.71	0.39	0.59
N	Selby 2019 WSZ	North		107	0.51	0.75	0.96	0.67	0.23	0.64	0.48	0.61
N	Loxley 2004 WSZ	South		103	0.76	0.82	0.80	0.46	0.54	0.35	0.35	0.58
N	Northallerton and Thirsk 2019 WSZ	North		102	0.58	0.46	0.25	0.26	0.39	0.63	0.58	0.45

Note: green rows are proposed for AMP9
Source: Yorkshire Water internal analysis

2.2.4 Preferred solution

For AMP8 we have chosen to reduce network sample failures and discolouration contacts through:

- Targeted conditioning of our large diameter mains by carrying out trunk main conditioning and automating this where appropriate.
- A flushing programme based upon the PODDS methodology in 16 identified WSZs across the region, with a further 11 proposed for the five year period beginning 2030.

The increased mains renewal programme (through a proposed targeted allowance) will reduce assets that have a condition grade 4 or 5 which also have the potential to cause discolouration and water quality risk, where conditioning or flushing is not suitable due to the overall poor condition of the asset. This renewal will be delivered through base and not enhancement expenditure.

Based upon the work carried out as part of the Legal Instruments for 10 WSZs in the 2020-25 period, we developed a costing methodology per WSZ, and applied this to programmes in the 2025-30 period. The methodology involved assumptions based upon traditional capital activity (mains renewal, cross connections and ancillary installations), purchase of equipment, and costs associated with flushing DMAs and trunk mains.

Our methodology suggests an estimated expenditure requirement of £558k per Water Supply Zone, amounting to a total of £9.37m for the selected 16 WSZs. Refer to the Cost Efficiency Chapter for more detail.

Our proposed approach was submitted for review to DWI and has received their support.

2.2.5 Quantification of impact on customers

Work on the initial 10 WSZs in the 2020-25 was completed in November 2022, with the calendar year 2023 considered an assessment year to review the impact of interventions. At this stage it is not possible to quantity the level of improved performance experienced by customers. However, following review of data at the end of 2023 we will be incorporating the measured levels into our criteria of success in our agreements with DWI.

Overall improved network performance will also contribute to the reduction in the regional contact rate as measured by the proposed common Drinking Water Contacts performance commitment. Refer to section 8.3.3 for the impact of all DWI initiatives on our performance commitments.

3 Improving taste/colour/odour – Ingbirchworth WTW

High levels of algal biomass can physically overwhelm WTW processes and lead to the formation of toxic disinfection by-products. Algae are the cause of multiple water quality and treatment risks. Under certain environmental conditions, cyanobacteria produce taste and odour (T&O) metabolites – such as 2MIB and geosmin that give an earthy T&O odour to the water that is detectable by customers at very low concentrations.

Reduced summer rainfall and increased temperature favours development of warm shallow reservoirs that promote cyanobacteria abundance. Additionally, research on T&O event triggers indicates that fluctuating weather conditions and associated pulses in key nutrients (ammonium and organic forms of phosphate) from agricultural practices greatly increase T&O risk. Extreme weather events, in particular summer rainfall and storm events, directly enhance this, leading to pulses of T&O metabolites.

3.1 Need

3.1.1 Need for treatment of algal growth

The reservoirs that supply the Ingbirchworth Water Treatment Works (WTW) – Ingbirchworth and Royd Moor – are surrounded by mixed agriculture, bringing a high risk of muck and slurry applications. Yorkshire Water tenants have regulations restricting slurry applications on high-risk land and are part of a rolling farm audit programme lead by the Land and Property Team. However, Yorkshire Water does not own the whole catchment for Ingbirchworth. Both tenants and private landowners follow regulations to reduce water and air pollution, such as the Farming Rules for Water Regulation, which is regulated by the Environment Agency (EA).

The area is also covered by Catchment Sensitive Farming (CSF). This enables farmers to have access to DEFRA's Countryside Stewardship schemes and water grants. The services include grants to improve farm infrastructure, one-to-one advice sessions and best practice workshops and events to improve the water and air environment.

Serious water quality events have occurred in the past two calendar years, with impacts on customers and exceeding regulatory standards. Short-term impact on customers has been strategically avoided in several ways. We have devised novel combinations of raw water supply, continually enhanced our raw water monitoring process, improved site operations, and reduced the downstream area that the site supplies.

However, currently available mitigating options require unrestricted use of raw water and capacity to allow reduced site throughput. Conditions throughout 2022 were significantly unusual, and so perhaps unlikely to be repeated in a short-term time frame. National models predicting change in climate do indicate that similar conditions are likely in the future.
As a result, it is forecast that taste and odour issues are likely to be a persistent and potentially increasing issue in the area supplied by Ingbirchworth WTW. This view is supported by the DWI. Given the immediate nature of this risk, a suitable solution is required in AMP8

3.2 Best option for customers

3.2.1 Options already implemented in previous AMPs

Table 3.1: Option Descriptions

Option	Description
Catchment management	Catchment management is the first line of defence for controlling water quality at source. The recent activity in the catchments supplying Ingbirchworth WTWs is typical of all our agricultural catchments. Engagement with landowners and tenants has been a priority at Ingbirchworth, raising awareness of the principles contained within Farming Rules for Water. We have also completed a catchment walkover with Natural England and Catchment Sensitive Farming, which identified several hazards. These were brought to the attention of the Environment Agency to investigate. There was a Nutrient Management Planning Farming event on the 8th of November 2023 held in the local area hosted by Catchment Sensitive Farming (CSF) and the Environment Agency to raise awareness of the Farming Rule of Water and the requirements for a nutrient management plan.
Catchment management – Raising awareness in the agricultural community	In the 2020-25 pricing period, Yorkshire Water attended the local agricultural show – Penistone Show in partnership with CSF to spread awareness about the local water quality issues and farming best practice. CSF also hosted a Nutrient Management Workshop in Penistone with the Environment Agency in November 2022 to raise awareness about the Farming Rule for Water regulation and requirements for nutrient management plans.
Reservoir management	Understanding the extent to which a reservoir stratifies, the dissolved oxygen demand of the sediment layer and the impact this has on the release of soluble ions, including nutrients from the sediment can be key to understanding the root cause of manganese and algae risk. This allows the correct intervention to be taken. Preventative action may be in the form of bubblers, mixers, oxygenators, blending options, alternative draw off and catchment management to control nutrient inputs. There are also some emerging nutrient stripping solutions that could be considered, although currently these are still at development stage. The starting point for any solution design is understanding the water quality in the reservoir at all depths.
Reservoir management – bubbler	Ingbirchworth reservoir has a bubbler installed, and a current project is in place to investigate best practice use and design of bubbling in the reservoir. If the equipment operates optimally, it could help to disperse algal blooms. The treatment works can handle a variable blend of the two water sources. Hence, preferential selection of the lower yield Royd Moor source and restriction of the downstream distribution area reduces the challenge to the treatment process. This process was successful in dealing with the unprecedented levels of manganese in 2021. Yorkshire Water is currently engaged in collaborative research projects with Cardiff and Bath Universities and UKCEH to understand the triggers for T&O events, and specifically how stratification and mixer selection and design could provide a holistic solution to mitigate manganese and algae-related risks. Intense reservoir monitoring is underway at Ingbirchworth for the research project and to meet the requirements of the legal instrument. The formal outputs from the research will be delivered in Dec 2024. This will inform whether a redesign of the bubbler system at Ingbirchworth is required.
Raw water source selection	Where reservoirs have known issues with algae, specifically T&O, seasonal use of raw water sources and blending are used to control risk. This approach has been adopted at Ingbirchworth WTW, and there is methodology in place to facilitate this.

3.2.2 Options for AMP8

We assessed the cost and benefits of building on past options:

Table 3.2: Comparison of cost and benefits of potential solutions

Options Considered	Capital Costs (£m)	Net Operational Costs (£m/pa)	Delivery Timescale (yrs)	Unplanned Outage Benefit (Ml/d)	CRI Benefit	Preferred Solution (AMP8)
Ingbirchworth WTW - Reservoir management & Treatment Solution	**22.61**	**0.47**	**5**	**22**	**0.21**	**Y**
Ingbirchworth WTW - Reservoir Management only	**4.43**	**0.05**	**5**	**22***	**0.1**	**N**
Catchment Management - Winscar, Thurlstone, B'Stones - DrWPA_ND	**0.00**	**0.24**	**5**	**N/A**	**N/A**	**Y**

Source: Yorkshire Water internal analysis

The preferred solution is the treatment option of process improvements, including the likely installation of ozone and GAC filtration, as this is the only solution that gives confidence in delivering the required improvements in treating raw water of this quality and reducing taste and odour issues for customers in the downstream supply area This will be supplemented by reservoir mixing solutions informed by our ongoing investigation. Other solutions were identified and will be explored further during scoping and definition, however at this stage there is not sufficient confidence that any of the other solutions are capable of achieving the sustainable, year round improvements required at this site.

Raw water entering Ingbirchworth WTW is monitored for light absorbance at 254nm by online instruments, and this represents a good measure of organic compounds entering the treatment process. This will be significantly enhanced by further parameters following installation of the column profiler at Ingbirchworth Impounding Reservoir.

We also propose to continue catchment management through WINEP and have not included these costs in this case.

Our proposed approach was submitted for review to DWI and has received their support. Refer to section 8.3.3 for the impact of all DWI initiatives on our performance commitments.

4 Raw Water Deterioration – Doncaster Boreholes

Changing weather patterns are beginning to challenge our processes for addressing water quality risk in the Doncaster region. A greater intensity of rainfall events causes rapid and more extreme deterioration in raw water quality, temporarily exceeding the design parameters of some treatment facilities. Our long-term risk planning takes account of how these changing weather patterns could affect water quality and the availability of sources.

In the 2025-30 period, we're looking at three immediate risks: Crypto, nitrates and pollutants requiring disinfection. All of these parameters are considered to be health impacting. For more information, please see the WHO guidelines on nitrates[3] and the DWI guidelines on Cryptosporidium[4] and disinfection.[5]

Read more about this at
www.dwi.gov.uk

4.1 Need

4.1.1 Need for disinfection

The issue is that two of Doncaster's pristine 'Class 4' boreholes are emerging as potentially dangerous to health, because of a deterioration in the surrounding groundwater. At the Austerfield WTW and Highfield Lane WTW boreholes, coliform, *E. coli,* and nitrate have been identified as hazards. Although currently classified as high quality – requiring chlorination only – these boreholes are in danger of being downgraded. A review of historical data also indicates the intermittent presence of indicator bacteria.

The challenge comes from significant deterioration in groundwater quality in the surrounding aquifer. Groundwater is treated at these sites, and catchment activity is deployed to manage risks from pesticides, nitrate, emerging contaminants, and microbiological parameters. However, the microbiological profile of the groundwater is putting pressure on existing treatment process. The site is at risk of shutdown in the near future, due to raw water conditions.

Further minor deterioration in raw water microbiological quality at either site could quickly overwhelm disinfection capability. It is not possible to provide an accurate prediction of the point of failure, however the current arrangement of independent sites is inherently non-resilient.

Our Water Resource Management Plan (WRMP) resource modelling indicates that on a regional basis there will be a deficit of supply by 2025. We are experiencing ever more frequent supply and demand pressures in the area, particularly in the summer, requiring grid support. A further loss of deployable source cannot be accommodated.

There is a reasonably high probability of microbiological content in the raw water supplying Austerfield and Highfield Lane, but relatively lower probability of detections of indicator organisms in outlet supply in the next 12 months. On a longer timescale, we consider that there is a high risk of failure at some point in the future.

4.2 Best option for customers

The catchment nitrate scheme in the WINEP programme currently running (starting in the 2020-25 period, continuing into the 2025-30 period) will deliver in the medium to long term. We are starting to see agriculture changes in the catchment and have added instrumentation that can document and track changes. The twin track approach of treatment and catchment management will continue.

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[3] apps.who.int/iris/bitstream/handle/10665/75380/WHO_SDE_WSH_04.03_56_eng.pdf

[4] www.dwi.gov.uk/consumers/learn-more-about-your-water/cryptosporidium/

[5] www.dwi.gov.uk/disinfection/

We identified several options for dealing with nitrate for AMP8:

- Drill a new borehole and rationalise/combine all sources.
- Replace an existing borehole – some of the existing ones are degrading.
- Bring two sites together into one to improve flexibility.
- Installation of new Contact Tank for additional disinfection.
- Installation of Ultra Violet (UV) for additional disinfection

After investigation alongside our strategic planning partner, it was concluded that the preferred solution was the installation of a contact tank, along with rationalisation for treatment of all sources at a single site. See Table 4.17. This option maximises opportunities for nitrate blending, provides wider resilience and increases disinfection across the sites.

During investigation, UV was considered but determined not to be an efficient solution as although the installation costs were comparable to the Contact Tank option, the requirement for an upgraded power supply and significantly increased opex led to it being ruled out early in optioneering.

The option to remove Littleworth boreholes from the solution was also considered in an effort to minimise costs. However, in order to maintain acceptable water quality standards by the end of AMP8, flows would need to be artificially reduced. Due to forecast supply and demand deficits, both in the local area and wider region by AMP8, this option is no longer viable and thus Littleworth must be included in order to maintain supplies to customers and ensure water quality standards are met.

We also propose to continue catchment management through WINEP and have not included these costs in this case.

Table 4.1: Costs and Benefits of Options Considered for Doncaster Boreholes

Options Considered	Capital Costs (£m)	Net Operational Costs (£m/pa)	Delivery Timescale (yrs)	Unplanned Outage Benefit (Ml/d)	CRI	Preferred Solution (AMP8)
Highfield/Austerfield Lane BHS – Disinfection Scheme + Littleworth Rehab	**20.54**	**2.32**	**5**	**36.50**	**0**	**Y**
Austerfield & Highfield Combine Flows and Treatment – Disinfection Scheme	**17.18**	**0.71**	**5**	**32.00**	**0**	**N**
Highfield Lane - Pesticide & Nitrate Catchment Management	**0.00**	**0.13**	**5**	**N/A**	**N/A**	**Y**

Source: Yorkshire Water internal analysis

Our proposed approach was submitted for review to DWI and has received their support.

5 Raw Water Deterioration – Haisthorpe Boreholes

Changing weather patterns are beginning to challenge our processes for addressing water quality risk. A greater intensity of rainfall events causes rapid and more extreme deterioration in raw water quality, temporarily exceeding the design parameters of some treatment facilities. Our long-term risk planning takes account of how these changing weather patterns could affect water quality and the availability of sources.

In the 2025-30 pricing period, we're looking at four immediate risks: THM, Crypto, nitrates and pollutants requiring disinfection. All of these parameters are considered to be health impacting. For more information, please see the WHO guidelines: on THM[6] and nitrates[7] and the DWI guidelines on Cryptosporidium[8] and disinfection.[9].

5.1 Need

5.1.1 Need for nitrate removal

Nitrate levels in the boreholes supplying Haisthorpe WTW have been steadily increasing in recent years. Haisthorpe is one of nine Water Treatment Works (WTW) benefiting from catchment actions to improve groundwater quality, however, like with Doncaster Boreholes (Austerfield, Highfield Lane and Littleworth), analysis now suggests that nitrate levels on the outlet of Haisthorpe WTW will reach unacceptable levels, during AMP8. As such, a treatment solution is now required, in conjunction with the existing catchment activity, to ensure Yorkshire Water is able to maintain supplies to customers, without breaching the upper limit for this health impacting measure. The DWI have supported this approach.

Haisthorpe WTW is served by a combination of borehole waters, which are blended on site:

- Bridlington BHS (borehole)
- Burton Agnes BHS (borehole)
- Haisthorpe West BHS (borehole)
- Haisthorpe Central BHS (borehole)
- Haisthorpe East BHS (borehole)
- Kilham BHS (borehole)
- Elmswell BHS (borehole)

Haisthorpe WTW, along with the smaller Hutton Cranswick WTW supply the Bridlington Water Supply System (WSS). This system is largely isolated from neighbouring systems with no reliable imports, except for a 2 Ml/d import from the East Coast Pipeline to Reighton CRE. As such, reliable flows from Haisthorpe WTW are required to ensure supplies are maintained to customers in the local area.

Nitrate levels are monitored at each of the supplying borehole groups: Bridlington, Burton Agnes, Elmswell, Haisthorpe, and Kilham.

The supplies from Elmswell and Kilham boreholes currently exceed the permitted level. While there's no history of exceeding the standard for nitrate at the WTW outlet or in downstream areas, our data suggests that keeping levels within legal limits at the Haisthorpe site may not be sustainable into 2025 period and beyond.

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[6] cdn.who.int/media/docs/default-source/wash-documents/wash-chemicals/trihalomethanes.pdf?sfvrsn=3d3a90e3_4

[7] apps.who.int/iris/bitstream/handle/10665/75380/WHO_SDE_WSH_04.03_56_eng.pdf

[8] www.dwi.gov.uk/consumers/learn-more-about-your-water/cryptosporidium/

[9] www.dwi.gov.uk/disinfection/

Nitrate levels are set to increase, with the capabilities of the site exceeded by 2027. The table below illustrates the projected nitrate levels (mg/l NO3) at each of the raw water sources until 2030 (based upon the increase in the last 5 years). The table also shows the maximum available flow (Ml/d) that can be achieved whilst maintaining the operational constraint of ensuring mixed nitrate does not exceed 46 mg/l NO3. The projection indicates that demand on the site may exceed the peak , sustainable supply of 26 Ml/d by 2027.

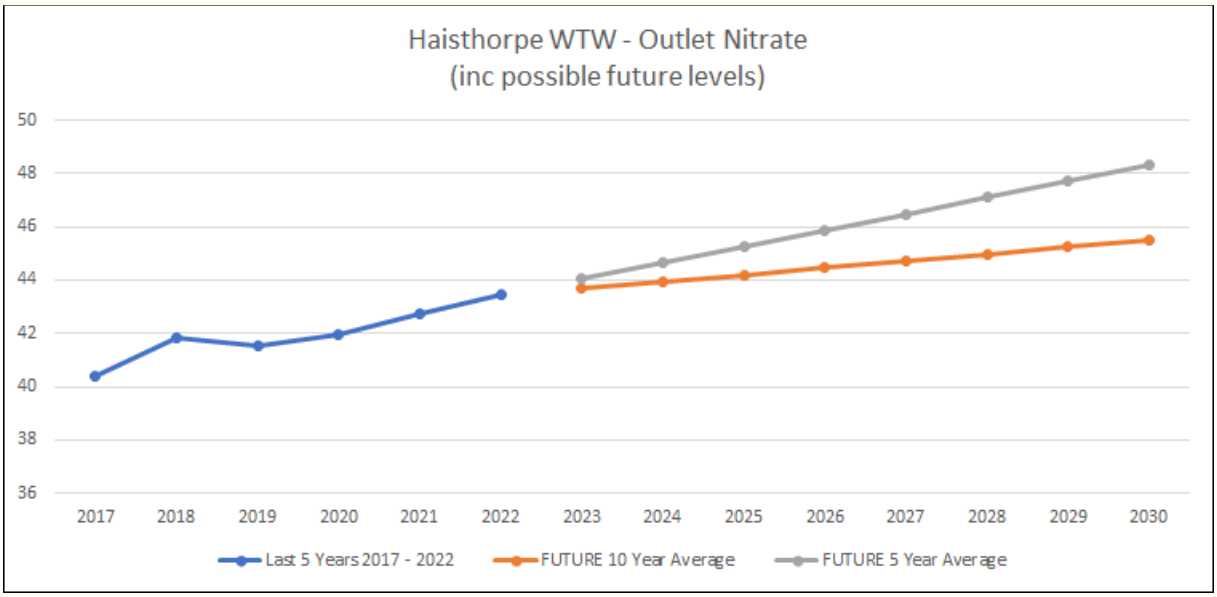
Table 5.1: Available Total Flow and Projected Nitrated Levels at Borehole Groups Feeding Haisthorpe WTW. Max daily demand of 26Ml/d, is forecast to be at risk from 2027.

	Future potential based on 5 year average change							
	2023	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Haisthorpe WTW Outlet	44.04	44.65	45.26	45.87	46.48	47.09	47.70	48.31
Kilham	63.92	64.25	64.59	64.92	65.25	65.58	65.91	66.24
Elmswell	58.03	59.09	60.15	61.21	62.27	63.33	64.39	65.45
Haisthorpe Central	38.95	39.14	39.33	39.52	39.71	39.90	40.09	40.28
Haisthorpe East	41.40	41.88	42.36	42.84	43.32	43.80	44.28	44.76
Burton Agnes	43.64	44.00	44.36	44.72	45.08	45.44	45.80	46.16
Brid Mill Lane	47.56	47.75	47.94	48.13	48.32	48.51	48.70	48.89
Total Available Flow (Ml/d)	28.63	27.94	27.28	26.49	25.8	25.2	24.67	24.19

Source: Yorkshire Water internal analysis

A further risk exists that should one of the low nitrate sources suffer an outage, throughput would be capped at c.20 Ml/d, which would be insufficient to meet average daily demand. The figure below shows the projected nitrate levels at Haisthorpe WTW based on the historic 5 year nitrate levels (grey) and 10 year nitrate levels (orange).

Figure 5.1: Forecast Nitrate Levels at Haisthorpe WTW Outlet



Source: Yorkshire Water internal analysis

Therefore, the site is at risk of shutdown in the near future, due to raw water conditions. Our Water Resource Management Plan (WRMP) resource modelling indicates that on a regional basis there will be a deficit of supply by 2025. We are experiencing ever more frequent supply and demand pressures in the area, particularly in the summer, requiring grid support. A further loss of deployable source cannot be tolerated.

5.2 Best option for customers

5.2.1 Source of the nitrate

The geology of the Haisthorpe boreholes comprises chalk, which has rapid travel times, and around six metres of sandy soil and boulder clay, which offers some aquifer protection. The area is predominantly agricultural, and nitrate applications to land by the farming community are very likely. Yorkshire Water does not own the catchment for Haisthorpe boreholes; the agricultural landowners follow regulations to reduce water and air pollution such as the Farming Rules for Water Regulation.

The area is within a nitrate vulnerable zone which has further regulations around nutrient applications and is regulated by the Environment Agency. The area is also covered by Catchment Sensitive Farming (CSF). This enables farmers to have access to DEFRA's Countryside Stewardship schemes and water grants. The services include grants to improve farm infrastructure, one-to-one advice, best practice workshops and events to improve the water and air environment.

In addition to the farming regulation and improving best practice in the catchment through the partnership with CSF, the boreholes have casings to prevent surface water infiltration. The source protection zones have also been part of a Water Industry National Environment Programme (WINEP) in the 2020-25 pricing period, to reduce nitrate leaching from the catchment. An innovation group (part of the Sustainable Landscapes programme) was established by our contractors, Future Food Solutions, in 2021. The group focuses on nitrogen efficiency, soil health and improvements in the wider environment as well as exploring more sustainable and more profitable ways of producing crops for the food and drink supply chain. The impact of the above control measures is not sufficient to adequately assure compliance, hence an alternative solution has now been developed for the 2025-30 period.

5.2.2 Options already implemented in previous AMPs

The WINEP programme included a nitrate scheme in the last price review which is set to continue into the 2025-30 period, including liaison and education with the agricultural sector to adopt low nitrate farming methods in the catchment. This is expected to yield positive results in the medium/long term. However, the rate of increase in nitrate levels at Haisthorpe suggests that failures are likely from 2025 onwards, and as such, a treatment solution is now required to ensure continued compliance.

5.2.3 Options for AMP8

The current operation of Haisthorpe WTW maintains a compliant supply to customers. Water from all sources is monitored and blended to achieve a supply that is less than 46 mg/l as NO3. Yorkshire Water's approach has been to implement this lower trigger in order to provide a safe dead-band for this health-impacting parameter.

The preferred option is the installation of a nitrate removal plant to treat raw water from the two highest nitrate sources. Initial considerations looked at treating all sources, but subsequent analysis suggests that treating the two high nitrate sources will be sufficient to reduce levels now and into the future. This solution is the only one able to adequately resolve the nitrate issue, whilst protecting yield and ensuring best value for customers.

Other options considered but discounted include:

- Network solution to import treated water from neighbouring systems: This was discounted on the basis that although it would resolve the nitrate issue, it would lead to a loss of yield, due to reduced flows at Haisthorpe WTW. This is unacceptable as YW is forecasting a supply-demand deficit in AMP8; therefore, overall yield must be protected as part of any solution.

- Installation of a new low nitrate borehole: This was considered as costing analysis showed this to be the most cost-effective solution. However, as this would require a licence variation it is unlikely to be deliverable in time. There are also no guarantees a new borehole would be of sufficient quality to resolve the nitrate issue. Furthermore, there is an increased element of cost uncertainty as both the investigation costs and any land purchase are unknown. Finally, it is not guaranteed that the Environment Agency would agree to a new licence in the area, when YW already have a licence for Haisthorpe with sufficient capacity to meet demand. Given the lack of confidence in the costs and deliverability of the new borehole solution and the fact the costs between this and the (preferred) nitrate removal solution, were relatively close, it was decided to progress with the nitrate removal solution.

Table 5.2: Summary of Solution Options Considered for Haisthorpe WTW

Options Considered	AMP8 Capital Costs (£m)	Net Operational Costs (£m/pa)	Delivery Timescale (yrs)	Unplanned Outage Benefit (Ml/d)	CRI	Preferred Solution (AMP8)
Haisthorpe WTW Option 1 - New Borehole	7.87	0.20	3	0	0.71	N
Haisthorpe WTW Option 2 - Nitrate Removal Plant - All Sources	18.58	0.60	4	3.87	0.77	N
Haisthorpe WTW Option 3 - Nitrate Removal Plant - High Nitrate Sources Only	7.69	0.36	4	3.87	0.77	Y
Haisthorpe WTW - Pesticide & Nitrate Catchment Management	0.00	0.64	5	N/A	N/A	Y

Our proposed approach was submitted for review to DWI and has received their support. Refer to section 8.3.3 for the impact of all DWI initiatives on our performance commitments.

6 Raw Water Deterioration – East Ness WTW

Changing weather patterns are beginning to challenge our processes for addressing water quality risk. A greater intensity of rainfall events causes rapid and more extreme deterioration in raw water quality, temporarily exceeding the design parameters of some treatment facilities. Our long-term risk planning takes account of how these changing weather patterns could affect water quality and the availability of sources.

In the 2025-30 period, we're looking at four immediate risks: THM, Crypto, nitrates and pollutants requiring disinfection. All of these parameters are considered to be health impacting. For more information, please see the WHO guidelines on THM[10] and nitrates[11] and the DWI guidelines on Cryptosporidium[12] and disinfection.[13].

6.1 Need

6.1.1 Need for Disinfection

There is an increase in detected levels of coliform bacteria in raw water affecting an important water treatment works that supplies a large area. The WTW at East Ness and Malton Norton supply the East Ness Water Supply (WSS) system, East Ness provides the majority of supply to the reservoirs in the system and is required to maintain supplies to customers.

Source waters for East Ness WTW have been found to contain indicator bacteria on an intermittent basis, and as a result, controlled disinfection by chlorine within a defined contact tank is an element of the treatment process. Recent data has indicated an increased occurrence of coliform bacteria in raw water sources.

The number of positive detections in samples collected from each of the boreholes supplying the site is shown below in Figure 6.1.

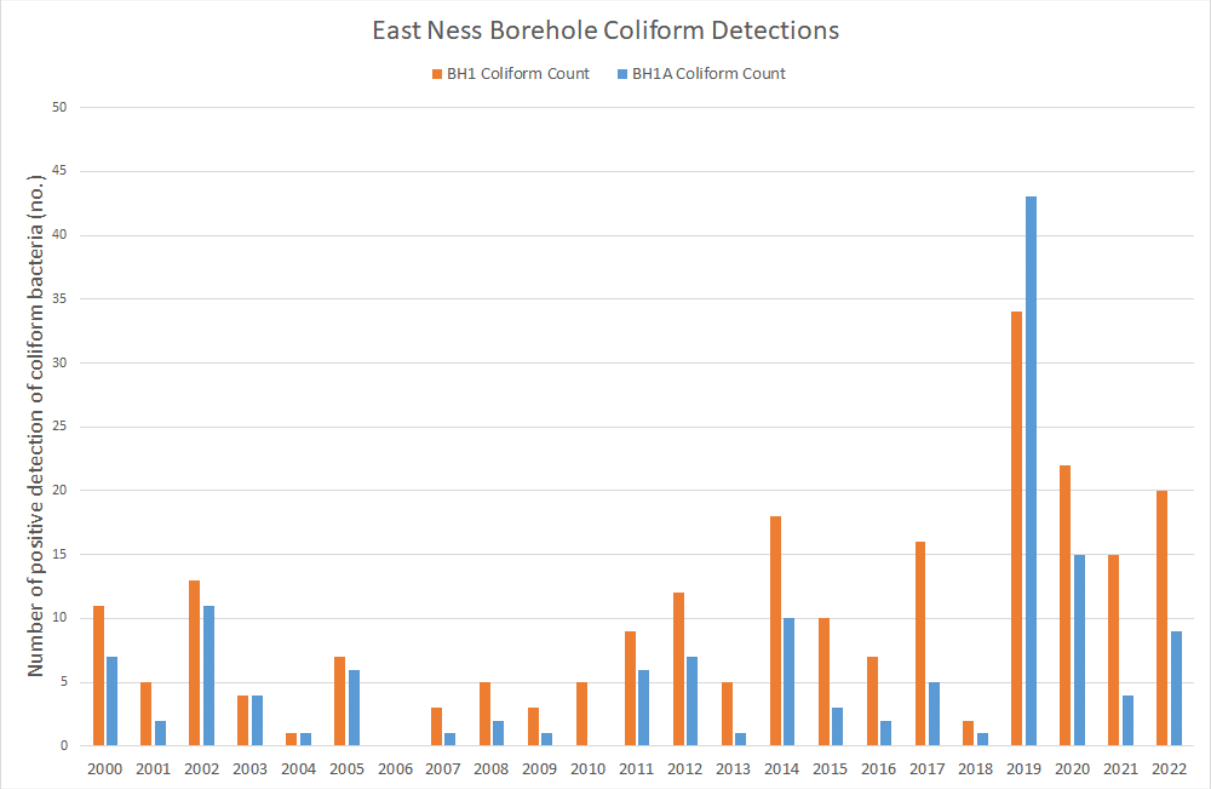
[10] cdn.who.int/media/docs/default-source/wash-documents/wash-chemicals/trihalomethanes.pdf?sfvrsn=3d3a90e3_4

[11] apps.who.int/iris/bitstream/handle/10665/75380/WHO_SDE_WSH_04.03_56_eng.pdf

[12] www.dwi.gov.uk/consumers/learn-more-about-your-water/cryptosporidium/

[13] www.dwi.gov.uk/disinfection/

Figure 6.1: Coliform Detections at East Ness Since 2000



Source: Yorkshire Water internal analysis

There was a notified water quality event at East Ness WTW on the 12th of September 2022 following the detection of *E. coli* bacteria in a regulatory sample. This follows recent detections of *Clostridia perfringens* bacteria in raw water at the site, indicating an underlying raw water deterioration.

The cause of the presence of *E. coli* was found to be related to a rapid recharge of ground aquifer following an extended period of dry weather. This was exacerbated by the arrangement and condition of borehole No.1A, which has been indicated by CCTV survey to require maintenance on the casing. Boreholes No.1 and No.1A are hydraulically linked.

Drier and hotter summers are expected to occur more frequently in national climate forecast models, and under similar circumstances to those occurring in 2022 – i.e. rapid recharge of ground water after an extended period of dry weather – a recurrence of bacteria in water supplied to customers is likely.

Full details of risk assessments are shown in the relevant Reg28 Reports, but in summary, the likelihood of coliform, *E. coli* or *Clostridia* occurring in customer water supplies is considered low in the next 12 months. However, in the context of increased likelihood of weather patterns seen in 2022 (very dry, and then very wet weather) the likely future presence of indicator organisms is considered a red risk. As a result, a treatment solution to reduce the risk coliform failures on site is required in AMP8. This view has been supported by the DWI.

6.2 Best option for customers

6.2.1 Options already implemented in previous AMPs

Filtration systems capable of removing *C. perfringens* have been installed at East Ness WTW since 2020. However, the original system restricted flow through the site to a maximum 10.5 Ml/d. The abstraction licence capacity of the site is 17Ml/d and a Base funded, upgraded filtration system rated at 17 Ml/d, is due for commissioning in 2023. This will allow the site to meet the current site throughput capacity of 12 Ml/d. The intention is to increase total site capacity to meet the abstraction licence as part of this scheme.

6.2.2 Options for AMP8

A number of options have been considered to resolve the bacteriological issues at East Ness WTW. A catchment investigation was completed, however no root cause or high-risk activity was identified, leading to very low confidence that a catchment-based approach would successfully manage the risk. The preferred option is a treatment solution from Table 6.1.

Table 6.1: Comparison of Cost and Benefits of Options

Options Considered	Capital Costs (£m)	Net Operational Costs (£m/pa)	Delivery Timescale (yrs)	Unplanned Outage Benefit (Ml/d)	CRI	Preferred Solution (AMP8)
East Ness WTW - New BH Arrangement & Distribution Pumping	**9.30**	**0.61**	**4**	**4.5**	**0.13**	**Y**
East Ness WTW - Enhanced Disinfection	**10.65**	**0.08**	**4**	**0**	**0.13**	**N**
East Ness WTW - Abandonment and Supply from Elvington WTW	**23.80**	**0.09**	**4**	**-12.5**	**0.13**	**N**

The preferred solution is for a new borehole arrangement and improved distribution pumping. This option has the similar estimated investment as option two, however, it addresses the issues with the short casings of the existing borehole (by re-lining BH1 and abandoning BH1A), and also includes the drilling of a new borehole at another site to allow site throughput to be increased to the 17Ml/d designated by the licence. Coupled with improvements to the distribution pumps on site, this solution improves water quality, resilience, and site throughput.

Other options considered include:

- Enhanced disinfection with de-chlorination: While initially considered a viable option, it would not eliminate the risk associated with the short casings in borehole 1A, nor would it be compatible with the strategy to increase site flows to the current licence (17 Ml/d), in order to increase deployable output and improve resilience. In addition, *C. perfringens* is relatively resistant to chlorine and it is not certain it could not be removed at appliable doses. Although this was marginally the most cost-effective solution, there is insufficient confidence it can deliver the outputs required whilst aligning with the drive to maintain yield in the face of the forecast supply-demand deficit in AMP8. As such, it was not considered a viable solution.

- Abandon East Ness WTW, replacing it with a new supply from Elvington WTW: This option was quickly discounted due to high cost (estimated twice the capex of other options) and because it would require abandoning a viable water resource. The WRMP has identified the need for new resources due to a supply/demand deficit and closing functioning resources would be problematic.

The preferred water quality solution will be delivered in conjunction with a network resilience solution to improve security of supplies in the Huby WSS. This resilience scheme is costed at £3.25m, these costs are not included in Table 6.110 or as part of this case as it will be delivered through base.

Our proposed approach was submitted for review to DWI and has received their support. Refer to section 8.3.3 for the impact of all DWI initiatives on our performance commitments.

7 Meeting Lead Standards

Lead is a well-recognized toxicant that has wide-ranging health impacts affecting the neurological, cardiovascular, gastrointestinal and haematological systems. Young children are particularly vulnerable because they have higher exposures than adults and because lead affects the developing brain, potentially resulting in reduced intellectual ability. Lead in the body is distributed to the brain, liver, kidney and bones. It is stored in the teeth and bones, where it accumulates over time. Lead in bone is released into blood during pregnancy and becomes a source of exposure to the developing fetus.

Human exposure is usually assessed through the measurement of lead in blood. There is no known safe blood lead concentration; even blood lead concentrations as low as 5 µg/dL may be associated with decreased intelligence in children, behavioural difficulties and learning problems. As lead exposure increases, the range and severity of symptoms and effects also increase.

Young children are particularly vulnerable to the toxic effects of lead, and can suffer profound and permanent adverse health impacts, particularly on the development of the brain and nervous system. Lead also causes long-term harm in adults, including increased risk of high blood pressure and kidney damage. Exposure of pregnant women to high levels of lead can cause miscarriage, stillbirth, premature birth and low birth weight.

7.1 Need

7.1.1 Need for lead pipe removal

There are several reasons that lead can be present in water from customers' taps, including:

- Lead pipework installed before the 1970s.
- Leaching from new brass fittings prior to build-up of phosphate layer.
- Inappropriate use of lead solders.

In all cases, local factors – such as the metals in a customer's fittings combined with physical disturbance – strongly influence the level of lead occurring at a specific property.
Yorkshire Water treats lead by:

- Dosing of phosphate-based chemicals into all Water Supply Zones.
- Replacing lead communication pipework, e.g. in response to customer requests or routine sampling of customer water.
- Opportunistic replacement of lead communication pipework in relation to other operational activity.

We plan to extend our successful lead communication and supply pipe renewal programme to high-risk communities. This work is not covered by capital maintenance because the pipes are operationally sound, apart from the risk of lead.

Under Regulation 17(9), we replace our pipes and fittings where a sample has exceeded the 10µg/l standard.

We collect samples from customer properties each year as part of the compliance sampling programme, and relatively few of these fail to meet the regulatory standard. Where a failure occurs and we find these properties to have a lead communication pipe, we replace it.

Full details of risk assessments are shown in the relevant Reg28 Reports, but in summary, the risk of lead in water is considered to be of the highest severity. The overall probability of occurrence at any specific water supply zone is relatively low, as lead issues are often concentrated in hotspot locations.

7.1.1.1 Long-Term Plan

Our research has concluded that increased enhancement activity could be driven through future legislative change (from the Drinking Water Inspectorate). A second important factor is changing societal awareness and tolerance of the presence of lead in the clean water network. Our

strategy currently suggests 3 potential alternative pathways to carry out full lead removal in the region over 25 years, 40 years, and 60 years.

Table 7.1: Proposed Costs by Strategy

		25 Year Plan		40 Year Plan		60 Year Plan	
		Annual	AMP	Annual	AMP	Annual	AMP
Lead Scenario Types	No. of Pipes	48,000	240,000	30,000	150,000	20,000	100,000
Communication Pipe Only	Cost (£m)	67	366	42	210	28	140
Full Service Pipe		91	456	57	285	38	190
End to End (incl. internal plumbing)		154	768	98	480	64	320

We recognise that affordability, pipe ownership and regulation will be factors requiring careful consideration, as well as Government support, to enable the full benefits of a Lead strategy to be delivered.

7.2 Best option for customers

7.2.1 Limited technology solutions

The guidance from the DWI recommends the replacement of lead pipes, our solutions align to this:

“In January 2021, in collaboration with WRc, the Inspectorate published the Long-term Strategies to Reduce Lead Exposure from Drinking Water research report[14]. The report provides compelling and significant evidence of the economic implications of exposure to lead through reduced societal intellectual capacity and physiological health. This has demonstrated via cost-benefit analyses that removing lead from drinking water has a significant overall economic benefit. Therefore the long term objective is to reduce exposure to lead in drinking water as there is no safe level of human exposure to lead (WHO)[15].

“Where companies are considering innovation, such as relining of pipes, they should also balance this decision with the consequence that *they must also plan for longer-term replacement*. Current lining technologies, by their nature will inevitably deteriorate with age this may in turn see a return to lead level exposure and other associated new issues with the lining deterioration. Since this option is a medium-term solution which would require further intervention, this will need be coupled to an undertaking to replace the affected lead supply pipes within a formally committed period prior to deterioration in the future.”

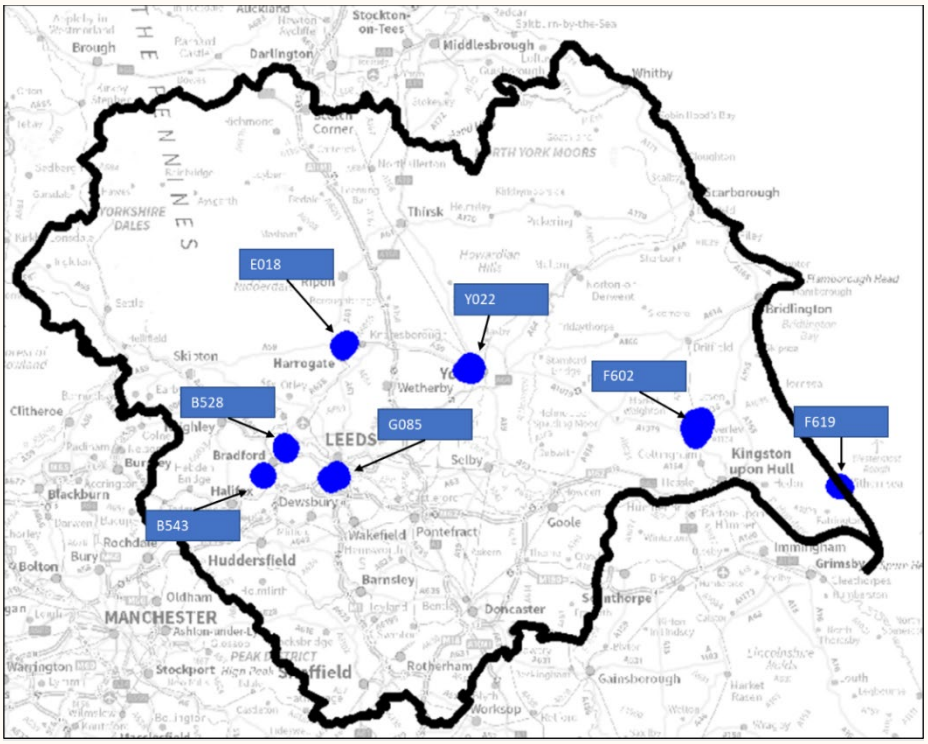
7.2.2 Zone selection

Locations of the DMA hot-spot schemes are shown below. The Lead Exceedance and Free and Matching scheme locations are unknown due to the sampling process or in relation to customer requests. The Educational Establishments scheme will be investigated at the start of the scheme, so the actual location of Lead Service pipe renewals is to be defined. Continued work to address lead risks to our customers on the priority services register will result in lead renewals at specific properties.

[14] https://cdn.dwi.gov.uk/wp-content/uploads/2021/02/08150815/DWI70-2- 320.pdf

[15] https://www.who.int/news-room/factsheets/detail/lead-poisoning-and-health

Figure 7.1: Location of Hotspot DMAs for Supply Pipe Replacement



Source: Yorkshire Water internal analysis

Hotspot service pipe replacement is to be carried out in seven targeted local DMA areas.

Table 7.2: Targeted DMAs

DMA Ref	Water Supply Zone	WSZ Ref	2023 WSZ Population
B528	Bradford City North 2019 WSZ	Z4800619	56787
B543	Denholme and Queensbury 2019 WSZ	Z4801219	90509
E018	Harrogate North 2019 WSZ	Z2802719	39118
F602	Beverley 2019 WSZ	Z2800519	94781
F619	Holderness 2019 WSZ	Z2803019	42246
G085	Leeds LL Robin Hood 2019 WSZ	Z1801219	67389
Y022	York West 2019 WSZ	Z9809719	92222

7.2.3 Scale of investment

We are planning to expand the lead programme to the seven higher risk locations identified across the region, see Table 7.313 below. Criteria for selection in the programme was where more than one exceedance of 4 micrograms per litre had occurred in a three-year period. Based on historical findings, we estimate 44% of properties have lead pipes. Overall, we intend to address fewer DMAs than AMP7, but a longer length of pipe as the entire service pipe will be replaced – so the investment will be greater than the 2020-25 period.

In addition, we intend to extend our targeted interventions at schools and other educational establishments. Working towards reducing the lead risk for the most vulnerable members of the community.

We determined the scale of investment based on historical projects and the extent of lead pipes we found in those areas.

Table 7.3: Costs per Location

Zone Ref	Name Part2	WSZNAME	Fail >= 4	Props	44% of total props	Costs based on £1817.95 unit rate for full length
G085	DEWSBURY RD PUMP DMA	LEEDS LL ROBIN HOOD 2019 (WSZ0455) WSZ	6	2273	1000.12	£1,818,168.15
F602	KELDGATE DMA	BEVERLEY 2019 (WSZ0422) WSZ	4	2370	1042.8	£1,895,758.26
F619	WITHERNSEA DMA	HOLDERNESS 2019 (WSZ0442) WSZ	4	3805	1674.2	£3,043,611.89
Y022	BOROUGHBRIDGE RD DMA	YORK WEST 2019 (WSZ0488) WSZ	4	4568	2009.92	£3,653,934.06
B528	RAVENSCLIFFE DMA	BRADFORD CITY NORTH 2019 (WSZ0423) WSZ	3	1482	652.08	£1,185,448.84
B543	SLACKSIDE DMA	DENHOLME/QUEENSBURY 2019 (WSZ0431) WSZ	3	1445	635.8	£1,155,852.61
E018	HIGH LV 350MM BL DMA	HARROGATE NORTH 2019 (WSZ0441) WSZ	3	2886	1269.84	£2,308,505.63

Source: Yorkshire Water internal analysis

The table below shows the proposed investment within the pricing period beginning 2025 of the different elements of the lead programme. See also the chapter ‘Cost efficiency’.

The chosen approach will increase the number of customers that benefit from reduced lead exposure to c63,000 in the 2025-30 period (an increase from c25,000 on the previous one). This is mainly due to an enhanced programme at educational establishments.

Other options considered included renewing only the communication pipe, but we decided to renew the service pipe to maximise the health benefits and avoid possibly having to return in order to replace a supply pipe at a future date.

Table 7.4: Costs of Proposed Interventions

PR24 Lead Programme Scenarios	AMP8 Proposed Investment	Estimated No. Of Renewals	Estimated No. of people to benefit	Timescales for delivery
Lead Exceedance	£607,497	434	1,041	AMP8 year 1-5
Lead Free & Matching	£2,934,477	2,096	5,031	AMP8 year 1-5
Lead DMA Hot Spot Medium Scenario (7 DMAs) Full Service Pipe	£15,061,694	8,285	19,883	AMP8 year 1-3
Lead Education Establishment High Scenario Full Service Pipe	£1,000,000	100	35,929	AMP8 year 1-5
Lead Helping Hands/Vulnerable Customers	£804,338	575	1,379	AMP8 year 1-3
	£20,408,005	**11,489**	**63,263**	

***Assumes an average of 359 pupils per education establishment and 2.4 people per property**

Our proposed approach was submitted for review to DWI. We are awaiting detailed feedback. Refer to section 8.3.3 for the impact of all DWI initiatives on our performance commitments.

8 All Drivers and Schemes

8.1 Cost Efficiency

8.1.1 Cost estimate for our preferred option

This section outlines how our overall approach to cost estimation, as outlined in section 7.3 in Introduction to Enhancement Cases, has been applied to this enhancement case. The table below summarises the costs for each driver.

Read more about this at
Introduction to Enhancement Cases

Table 8.1: Enhancement Costs

Driver	Total Capex Enhancement Expenditure (£m)	Total Opex Enhancement Expenditure (£m)
Improving taste / odour / colour	31.98	0.47
Investment to address raw water deterioration	37.53	3.29
Meeting lead standards	21.42	0.00
Total	**90.92**	**3.76**

In the rest of this section, we take each driver in turn and explain how we have developed our costs. There is no third party funding for any of our DWI schemes.

8.1.1.1 Improving taste, odour and colour

The total enhancement expenditure required to address taste, odour and colour in AMP8 is £31.98m. To address taste, colour and odour within our network, we are proposing to undertake two activities:

- trunk mains conditioning and flushing, costing £9.37m and
- Preventative action and process improvements at Ingbirchworth, costing £22.61m.

In developing our cost estimates for trunk mains conditioning and flushing, we have applied a detailed bottom-up approach, building on our experience of delivering similar projects. Our cost estimates have been informed by historic cost information from similar activities.

The total cost estimate for the flushing activity has been developed using the following assumptions:

- We are proposing to flush 16 out of a total of 89 water supply zones, equating to 17.9% of our network.
- Our network has a total of 3,000 district metering areas (DMAs), and we have applied the 17.9% to estimate that we will be flushing a total of 537 DMAs.
- Each DMA will be flushed at least once, and we expect that 50% of the DMAs will need to be flushed twice. This assumption is based on our experience of undertaking similar activity, where the highest risk areas require more flushing. The results in 805 flushes.
- The cost of flushing a DMA once is £1,304, this is the cost we currently incur.
- The total cost is therefore £1,304 multiplied by the 805 expected flushes, resulting in a total cost of £1.05m.

The total cost estimate for the conditioning activity has been developed using the following assumptions:

- The total cost for the conditioning of 6 water supply zones in AMP7 is £2.6m. This includes capital activity such as mains renewal, cross connections, ancillary installations and automation.
- The average cost per water supply zone is therefore £0.43m.
- This figure has then been inflated to the CPIH average for 2022-23 to £0.48m
- We have used this average cost to calculate the total cost of £7.27m for the 16 water supply zones.
-

We have also included the cost of the additional resource required to undertake this programme of activity. The resource requirement has been identified based on our historical resource requirement for similar types of activities. We have set out these costs in the table below, along with the total cost to address taste, colour and odour.

Table 8.2: Flushing Costs

	Unit cost rates per (£m, April 22/23 prices)	Unit costs in 22/23 price base (£m)
Total flushing cost	1.0	1.05
Total conditioning cost	6.93	7.27
Discolouration Engineer	0.05	0.05
5.1 FTEs of field resource	0.41	0.43
Engineering support plus 2 trunk main engineers for 2 years	0.53	0.56
Total cost	**8.93**	**9.37**

We have costed the preventative action and process improvements at Ingbirchworth WTW in our Enterprise Decision Analytics (EDA) tool. Unit Cost Database (UCD) cost models were applied within EDA using out-turn cost data from capital projects delivered by our main contract partners to derive cost estimates. We are proposing enhancement expenditure of £22.61m to develop the solution outlined earlier in this enhance case.

8.1.1.2 Raw water deterioration

The total enhancement expenditure required to address raw water deterioration in AMP8 is £40.81m. To address raw water deterioration we are proposing to undertake three schemes.

The schemes we are proposing to undertake for AMP8 are detailed in the table below:

Table 8.3 Scheme Costs - Raw Water Deterioration

Scheme name	Totex Cost (£m)
East Ness WTW - New Borehole Arrangement & Distribution Pumping	9.90
Haisthorpe WTW Option 4 - Nitrate Removal Plant High Sources	8.05
Highfield/Austerfield Lane(Doncaster Boreholes) - Disinfection Scheme and Littleworth Rehab	22.86
Total Cost	**40.81**

As described in our approach to optioneering, a wide range of options were considered in identifying our preferred solutions to address raw water deterioration. These options were developed by our Strategic Planning Partner in conjunction with YW Asset Planning and costed and captured in our Enterprise Decision Analytics (EDA) tool. Unit Cost Database (UCD) cost models were applied within EDA using out-turn cost data from capital projects delivered by our main contract partners to derive cost estimates. These costs were then further validated by an existing YW Tier 1 Capital Partner to ensure the cost are reflective of current market conditions.

A cost benefit assessment was then carried out to ensure the preferred solution was able to address the specific risk in the most efficient way. See the sections on Raw Water Deterioration – Nitrate and disinfection for Doncaster Boreholes, Raw Water Deterioration – Disinfection at East Ness and Raw Water Deterioration – Nitrate removal plant at Haisthorpe sections 3-6 for more detail.

8.1.1.3 Meeting Lead Standards

The total enhancement expenditure required to meet lead standards in AMP8 is £21.42m. We are proposing to undertake lead pipe replacement across 5 programmes of work. We summarise the programmes, total cost, unit rate and number of renewals in the table below:

Table 8.4: Unit Costs

Programme Name	AMP8 proposed investment (£m)	Estimated renewals	Unit rate (£ per m)
Lead exceedance	0.64	434	1,475
Lead free and matching	3.08	2,096	1,475
Lead DMA hot spot	15.81	8,285	1,908
Lead education establishments	1.05	100	10,496
Lead helping hand and vulnerable customers	0.84	575	1,475
Total	**21.42**	**11,490**	

We are proposing three unit rates for lead pipe replacement in AMP8, these unit rates are based on our current costs from our delivery partners, and we summarise each unit rate and the rationale below:

- **Lead pipe replacement for comms pipe only:** £1,475 per meter is the current cost of replacement. We are proposing to use this rate for our lead exceedance, lead free and matching and vulnerable customer schemes.
- **Lead pipe replacement for comms pipe and service pipe:** £1,908 per meter is the current cost of replacement, we are proposing to replacement both the comms pipe and service pipe for our lead hotspot programme.
- **Lead pipe replacement for school service pipe:** we have used the historical average cost to replace service pipes at schools during AMP7 to inform our AMP8 costs. We are proposing a unit rate of £10,496 per pipe.

8.1.2 Efficiency of our cost estimate

Section 7.3 of the introduction to our enhancement cases outlines our approach to cost efficiency, and how our internal process and delivery decisions are designed with efficiency in mind. This section outlines the application of this approach to this specific enhancement case:

- Our estimates utilise models aligned with models from our Unit Cost Database, with estimates developed using historic cost information on individual components of an overall solution.

- We also cross checked our costs against information held in the national water industry costing database where applicable (TR61 v14).

The preferred solutions for each of the above schemes were produced in close collaboration with our Strategic Planning Partner. As part of this process, opportunities for innovative solutions were explored to maximise efficiency and areas of potential over-engineering were challenged, while simultaneously, ensuring an acceptable degree of confidence in achieving the required outputs. An example of this process is the solution at Haisthorpe; the initial view that that a nitrate removal plant to treat full site flows would be required at a cost of c.£17m. However, following a challenge to that assumption, further investigation revealed that the installation of a nitrate removal plant on the two high nitrate sources would still achieve the required improvements, but with a c.£9m cost efficiency.

Once the preferred solutions were confirmed, detailed costing itemised sheets were produced, and the information used in conjunction with YW cost models/database to produce a cost estimate for each scheme. Scheme costs were also validated by one of our Tier 1 capital partners using the same data inputted into the YW cost models with the results were broadly in line. Further work is required during scoping, definition, detailed design and tender to ensure upwards pressures (E.g. inflation) are minimised and further opportunities for efficiency are recognised.

8.1.3 Need for enhancement model adjustment (modelled adjustment only)

Without a view of the Ofwat's approach to setting cost allowances to each driver, anticipating any model adjustment requirements is challenging.

Taste, Odour, Colour & Raw Water Deterioration - We note that the variety of interventions and drivers being addressed in this area will make identification of appropriate cost drivers difficult and therefore we anticipate (based on PR19) that Ofwat will not produce a cost model and would assess this expenditure through deep or shallow dive approaches dependent on materiality.

Lead Pipes - We anticipate that Ofwat will continue to model lead pipe interventions through simple unit rate / regression models. We have no reason to believe at this stage that these will require adjustments but would obviously review this once any model is available.

8.2 External assurance

Atkins were appointed to provide external assurance on Yorkshire Water's PR24 DWI submission with their overall approach to assurance based around 2 stage audits looking at methodology and data. The DWI submission was signed off by Atkins prior to it being submitted at the end of March 2023.

For more information on Assurance please see section 7.4 in Introduction to Enhancement Cases.

8.3 Customer Protection

For information on the methodology we have used and the central assumptions we have applied for our Price Control Deliverables (PCDs) please see section 8.2 in Introduction to Enhancement Cases.

We reviewed Ofwat guidance in 23/05 and found this enhancement case meets the materiality threshold for PCDW13 Improvements to taste, odour and colour and PCDW14 Addressing raw water quality deterioration.

Our proposed AMP8 programme for lead pipe replacement does not meet the materiality threshold for PCDW15 Lead communications/supply pipe replacements and other programmes. Similarly our investigations for not meet the threshold for PCDW8.

We highlight there is no third-party funding under this enhancement case.

8.3.1 Price Control Deliverable – taste / colour / odour

We set out our PCD parameters and payment rate in the following tables.

Table 8.5: PCD Parameters – Taste / Colour / Odour

PCD Delivery Expectation	
Description	Improving the taste, colour and odour of water supplies by removing turbidity and metabolites from source water and the network. The company will: • undertake trunk main conditioning across 16 water supply zones (WSZ) to prevent the disturbance of iron and manganese sediment that discolours water. • reduce to acceptable levels, the noticeable taste and odour compounds, resulting from naturally occurring algal blooms in the raw water at Ingbirchworth water treatment works (WTW).
Output measurement and reporting	Number of WSZs with trunk mains conditioning completed in line with the DWI obligation, reported to zero decimal places. Achieve compliance at Ingbirchworth WTW for taste and odour consistent with the company's DWI notice, reported annually on extent of milestones completed. The company will report in parallel with the APR.
Assurance	The company must commission an independent, third-party assurer, with a duty of care to Ofwat, to assure, to our satisfaction, that the conditions below have been met and the outputs of the scheme set out below have been delivered.
Conditions on Scheme	None

We are currently working with DWI to confirm our regulatory deadlines by the end of February 2024[16]. We propose an indicative delivery profile for each deliverable to demonstrate how the PCD would operate.

For our trunk mains conditioning activities, we propose to adopt the same approach as AMP7. We will undertake the work programme in two batches that include monitoring and optimisation to reach completion.

8.3.1.1 Forecast deliverables

Table 8.6: Forecast Deliverables – Taste / Colour / Odour

Deliverable	Unit	Forecast Deliverables				
		2025/26	2026/27	2027/28	2028/29	2029/30
Water Supply Zones conditioned	Number (cumul)	0	0	8	8	16
Ingbirchworth algae removed	Scheme milestone		Confirmation of preferred solution	Detailed Design		Beneficial completion

[16] www.dwi.gov.uk/water-companies/price-review-process/

8.3.1.2 Proposed PCD payment rate

We proposed an average unit cost for our trunk mains conditioning as the work programme is equivalent across all DMAs. The PCD payment will be calculated on the different between forecast WRZs and actual WRZs completed at the end 2029/30.

We propose PCD payments for uncompleted deliverables for the Ingbirchworth Taste and Odour scheme. E.g. if proportion of funding to be returned if subsequent investigation reveals that it is not necessary to deliver the scheme.

Table 8.7 below shows funding to be returned should the scheme not progress to the next deliverable.

8.3.1.3 PCD payment rate

Table 8.7: PCD Payment Rate – Taste / Colour / Odour

Deliverable	Unit payment (£m)
£m per WSZ trunk mains conditioned	= 9.37 ÷ 16 = 0.586
£m for up to Ingbirchworth confirm preferred solution	= 23.07 x 90% = 20.763
£m for up to Ingbirchworth detailed design	= 23.07 x 80% = 18.46

8.3.2 Price Control Deliverable – raw water quality deterioration

We set out our PCD parameters and payment rate in the following tables.

Table 8.8: PCD Parameters – Raw Water Quality Deterioration

PCD Delivery Expectation	
Description	Safeguarding against raw water deterioration to ensure compliance with DWI regulations. The company will adopt a range of solutions across four sites for Cryptosporidium, coliform bacteria, nitrates and pollutants requiring disinfection, ranging from nitrate removal, raw water blending, new boreholes and enhanced disinfection. The three sites require solutions For more information, please see the WHO guidelines: on nitrates and the DWI guidelines on Cryptosporidium and disinfection.
Output measurement and reporting	The company will report on interim milestones and the completion of its process and equipment upgrades at 3 key sites: • Haisthorpe WTW: nitrate removal plant to mitigate for increased nitrates in groundwater. • East Ness WTW: new borehole and enhancement to distribution. • Highfield/Austerfield Lane borehole water – blending to mitigate increased groundwater nitrate and enhanced disinfection scheme The company will report in parallel with its APR.
Assurance	The company must commission an independent, third-party assurer, with a duty of care to Ofwat, to assure, to our satisfaction, that the conditions below have been met and the outputs of the scheme set out below have been delivered.
Conditions on Scheme	None

We propose a delivery profile for each deliverable that is consistent with our obligations under our DWI notices and out trunk mains conditioning schedule.

Compliance dates have not yet been agreed with the DWI. As a result, all milestones are indicative and subject to change, depending on to the determined legal instrument compliance dates. We will confirm these prior to Draft Determination.

8.3.2.1 Forecast deliverables

Table 8.9: Forecast Deliverables – Raw Water Quality Deterioration

Deliverable	Nutrient of concern	Preferred solution agreed	Detailed design	Date of delivery
Highfield/Austerfield Lane borehole water	Nitrates and microbiological	2026/27	2027/28	2029/30
Haisthorpe WTW	Nitrates	2026/27	2027/28	2029/30
East Ness WTW	Microbiological	2026/27	2027/28	2029/30

8.3.2.2 Proposed PCD payment rate

We propose PCD payments for unmet milestones. For clarity we have excluded our investigation costs as these are immaterial and relate to PCDW8.

8.3.2.3 PCD payment rate

Table 8.10: PCD Payment Rate – Raw Water Quality Deterioration

Deliverable	Unit payment (£)
£m for up to confirm preferred solution	= scheme cost x 90%
£m for up to detailed design	= scheme cost x 80%

Where scheme costs are:

Table 8.11: Scheme Costs – Raw Water Quality Deterioration

Scheme name	Totex Cost (£m)
East Ness WTW - New Borehole Arrangement & Distribution Pumping	9.90
Haisthorpe WTW Option 4 - Nitrate Removal Plant High Sources	8.05
Highfield/Austerfield Lane (Doncaster Boreholes) - Disinfection Scheme and Littleworth Refurbishment	22.86

8.3.3 Annualised Outcome Delivery Incentives

There are three common performance commitments that are robustly quantifiable for this enhancement case. We have only included the forecast performance from enhancement totex to calculate the ODI impact for this case.

We have estimated the benefit across AMP8 because, as stated previously, we do not yet have a confirmed regulatory schedule for delivery.

Only CRI benefit at East Ness WTW and Ingbirchworth WTW has been included in the benefits for AMP8, due to the fact that issues at both sites have already manifested in failures and hence, contribute to our current CRI performance.

Issues at both Haisthorpe and Highfield Lane are forecast to contribute to CRI performance from AMP9. As such, the CRI benefit from these schemes is not included in the table below, due to the fact it is offsetting future CRI increase, rather than actively improving the current score.

8.3.3.1 Forecast benefits

We note that the increasing numbers reflect reductions in performance commitments towards the target of zero.

Table 8.12: PC Benefits

PC	Unit	Forecast Benefits				
		2025/26	2026/27	2027/28	2028/29	2029/30
CRI	Score	0.07	0.14	0.2	0.28	0.35
Customer contacts	Number	0.02	0.04	0.06	0.08	0.1
Unplanned outage	%	0.05	0.10	0.15	0.20	0.25

8.3.3.2 ODI exposure

Table 8.13: ODI Exposure

PC	ODI rate (£m per unit)	Total ODI exposure (£m)
CRI	£1.39	£1.46m
Customer contacts	£13.93	£4.18m
Unplanned outage	£1.97	£1.48m

8.3.4 Annualised time delivery incentive

We consider a time delivery incentive is not appropriate. Our enhancement case for taste / colour / odour is only marginally material. Our trunk mains conditioning programme is a lengthy programme of work for each water supply zone to optimise the operation.

We also consider the ODI exposure for our raw water quality deterioration enhancement is greater than 3.5% of the associated enhancement totex. Therefore we do not require a delay incentive for our three sites scheduled for upgrade.

We note that we work closely with DWI throughout the solution development and implementation in order to meet its notices.

8.3.5 Third Party Funding or Delivery Arrangements

This is not applicable for this case as no third party funding or DPC is proposed.

Annexes

A. Long-Term Statement on Drinking Water Quality

Long-term Statement on Drinking Water Quality

Yorkshire Water

January 2023

YorkshireWater

Executive Summary

This long-term statement on drinking water Quality has been produced as part of our PR24 programme. It sets out how we monitor and respond to existing and future risks in respect of drinking water quality. It provides the long-term context to support the submission to the Drinking Water Inspectorate of a programme of work to protect and enhance drinking water quality for AMP8 (2025-2030).

Our customers rank the provision of clean and safe drinking water as their highest priority. Our fundamental approaches to delivering this outcome are a risk-based understanding of existing and emergent risks and our hierarchy of intervention. Our approach to Drinking Water Safety Planning (DWSP) is well established and is critical to the identification of specific hazards and risks that we consider have the potential to result in deterioration of drinking water quality or acceptability over the short, medium, and long-term. Our hierarchy of intervention focusses on reducing risks at source – we are strongly committed to catchment management, as the water catchments are our primary treatment system. We are developing strong and active partnerships with land users; rivers trusts and regulators which will protect our catchments for the future.

Where catchment solutions are unsuitable, uncertain or are unlikely to fully mitigate raw water quality risks, we develop treatment interventions. Under the Water Quality programme for AMP8, we propose 5 treatment schemes to address risks associated with taste and odour, raw water colour, pesticides, nitrates and microbial parameters.

Our network and storage assets make a critical contribution to delivering a clean wholesome supply of water to our customers. Managing the health of our network assets is critical and in the AMP8 period, we propose interventions to manage the risk of discolouration and exposure to lead.

In AMP8, we also propose a regional investigation to better understand taste and odour risk as a result of the presence of algae in reservoirs. This investigation will cover six sites to understand the likely risks and options for mitigation.

We have further developed our approach to understanding the resilience of our Water Supply Systems and have considered our plans for protecting and enhancing drinking water quality in the context of our Water Resource Management Plan (WRMP) for PR24. There is close alignment between our plans to protect and enhance drinking water quality and the Water Industry National Environment Programme (WINEP). Our proposed WINEP24 programme sets out

several actions in upland, lowland and groundwater catchments to prevent raw water deterioration and drive improvements in drinking water quality.

We have described at a high level our approach to meeting the requirements of the Security and Emergency Measures Direction and Network and Information Security Directive. Further details of these components will be provided in a separate submission in April 2023.

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1.0 Introduction

This long-term Statement on Drinking Water Quality has been produced as part of our PR24 programme. It sets out how we monitor and respond to existing and future risks in respect of drinking water quality. It provides the long-term context to support the submission to the Drinking Water Inspectorate (DWI) of a programme of work to protect and enhance drinking water quality for AMP8 (2025-2030). Our customers rank the provision of clean and safe drinking water as their highest priority[1], and we recognise that we need to ensure that our services are resilient to shocks and stresses now and in the future.

In May 2018, we published a similar long-term statement on drinking water quality to support our AMP7 (2020-2025) plans. This updated document builds on our previous one, with many of our core processes and principles remaining. Our fundamental approaches to a risk-based understanding of existing and emergent risks and our hierarchy of intervention, which prioritises catchment-based interventions ahead of treatment solutions, has not changed. We are strongly committed to catchment management as this is our primary treatment system, and managing catchments proactively provides efficient cost-effective improvements to raw water quality. We are developing strong and active partnerships with land users; rivers trusts and regulators which will protect our catchments for the future.

We have further developed our approach to understanding the resilience of our Water Supply Systems and have considered our plans for protecting and enhancing drinking water quality in the context of our Water Resource Management Plan (WRMP) for PR24.

We continue to optimise and enhance our treatment capabilities and distribution system to ensure we provide a safe and resilient service, through to the customers tap.

[1] PR24 Valuing Water Research, Yorkshire Water, 2022.

2.0 Developing a long-term strategy for drinking water quality

2.1 Alignment with Yorkshire Water's corporate strategy

Our purpose is 'we're proud to play water's role in making Yorkshire a brilliant place to be - now and always'. We provide some of life's most essential services to the people and businesses of the Yorkshire and Humberside region, playing a key role in the region's health, wellbeing, and prosperity. We do this by supplying water and wastewater services and being custodians of essential infrastructure and the natural environment.

Water is one of life's essentials and we understand the importance of taking care of it in the right way for everyone, all the time. How we do this really matters: our services rely on the natural resources we take from and return to the environment; therefore, we need to protect and enhance Yorkshire's environment. How we transport and recycle water that has been used by our customers, the way we look after our land, our broader support to local communities and the partnerships we develop, will make a difference to Yorkshire.

Customers continue to prioritise high quality, uninterrupted services, meaning that service resilience is a priority. We need to plan carefully to ensure that we can not only deliver resilient services today, but that we can continue to do this in the future, despite the increasing pressures from climate change, population growth and increasing pressures on the environment. Our services impact and are impacted by environmental and community resilience and we look to enhance these in how we deliver our services.

As a result of the fast-changing external landscape, and increasing stakeholder expectations, we continue to evolve our long-term strategy. Over the last year there have been several significant changes in some of the external factors that impact on our organisation, our customers, stakeholder and partners. The impact of these changes is acutely felt by customers and communities in respect of the cost-of-living crisis and by businesses in increasing costs to deliver services. Increasing political, regulatory and stakeholder expectations, particularly in respect of the environment have been seen through amendments to the Environment Act, resulting in stretching targets for the water industry.

Our strategic response is to continue to develop our plans to do more to benefit the environment, including our ambitious net zero operational carbon plans, commitment to monitor and provide transparent data on the operational of all our storm overflows and our plans to improve Yorkshire's rivers and coasts. This is underpinned by prioritising high quality uninterrupted services.

2.2 Customer's views – PR24 Valuing Water Research

We engage with our customers on an on-going basis, but at regular intervals we carry out specific research to inform our future plans. In October 2022, we completed a research programme called 'Valuing Water' to inform our PR24 plans. This research provides a comprehensive assessment of the views of Yorkshire Water's customers and stakeholders. It identifies the main priorities that they'd like to see the company focus on, alongside detailed explanation of why these things matter, and why others aspects are considered to be of less importance.

The research highlights that customers consider that the highest priority for YW remains 'providing a continuous supply of water that is safe to drink'. Most households focus on short-term challenges which have an immediate impact on them, with the cost-of-living crisis at the forefront of many minds and an expectation that this will get worse over the next 12 months. This appears to be having a big influence on priorities with 'keeping bills affordable for all' being second in the ranked list. Although the majority of customers currently feel their water bills are reasonable, a third worry about not being able to pay their water bill.

There is an underlying concern amongst customers about water becoming scarcer and the impact we all have on the planet. However, there is also a high degree of complacency with a majority admitting that they take water and sewerage services for granted. This highlights the challenges in getting customers to first recognise and then change their behaviours when it comes to water usage.

We develop our future plans for water knowing that provision of a continuous supply of water that is safe to drink is the highest priority for our customers.

2.3 What we considered in the development of our long-term plans

We have considered what is required to enable us to provide drinking water services into the future, from both a water resource perspective, through our PR24 WRMP and from a water quality perspective. Our approach to protecting water quality in the long-term is focussed on a risk-based approach and the strengthening of risk barriers in a holistic long-term plan. By risk barriers, we mean the safety measures or controls that are in place to prevent unwanted events from taking place and to protect against their consequences.

This starts within the water catchments with the protection and enhancement of water quality – articulated as our 'catchment first' approach. Risk barriers in water treatment range from process design, process control and visibility to remote access and auto-shut down of our treatment plants. This continues in the network with, for example, monitoring, operational controls and the application of Water Regulations. Additional risk barriers are provided across the process in the form of inspection, maintenance, monitoring, policies and procedures, training and accreditation, drinking water safety planning, incident management, Network and Information Systems (NIS) and Security and Emergency Measures Direction (SEMD). This approach is shown diagrammatically in Figure 2.1.

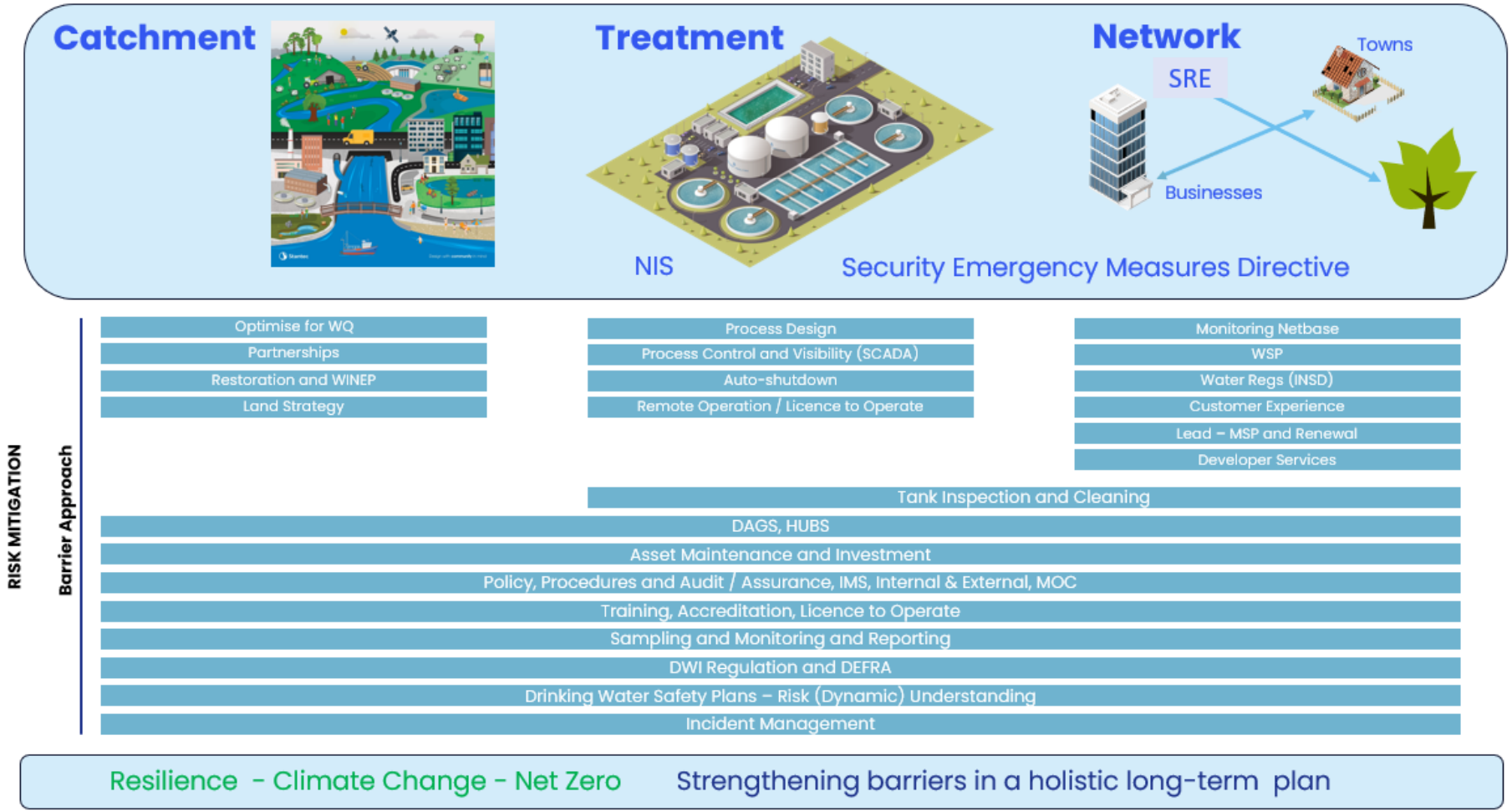


Figure 2.1 Risk barriers to protect water quality

2.3.1 Drinking Water Safety Plans

The link of our future strategy for drinking water quality to the Drinking Water Safety Planning (DWSP) approach for managing risks to water quality and sufficiency is well established and has been used to develop our Asset Management Plan (AMP) specific programme in AMP7 and for AMP8, along with the early identification of requirements for AMP 9 and 10. This approach results in the detection of specific hazards and risks that we consider have the potential to result in deterioration of drinking water quality or acceptability over the short, medium or long-term. Our DWSP approach is a holistic and consistent approach to the assessment of hazards to water quality from catchment to tap. Figure 2.2 Shows the number of risks recorded in our Drinking Water Safety Plans and their point of impact from catchment to tap.

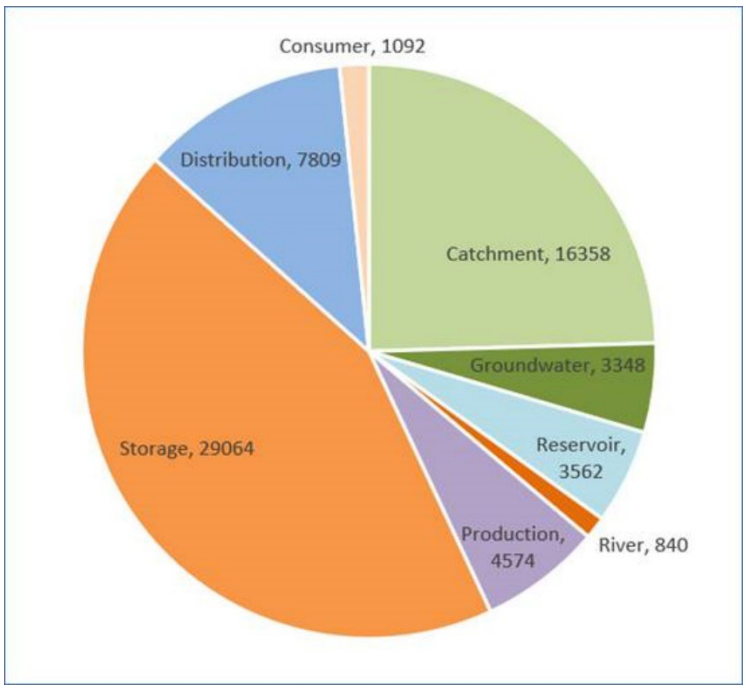


Figure 2.2: Total Drinking Water Safety Plan Risks

2.3.2 Risk Assessment Process

In preparing this long-term statement and our proposals for PR24 (AMP8), a review of water quality risks has been undertaken utilising data from various sources. Our DWSPs are a key component, but other data and information is considered:

- Drinking Water Safety Plans (DWSPs)
- Compliance Risk Index trends in water quality sample detections
- Microbiology and coliform compliance
- Aesthetic (including discolouration) & metals sample and incident data
- Taste and Odour sample and incident data
- Lead monitoring programme data

- Notified Water Quality events
- Raw water data – identification of deteriorating trends such as colour in upland raw waters or increase in groundwater nitrates
- Managed operational restrictions – e.g. self-imposed reduction in Water Treatment Works through put or requirements for mixing that are implemented as mitigation to water quality parameter failure risk.
- Monitoring of emerging risks

These risks are assessed through the application of a risk score, then monitored, and reviewed against the barriers in place to protect public health and customer acceptability. Understanding how effective the barriers are at mitigating existing and emerging risks supports decision making and plans for additional intervention that may be required. We use future risk trends to estimate when, if un-mitigated, raw water quality would be impacted, such that it would result in the reduction in treatment works through-put or in an unacceptable deterioration in treated water quality.

In preparation for PR24, these risks have been reviewed alongside system performance data and changing regulation, against a back-drop of climate change and overall water supply resilience. This includes - but is not exclusively - compliance and events, customer contacts, triggers, rising trends and emerging risks. System performance also considers security (cyber and physical) and information systems which support the overall protection of public health.

Particular attention is given to highest risk parameters and significant consideration is also given to parameters that may not have the highest direct public health impact, but which cause impact on the aesthetic quality of water supplied to customers.

To address raw water deterioration risks, catchment management remains our primary strategic approach and our first-choice intervention. By understanding the timescale to impact we can determine whether catchment management, additional treatment, or a combination of both, provide the most appropriate solution. This hierarchy of intervention is mirrored across our broader programme of interventions, with catchment and natured-based solutions offering multiple benefits in respect of reduced carbon, improved soil health, reduced flood risk, increased biodiversity and other natural and social capital benefits.

In line with our strategy outlined in AMP7, this ongoing review has identified risks which are considered to have significant potential impact on our customers and will require intervention during AMP8 and AMP9. The ongoing programme of base maintenance supports the management of risk and the maintenance of existing barriers and underpins the strategic plan.

2.3.3 Options Development

The risks requiring planned interventions are summarised in the table below. As stated previously these interventions seek to strengthen and improve the layers of protection which can be across several suitable barriers within the source to tap system but will focus on the catchment first where effective to do so.

Table 2.1 Summary of risks requiring intervention in AMPs 8 and 9

	Reservoir	River	Groundwater	Production	Storage	Distribution	Consumer
1	Colour / UV Light abs @254			Trihalomethanes	Trihalomethanes	Trihalomethanes	
2	Algae			Taste and Odour	Taste and Odour	Taste and Odour	
3			Total Coliforms	Total Coliforms	Total Coliforms		
4			E.Coli (faecal coliforms)	E.Coli (faecal coliforms)	E.Coli (faecal coliforms)		
5			Clostridia perfringens				
6			Nitrate				
7						Lead	Lead
8						Iron Total and discolouration	

Following the identification of areas of risk, options for mitigation were developed, taking consideration of:

- Time to impact – this influences both the timing and type of intervention. Evidence is required to show that mitigation is required in the next five-year period. The type of mitigation will be influenced by the time to impact, for example, YW can deploy its' 'catchment first' approach where time to impact is beyond five years. If time to impact is more immediate, a treatment-based intervention would be required.
- Connectivity with other programmes of work, planning frameworks and business plan components, such as the WRMP and WINEP.
- The speed of performance improvement or risk mitigation - for example, the removal of lead from the water supply network is a long-term approach, the speed at which lead removal is delivered is a choice which influences the costs associated with delivery.
- Solution type – may involve a catchment or treatment or combined solution. Technology choice for treatment solutions. Operational risk mitigation such as throughput reduction could be appropriate in certain situations.

In addition, new and emergent risks such as PFAS must be monitored and considered for appropriate intervention. Although these have not triggered the need for medium term intervention currently, they will continue to be monitored and responded to accordingly.

2.4 Alignment with Long-term Delivery Strategy (LTDS) and other Strategic Planning Frameworks

2.4.1 Long-term Delivery Strategy (LTDS)

The LTDS is an integral mandatory part of our PR24 submission and a new requirement for PR24. The expectations for adaptive pathways and a longer term view out to 2050 is designed to provide Ofwat with greater confidence that the PR24 submission is not just a five-year view, but founded on the long-term ambitions of Yorkshire Water, its customers and stakeholders.

The strategic planning frameworks (Water Resource Management Plan (WRMP), Drainage and Wastewater Management Plan (DWMP) and Water Industry National Environment Programme (WINEP)) will feed into the LTDS. The LTDS is primarily concerned with future enhancement investment and on that basis, the AMP8 and future DWI water quality submission components will be included. The future risks identified in DWI Appendix A for AMPs 8-10, will be included in the LTDS.

The LTDS will also consider resilience risks and interventions. We have further developed our approach to resilience that we described in our May 2018 Long-term Statement on Drinking Water Quality, through the approach we have labelled our 'Water Supply Systems Resilience strategy (WSSRS)'. A phased approach is being taken to understand resilience at a water supply systems level and across interacting water supply systems. This approach provides a series of options to reduce and mitigate risk. The outputs of these studies, in conjunction with DWSPs, asset deterioration assessment, risks related to climate change and population growth inform efficient strategies, with interventions identified at both a site and system level. These interventions could be components of our enhancement or base maintenance programmes or interventions driven by water availability and progressed through the WRMP.

The WSSRS has identified the following resilience interventions:

- 40+ resilience options in 8 Water Supply Zones to be considered for investment over the next 25 years, c£450m.
- The solutions to these options have been prioritised for AMP8 risk review (c£130m) and will be considered through the PR24 process and incorporated as appropriate into our adaptive planning pathways.
- An additional 10+ solutions identified from the WSSRS process have been included in the WRMP optimisation process.

2.4.2 Water Resource Management Plan (WRMP)

Our Water Resources Management Plan 2024 (WRMP24) builds on our previous plan (WRMP19) and incorporates new information and the latest methodologies. It shows that the risk of climate change reducing water availability, which was driving a deficit in our WRMP19, still poses a significant threat to our security of supply if we do not act.

Additional and significant risks have been identified in our WRMP24 and have reshaped our future water resource position. These risks include a need for our neighbouring company, Severn Trent Water, to cease an existing transfer of raw water it provides to our South Yorkshire area. The transfer is planned to cease by 2035 and we shall invest in an alternative supply so that the loss of the transfer does not impact on our ability to meet our customers' needs.

Further risks include future licence reductions to protect the environment, an increase in peak demand during dry weather and localised housing growth "hot spots". We have also experienced extreme weather events in 2018 and 2022. Our WRMP24 is planning for a severe drought risk with a return period of 1 in 500 years. The Covid-19 pandemic in 2020 also led to unprecedented demands that tested our supply system.

Once all the emerging risks were incorporated into our forecasts for supply and demand over a 60-year planning period, our WRMP24 indicated, in extreme dry years there is a risk of a supply-demand deficit throughout the planning period (2025 to 2085). Our plan to address the risks is a twin track approach investing in demand reduction and new supplies.

Any new water supply will require an extensive drinking water quality risk assessment and interventions driven by drinking water quality will support the deployable output requirements within the WRMP (reducing the risk of water treatment works (WTW) through-put restrictions to mitigate water quality risks).

2.4.3 Water Industry National Environment Programme (WINEP)

The WINEP sets out actions that we will be required to take to meet environmental obligations. The requirements are set by Defra and implemented through guidance set by the Environment Agency (EA). We submitted our proposed WINEP programme to the EA in two phases, in November 2022 and January 2023. Some of the interventions within our WINEP24 plan have a primary focus on the protection and enhancement of raw water quality. These interventions are summarised below:

- Upland Drinking Water Protected areas – 30 restoration actions, benefiting 19 WTWs
- Lowland Drinking Water Protected areas – 6 no deterioration actions, benefitting 6 WTWs
- 1 investigation action assessing the benefits of weather station data on providing early warning / guidance on the application of agro-chemicals
- 26 actions under Water Framework Groundwater drivers benefitting 8 WTWs.

The interventions proposed through the water quality programme and the strategic planning frameworks represent only part of our overall plan for water quality in AMP8. Base maintenance activity and work on resilience will target other areas of performance such as Water Treatment Works coliforms and throughput, asset replacement and refurbishment.

3.0 Yorkshire Water 's Water Supply System

We have a highly connected network that can transfer water around our supply area. Approximately 45% of the water that we supply is from impounding reservoirs, 33% from rivers and 22% from groundwater abstractions. This varies year on year depending on weather conditions. The west and south of the region is largely upland source (Pennines) and the southern and eastern parts of the region are predominantly low lying and river and groundwater fed. Topography and climatic conditions are a major influence on the existing and emerging water quality risks within catchments.

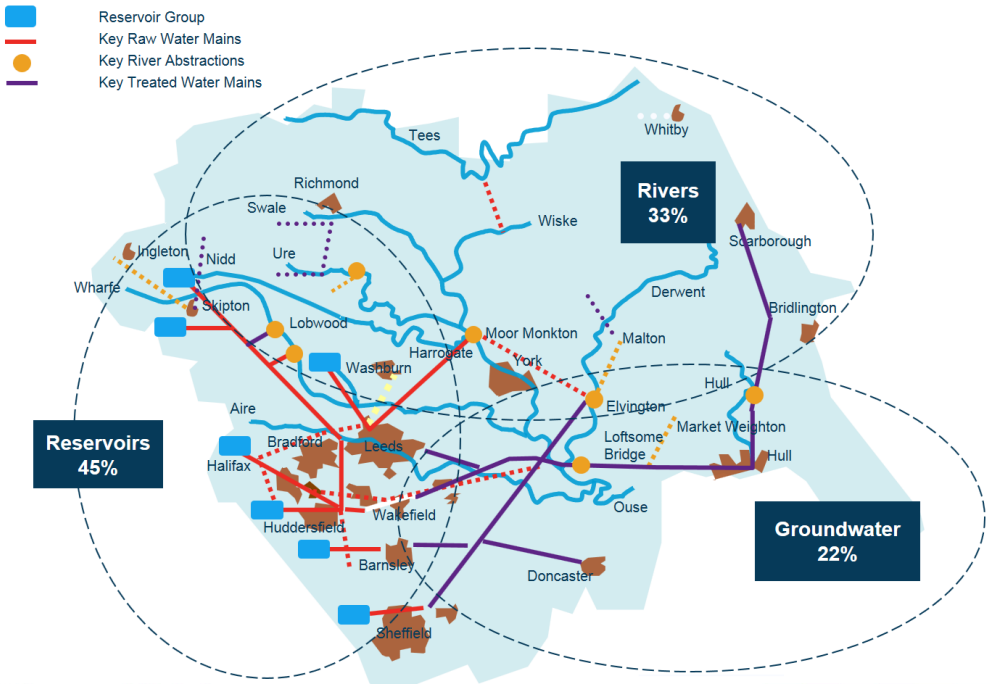


Figure 3.1: Water Resources in the Yorkshire region

Our treated water grid system enables highly effective conjunctive use of different water resources, which mitigates risk and allows optimal planning, optimal source operation, and resilient sources of supply both in drought and during floods.

In the following section of this document, we identify the challenges we face across all our catchments. The risks are diverse and vary according to raw water source type and location.

4.0 Catchment Management

4.1 Catchment Management Programme

The quality of the raw water we collect has been deteriorating in many of our catchments over the past two decades. This is a consequence of pollution, unsustainable land management practices and climate change. Climate change presents several risks to our ability to deliver clean, and safe drinking water.

While we invest in enhanced water treatment works capabilities to ensure our customers always receive the highest quality drinking water, our strategic approach is to address issues at the source – to take a 'catchment first' approach.

Our catchment management programme includes managing our 25,000 hectares of natural habitats to protect Yorkshire's raw water and biodiversity. In our region, many of the key catchments contain upland peat which must be in a good natural state to provide clean water to our reservoirs, rivers and water treatment works. Our catchment programme tackles a range of water quality issues, such as colour, pesticides, nitrates and saline intrusion.

The objectives for our catchment management programme are to deliver positive and sustained outcomes for the water environment, tackle risks to water quality and availability, and to encourage local collaboration and more transparent decision-making when both planning and delivering activities to improve the water environment.

Our catchment management programme covers a range of water quality parameters including colour, pesticides, nitrates, nutrient loading, and microbial challenge. We are focusing our future moorland restoration activity on catchments where colour pollution is likely to overwhelm WTW capacity in the longer term. Our programme covers both implementation and investigations. Our activities will be delivered in partnership with a range of NGO's, charities, landowners, regulatory agencies, and other stakeholders where this is mutually beneficial.

The key risks in our catchments are from land management practices causing pollution of the water we abstract from the environment for treatment and supply and climate change. Our catchment management programme is a complex area with multiple factors affecting land and how it is managed and often requires partnerships for successful outcomes to be achieved.

4.1.1 Beyond Nature

Beyond Nature is a Yorkshire Water land strategy initiative focused on supporting farmers who look after catchment land and helping them get the most out of it, whilst managing the landscape for positive water outcomes. Since 2016, we have been working with our tenant farmers to get them involved in the Beyond Nature initiative. We currently have 5,000 hectares of land signed up across 9 farms. We have made a long-term commitment to bring all our 22,000 hectares of farmland into Beyond Nature management. This is part of

our aim to protect the Yorkshire landscape for future generations, play a key role in tackling climate change and support sustainable farming.

This approach is evidence led and we are able to demonstrate how this approach supports multiple regional priorities. Figure 4.1 shows the areas in which benefits are delivered, notably water quality and flood risk. This strategic approach seeks to embed our six capitals approach (*https://www.yorkshirewater.com/about-us/capitals).* This approach enables our plans to be articulated to others and has been successful in bringing together external stakeholders into the delivery or maintenance of measures.

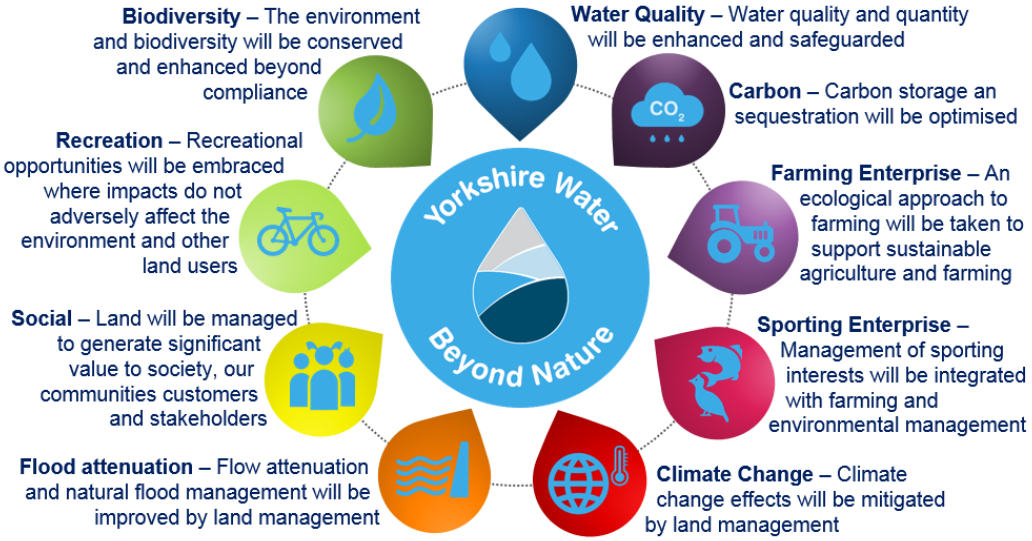


Figure 4.1 Beyond Nature approach – themes

4.2 Upland Catchment Risks

For upland impounding reservoirs key risks include colour and manganese, and *Cryptosporidium* due to land use activities. The increase in cultivated marginal land poses an increased risk of pesticides and nutrient usage and subsequent impact on run-off. There has been a rise in algal blooms at key sites leading to taste & odour causing compounds, and increased pressure on the downstream treatment processes. Therefore, this is an area of risk which needs intervention in AMP8.

There is an ongoing programme of catchment restoration and intervention work through AMP7 and planned for AMP8. The work is tailored to address specific hazards but also provides additional benefits for the management of climate adaptation and carbon sequestration. This activity is shown in Figures 4.2 and 4.3 respectively.

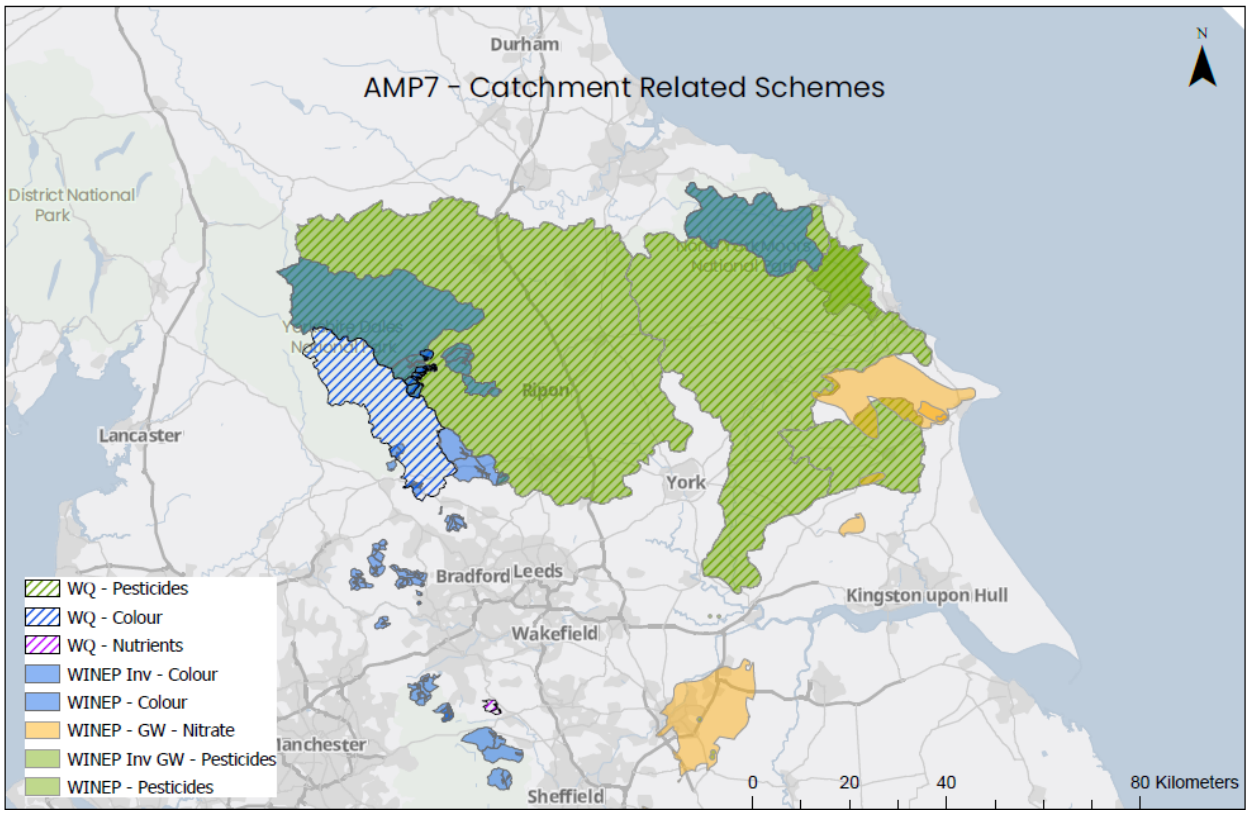


Figure 4.2 Regional Map showing AMP7 catchment related activity

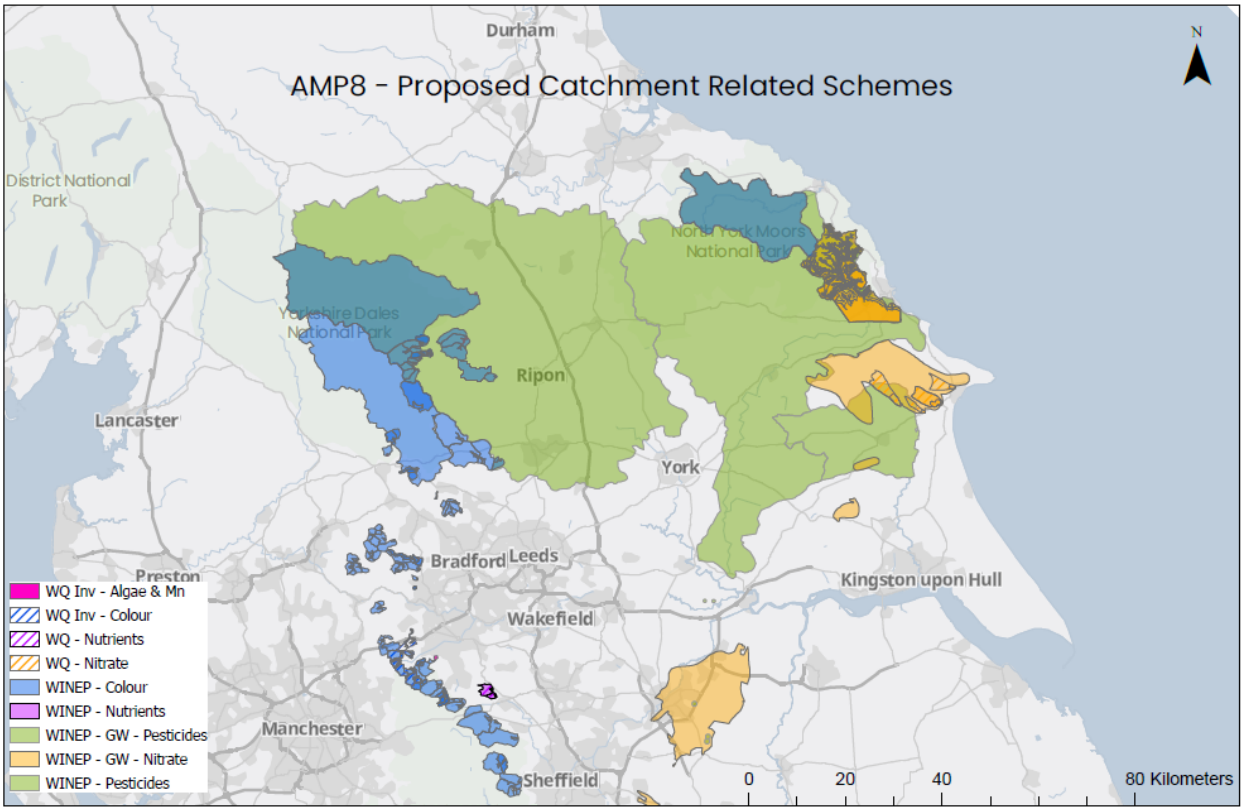


Figure 4.3 Regional Map showing AMP8 proposed catchment related activity

Figure 4.3 shows the plans for AMP8 and highlights the overlap between water quality and WINEP programmes, showing a considerable area of the region undergoing catchment improvements. The map also signposts the work being undertaken to investigate nutrient impact and algal blooms which is a risk we need to start targeting in AMP8.

Adopting a 'catchment first' approach means the continual monitoring of water quality in catchments and sub-catchments. Where the WTW remains capable of treating the incoming raw water quality this will continue. Where there is evidence of risk to performance or significant WTW through-put reductions due to incoming raw water quality, work is planned at these sites to mitigate the risk. The interventions can be both catchment based or treatment based. The preferred intervention type is catchment activity, but where this is unlikely to mitigate the risk, a treatment intervention will be required. For sites impacted by colour, in most cases treatment solutions will run in tandem with ongoing work in the catchment.

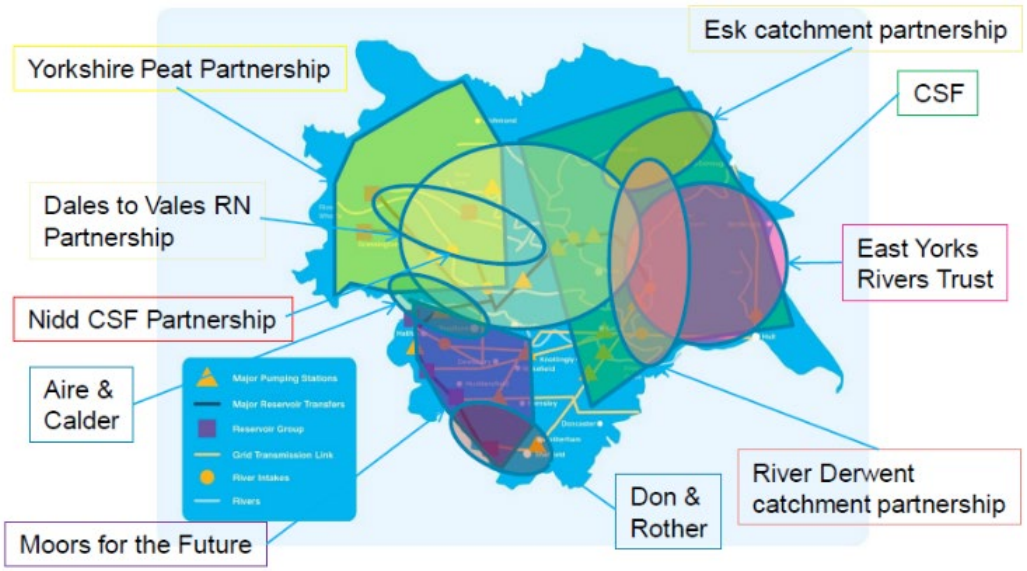
The current sites where catchment restoration will take place in AMP8 are listed in appendix A. The proposed sites that will require treatment upgrades to address raw water deterioration for colour, to minimise disinfection by-products (DBP's), are covered in section 5.0.

During AMP6 and AMP7, we have seen increased algal blooms and subsequent impact on impounding reservoir performance both for taste and odour forming compounds, and manganese due to changes in the reservoir ecosystem. During AMP7 we have collaborated in research with Universities of Cardiff, Bath and UKCEH and with other water companies in the UK and abroad. We have used genomic techniques to better understand algal communities in reservoirs and the environmental triggers for taste and odour events. Applying the methods and learning from this research we have plans to investigate 5 further reservoirs in Yorkshire in AMP8, to understand the presence of risk factors, with a view to manging reservoirs and catchments differently. Where a catchment first approach is not deemed to be effective enough at controlling the algae related risk, then an end-of-pipe solutions will be planned.

4.3 River and Lowland Abstraction Risks

River catchments are highly influenced by agricultural activity and are therefore at risk from multiple sources. Increased sediment into the watercourses has associated risks such as nutrient loses, bacteria, *Cryptosporidium* and pesticides. Therefore, catchment management to reduce sediment loading on a river system can have multiple benefits, as well as improving the sustainability of land for agriculture.

Significant ongoing partnership activity supports the raw water quality in our lowland catchments, this is described further in 4.3.1. Figure 4.4 demonstrates the diversity of projects started during AMP6 and AMP7 and the associated partnerships, which have developed significantly.



CSF – Catchment Sensitive Farming

Figure 4.4 Regional Map showing diverse partnerships to target risks to Water Quality

Risks relating to metaldehyde have been managed through a programme of interventions within an undertaking in AMP7, covering river abstractions with a combined catchment area of around 5,000km^2. Monitoring for this pesticide became well established in 2009 and the number of exceedances of the pesticide standard across the region since then are shown in the Table 4.1.

Table 4.1 Number of metaldehyde failures by year since 2009.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total	18	1	6	33	2	15	9	8	11	0	0	0	0	0

In relation to Metaldehyde, significant progress has been made to achieve compliance with the pesticide standard during AMP7. The approach in the upper River Derwent catchment was readily adopted by farmers and continued until the withdrawal of the pesticide in 2022 where the group now focuses on improving soil health and farming in line with best practice.

However, the activities associated with the reduction of metaldehyde risk are generally protective of risks from other pesticides and nutrients. Following the metaldehyde ban, the solutions adopted have evolved to see greater multiple water quality and environmental benefits. The long-term investment in raw water quality requires these catchment-based activities to continue in support of a general pesticide risk and nutrient reduction in raw waters. This is part of the catchment first principle and will contribute to reducing the requirements for additional treatment in the future.

4.3.1 Sustainable Landscapes

Sustainable Landscapes was launched during 2017 in collaboration with Future Food Solutions and has developed a partnership between the Yorkshire Water and farmers by:

- Practically demonstrating the close connection between soil health and water quality.
- Introducing farmers to a range of regenerative agriculture practices that boost sustainability and resilience.
- Measuring the impact of each change in farm practice on soil and water, quantifying success.
- Building a knowledge sharing and information exchange network to support and refine farming practices.
- De-risking the implementation of innovative practices, allowing farmers to develop confidence and capability.
- Culturally shifting the working relationship between farmers and Yorkshire Water.

The movement of nitrates, phosphates, chemical residues and soil particles from farm, through the catchment, represents a significant loss for agriculture and a major challenge for water quality. Implementing farming practices that hold these materials in the field, where they do good, rather than let them move into water, where they do harm, delivers benefits for all stakeholders. However, focusing farming activities on improving soil health in order to enhance water quality is clearly delivering multiple additional agronomic, economic and environmental benefits.

One of the primary practices, cover cropping, involves growing a specific mix of fast-growing plants in the time between harvesting one crop and planting another, in what would ordinarily be bare, unproductive stubble. This happens at a time when soils are most vulnerable to nutrient loss and erosion. The aim is to use the cover crop to slow the flow of water through the soil, which in turn reduces nutrient leaching and erosion. The cover crop is also designed to improve biodiversity, boost crop performance, and reduce farm reliance on synthetic inputs.

When we first commenced the Sustainable Landscapes program less than 6 farmers had experimented with cover crops. In 2022, all of the 80 farmers had them on their farm. The farmers currently taking part in the four Sustainable Landscapes programmes, are responsible for managing close to 36,000 hectares of agricultural land in sensitive catchments. Arable crop production in Yorkshire extends to approximately 460,000 hectares. Of this, 8% is currently influenced by land managers who actively participate in the Sustainable Landscapes programme and who now see Yorkshire Water as a valued partner. Our long-term aim is to extend this programme across all of the sensitive catchment land in the region.

4.4 Groundwater Abstraction Risks

The key risks for our groundwater abstractions are nitrate, pesticides, turbidity, bacteria, and C*ryptosporidium*. During our WINEP programme in AMP6 we established agricultural activity as the main cause of high nitrate in groundwater. Pesticides are being investigated in AMP7 along with the delivery of additional nitrate risk identification and mitigation. This work is further demonstrating that agriculture, appears to be the main source of these pollutants and on a significant proportion of catchment land, catchment management is now in place, to address these risks.

Through surveying and monitoring we continuously assess water quality risk from groundwater abstractions. This feeds into our strategic planning for maintenance and renewal of assets. Where necessary we plan for construction of new assets to replace those that are damaged or asset life expired. Monitoring and surveying are a critical part of our Drinking Water Safety Plan process that give us a long-term view of changes in asset condition and raw water quality.

Turbidity is an increasing concern in boreholes in the Sherwood Sandstone aquifer, options for managing this risk will include passive treatment and borehole replacement. We expect to take these options further in AMP8. Also planned for AMP8 are replacement of defective boreholes and in some cases additional treatment. There will also be a continuation, expansion and development of catchment management and increased catchment instrumentation to monitor and manage the effects of changes in land use that result from our engagement with farmers.

Through the ongoing monitoring programme, there has been groundwater detections for PFAS but these are currently below levels of concern. As this is an emerging risk and area of concern monitoring will continue in collaboration with the Environment Agency, the Drinking Water Inspectorate, and other stakeholders.

At sites where groundwater quality has significantly deteriorated in the surrounding aquifer and this poses a challenge to the existing treatment process based on original design, interventions are planned to enhance the treatment processes to address the risks. This is covered in section 5.0.

4.5 Evolution of the catchment management principles and programme

To summarise, catchment management activities continue to evolve and now cover a wide range of risks to water quality including:

- Colour arising from peat degradation – our investment in peatland restoration has allowed our delivery partners to access significant (c£10m) additional funding through the government's Nature for Climate initiative.

- Nitrate – our work on cover crops and nitrogen efficiency takes a holistic and opportunistic approach, seeking to promote cultural and behavioural change in agriculture in a supportive way.

- Pesticides - through the sponsorship of cover crop seeds and the evaluation and promotion of the benefits of functional field margins, we are intending to use in-field acoustic frequency sensors. This will confirm the spatial and temporal presence of natural predators, such as parasitic wasps, reducing the need for some pesticides in the future.

- Nutrients – improved soil organic matter and precise application of fertilisers will reduce the amount of nutrients lost to the aquatic environment. Research project to investigate the impact of nutrients on algal growth and identify interventions to minimise this.

The key activities identified for AMP8 are:

- Expansion of Catchment Sensitive Farming (CSF) officers to cover the whole Yorkshire region rather than just priority areas.
- Expansion of the AMP7 colour monitoring for WINEP to include a weather station project for enhanced catchment monitoring.
- Full utilisation of a granular risk mapping and GIS tools to maximise impact of Catchment Officers and record hazards in the field.
- Provision of soil health advice to minimise use of chemical control products in general - we have sponsored the development of the 'Good Soils Guide'. This is a free resource which is currently being actively used in 43 countries around the world.
- Identifying further ways of driving best practice farming activities from the early adopters into the catchments – now working with supply chain and farmers covering c10% of the arable land in Yorkshire through four innovation groups.
- Integration with the supply chain for arable products to promote soil health and minimise erosion using cover crops, nitrogen management and investment in carbon sequestration.
- Sustainable links with catchment stakeholders such as the Rivers Trust, Yorkshire Wildlife Trust, multiple partners, and agronomists as shown in Figure 4.4.

The experience we have gained through the last 10-15 years of catchment activity to protect and enhance raw water quality will be applied broadly within our WINEP24 programme and

we plan to expand the scale of our catchment interventions to include catchment and nature-based interventions to manage nutrients, particularly phosphorous reductions, driven by the Water Framework Directive and the Environment Act.

5.0 Water Treatment

Water treatment risks includes risks inherent to the water treatment process but also the degree to which we assess trends in raw water quality impacting on future risk to compliance. Understanding raw water risks and the effective barriers that are in place to mitigate these, enables the assessment of water treatment works (WTWs) capability to deliver safe, compliant, and acceptable water now and in the future. The dynamic understanding of risk through performance monitoring and drinking water safety planning allows a forecast to be made of when catchment management actions should be triggered and when additional treatment will be required.

5.1 Adaptive planning and resilience

The importance of achieving safe and complaint water quality as a priority under all conditions underpins our approach to resilience. In section 2.4.1, we described our Water Supply Systems Resilience Strategy, which is a continuation of phase 1 of our system resilience work started in AMP6. For water treatment systems a phased approach is being taken to understand resilience at a water supply systems level and across interacting water supply systems. This approach provides a series of options to reduce and mitigate risk. The outputs of these studies, in conjunction with DWSPs, asset deterioration assessment, assessment of risks related to climate change and population growth inform future strategies, with interventions identified at both a site and system level. These interventions could be components of our enhancement or base maintenance programmes, or interventions driven by water availability and progressed through the WRMP.

Risks identified in Section 4.0, Catchment Management, highlighted key drivers and challenges to current treatment strategies and assets. This methodology forms the basis for developing the plan against forecast raw water quality changes and other critical inputs from now until AMP11. These predictions are uncertain as intervention activities such as catchment restoration and protection can have significant positive impacts – equally there are emerging risks which may deteriorate and so the treatment plan must be fully adaptive. End-of-pipe solutions are adopted as a second-choice option when evidence shows catchment, stakeholder and alternative options will not address the risks to customers within acceptable timescales.

5.2 Base Maintenance

The barrier approach to public health protection from source to tap relies on robust treatment works operation and maintenance. Asset performance data and condition are used to assess where treatment facilities will require capital activity to replace life-expired assets or asset shortfalls where service and water quality are at risk. The plan associated with performance shortfalls on existing assets relating to fitness for purpose and condition continues to be targeted through the base maintenance programme.

During AMP7 work has been identified to improve resilience across several treatment assets in relation to control systems. The scope of the project and the assets requiring intervention emerged from work undertaken as part of the wider resilience framework. The work was

planned for AMP7 but was catalysed by an incident at Graincliffe WTW and now falls under a new Legal Instrument due for completion by 2025.

Additional Legal Instruments have also been agreed with the Drinking Water Inspectorate in AMP7 to improve processes and performance associated with incidents for taste and odour at Chellow Heights WTW and manganese due to raw water conditions at Ingbirchworth.

Both projects directly connect to and support the need for further investigation and work associated with the management of raw water in reservoirs and specifically the impact of nutrient and algal blooms. This will benefit 6 sites in AMP8 and is described in section 4 under catchment projects. This work is a new and significant area of focus in AMP7 and will provide insight into reservoir performance and the interventions which can be deployed for the sustainable management of water quality.

5.3 End-of-Pipe Treatment Options

As acceptability of water to customers is a priority within the strategy, in addition to the reservoir projects to address algal blooms and taste and odour, the proposed plan will also include an end-of-pipe solution for Ingbirchworth WTW. This is to ensure the options implemented will fully mitigate the risk as the planned reservoir project and ongoing work at Ingbirchworth are investigatory and may have uncertain outcomes. Through an adaptive plan the solution options will be tailored to the optimum outcome for customers.

Several sites have been identified where catchment restoration and partnership working has not yet sufficiently reduced the risks to water quality from colour and dissolved organic carbon (DOC) to ensure compliance. This results in risks to public health from disinfection-by-products or significant reductions in plant throughput to manage the risk to compliance and public health. Current sites signposted through the methodology which will require treatment upgrades to address raw water deterioration for colour to minimise disinfection by-products (DBP's) over the coming AMPs are:

- Loxley WTW in AMP8
- Blackmoorfoot and Longwood WTWs likely to be in AMP9/10

For our sites treating groundwater, catchment activity is deployed to manage risks from pesticides, nitrate, emerging contaminants, and microbiological parameters. At sites where groundwater quality has significantly deteriorated in the surrounding aquifer (for microbiological parameters) and this poses a challenge to the existing treatment process, when considering the original design envelope, interventions are planned to enhance the treatment processes to address the risks. WTWs where the evidence shows this is the case in AMP8 are:

- East Ness
- Doncaster boreholes

Where activities undertaken to manage nitrate levels in the raw water are not reliably able to guarantee compliance at customers taps and trends are continuing to rise, treatment

systems will be designed to remove or significantly reduce the risk. Currently there are two areas in the region where treatment processes are being proposed and catchment activity will continue in tandem. These sites are in:

- Doncaster boreholes
- Haisthorpe boreholes

We recognise that the risks to water quality are constantly evolving, and that customer and regulatory expectations of our treatment processes increase over time. We have a strong record of investment in research into treatment technology, and this continues in support of our AMP8 plans and beyond.

Appendix 2 'Water quality programme decision and optioneering considerations' provides a summary of the rationale for the selection and consideration of schemes included in the DWI Appendix A submission (January 2023).

6.0 Water network, storage, and customers

6.1 Water Network risks and resilience

There are key water quality challenges to overcome in relation to our distribution network.

One of the main challenges faced is discoloured water caused by a build-up and release of material in the pipes. Acceptability of water to customers is a key priority and remains an important component of our plan, with year-on-year improvements having already been delivered for water quality customer contacts performance.

An area where we have identified a proportionally higher level of risk is associated with the storage of treated water in clean water tanks. There is a current Legal Instrument which has been entered into during AMP7 for all clean water tanks and associated assets, which are an intrinsic part of resilient network operation. The work covers all aspects of operations, inspection, and maintenance, as well as supporting our ongoing programme of asset refurbishment and replacement through the base maintenance programme. Data collected during delivery of the AMP7 activity, will further support understanding specific risks within the asset base to tailor our approach and identify where some strategic assets may require replacement in the 25-year plan.

The health risks associated with exposure to lead, which has no safe limit, and most usually results from the presence of lead pipes in some properties is a complex area. We are supportive of a long-term plan in respect of this risk and will provide a separate update on our lead strategy as requested by the DWI in March 2023. We are strongly in favour of the need for a long-term national strategy for lead, with clear policy positions set out by Government. We will continue to play our part in the development of a future approach to eradicating the risks associated with exposure to lead but are clear that this is a wider societal issue than cannot be effectively or efficiently tackled by the water industry working in isolation.

Our Water Supply System Resilience Strategy, described in section 2.4.1 considers resilience of our networks.

Our Network Strategy focuses on how we deliver the five key water network outcomes that our customers expect, in the short, medium, and longer term. These are:

- Water quality – our customers expect a clean wholesome supply of water, so passage through our water network should not have a detrimental effect on water quality.
- Asset reliability and health – customers expect us to maintain and where necessary renew our assets so that burst mains reduce over time, service reservoirs are fully serviceable, and our pumping stations are reliable and efficient.
- Interruptions to supply – customers expect a continuous supply of clean wholesome water.

- Leakage – from the start of AMP7 our aim has been to achieve a 50% reduction in leakage by 2050.
- Resilience – our approach to network resilience considers how to mitigate low probability, high impacting events that cause a significant risk to both interruptions to supply and water quality.

6.2 Trunk Mains

Trunk mains are strategic water transmission assets with high consequence of failure in terms of service and cost. Considerable activity has been carried out in AMP7, using the Prediction of Discolouration in Distribution Systems (PODDS) approach, to support the understanding of the part played by trunk mains in water quality impacts, specifically discolouration. Figure 6.1 summarises the PODDS approach. The AMP8 plan expands this activity to provide further support to the ongoing reduction in customer contacts and reduced risk of contacts following bursts and incidents.

Throughout AMP7 and beyond, where it is possible to do so, our approach to addressing discolouration risk in our large diameter mains will be to carry out trunk main conditioning, and where appropriate, automate this. We trialled this in AMP6, rolled it out on a much larger scale throughout AMP7 and will continue in AMP8 and beyond. It will give a benefit to stopping large scale 'one off' incidents, as well as reducing the amount of sediment transferred from our trunk main system into the DMAs. Once sediment enters a DMA, any changes in flow in the distribution mains could result in customer's being impacted by discolouration. Based on a risk-based approach to addressing discolouration using the PODDS principles, our AMP8 proposal is expected to benefit approximately 1.2 million of our customers, an increase from the circa 900,000 that will benefit in AMP7.

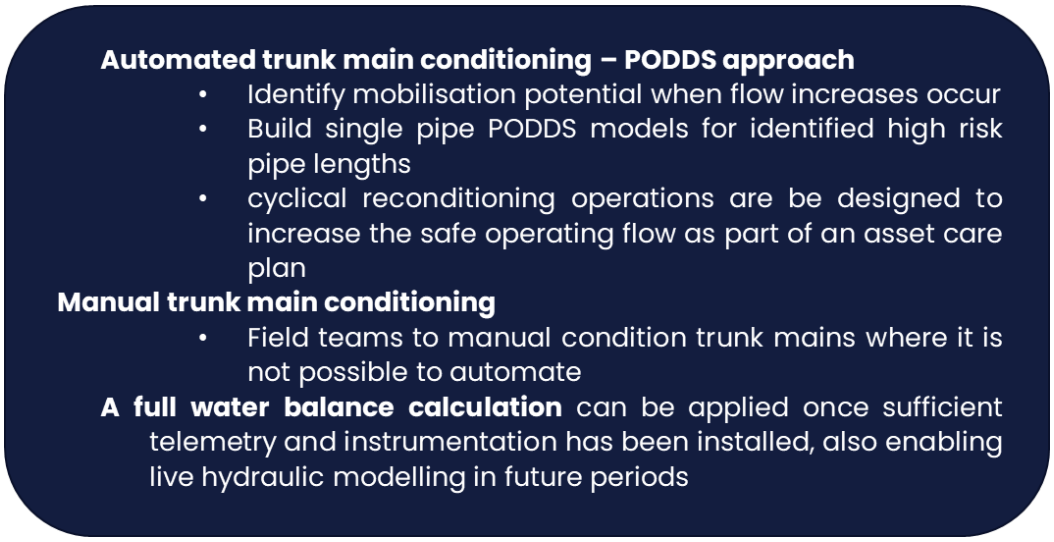


Figure 6.1 PODDS approach to trunk main conditioning

6.3 Distribution Network

The number of mains repairs is a key measure of the reliability of our water network and a principal measure of the overall health of the infrastructure asset base. Our mains repair frequency is constantly monitored to understand overall performance and inform our investment strategy. Any leak or burst on a water main (either distribution or trunk main) has the potential to impact multiple customers by causing loss of pressure, disturbed flow patterns, discolouration and interruption to supply. There is also the risk of disruption whilst repairs are being undertaken, for example disruption to traffic, or the requirement for excavation on private property. We have developed our systems and processes to repair c.80% of mains bursts 'live', without the need to depressurise our network or disrupt water service.

Our water infrastructure investment strategy aims to reduce mains bursts and the number of consequential mains repairs we need to carryout, therefore reducing the chance of either an interruption to supply or water quality issue. The structural mains programme involves renewal or relining of mains where appropriate, to improve the structural integrity of pipes and to ensure we continue to have a reliable asset base into the future. In the future, we forecast the need to increase the rate of structural mains renewal or relining, as the existing rates will be insufficient over the long term to maintain and improve the burst rate.

Over the next 25 years we aim to reduce the burst frequency on our network by over 25%, and anticipate that we will need to increase our distribution mains renewal or structural lining programme to around 1% per year by 2032 (ie 300km / year). This would involve targeting the prevention of corrosion and ground movement related bursts, to get the highest rate of benefit.

The replacement of pipes of specific materials will form part of our future approach. We have unlined cast iron mains which contribute to discolouration. To manage this risk, we will target replacement of unlined cast iron pipes and undertake research on the optimum pH and the impact of changing water sources on the rate of internal pipe corrosion. We are undertaking investigations on the rate of de-alkalisation of Asbestos Cement (AC) mains to understand clearly their expected residual life and allow their replacement to be appropriately timed and prioritised in our asset replacement planning.

This is supported by improvements in operational practices, such as calm networks training, and other capital solutions to reduce the number of bursts and ultimate contribute towards a stable and reliable asset base.

6.3.1 Smart Networks Programme

Throughout AMP7 we have deployed a smart water networks programme. This has enabled the deployment of solutions which improve the efficiency, longevity, and reliability of the clean water asset base through enhanced monitoring, DMA optimisation, pressure management, data collection, data management and modelling. In the early stages of this programme of work, we focussed activity at DMA level, but this has been expanded to city and water supply system level monitoring and asset improvement.

One of the key components of our smart networks programme is to improve pressure management. Pressures need to be high enough to satisfy customers, but low enough not to drive up leakage, bursts, energy consumption, operating costs and increase the chance of sediment mobilisation which leads to customers experiencing discoloured water. As part of the smart network strategy in AMP8, we aim to increase the deployment of instrumentation across the network, increasing our understanding of how the network is performing and providing increased data and visibility that inform risk management processes.

6.3.2 Water acceptability - turbidity, iron and manganese

The levels of turbidity, iron and manganese leaving water treatment works have reduced significantly over the last 20 years as a result of investment in additional treatment and tighter operational practices. We have also undertaken significant mains rehabilitation activity to drive down the levels of metals non-compliance. This programme of work has had a significant impact on the number of customer contacts received and has delivered improvements to water quality.

Within AMP6 we began an intensive systematic DMA flushing programme, which has delivered further benefits to customers and compliance. On average, we have been flushing about 25% of the network every year. Although the principle of flushing is not seen as being particularly innovative and has probably been taking place for 50 years, the approach we developed to allow risk-based targeting of flushing activity is innovative. The ability to be able to calculate sediment depth from a scientific end to end process allows us to model and then predict, based upon risk, which DMAs are likely to cause discolouration should there be a change in flow patterns. We can then build our DMA flushing programme on risk of discolouration (depth of sediment) rather than responding reactively to customer contacts. This has helped drive our discolouration performance to lower levels.

In AMP8 we are targeting a reduction in network sample failures and discolouration contacts through a targeted conditioning and flushing programme based upon the PODDS methodology in 16 identified WSZs across the region, with a further 11 proposed for AMP9. The increased mains renewal and relining programme will also target assets that have the potential to cause discolouration and water quality risk.

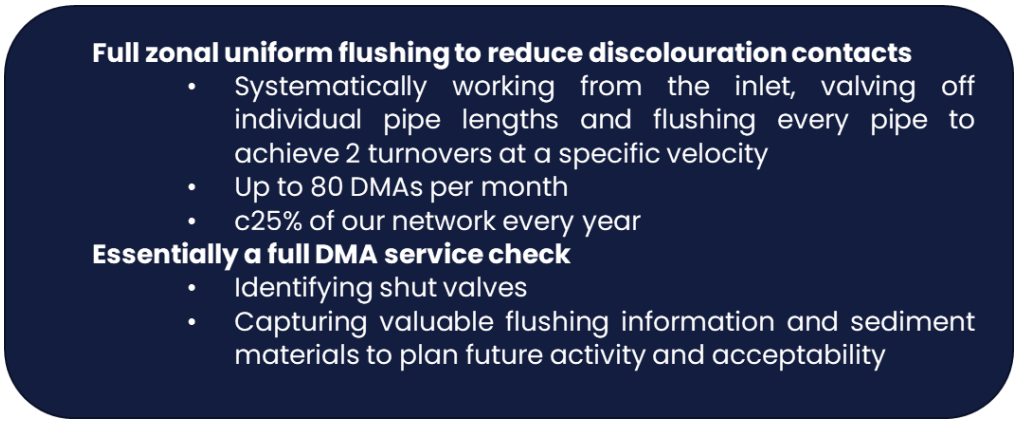


Figure 6.2 DMA flushing approach

6.3.3 Water acceptability – taste and odour

One of the key areas of water acceptability that impacts customers is taste and odour. This has three primary sources:

- Raw water (for example, algal content)
- Chlorine and chlorine reacting with compounds in treated water
- Interaction between plumbing and materials within the customer's property (usually plastic fittings, such as the tap) and chlorine with water characteristics (for example, bromide)

Our approach is to maintain a programme of chlorine optimisation, focused on our secondary dosing units and managed by a dedicated team of technicians. The aim of this programme is to maintain stable low levels of chlorine throughout the network. In some cases, contacts form customers are not directly related to chlorine itself but to its interaction with plastic fittings within the home. In some areas where water chemistry makes such occurrences more likely (e.g. high bromide groundwaters), we condition the water using chloramination to mitigate this issue.

6.4 Service Reservoirs - Reduction in risk of microbial contamination

Our highest risk of compromising bacterial quality is at service reservoirs. To maintain asset reliability, we have a long-term programme of service reservoir re-builds for stable asset condition. Over the past few AMP periods this programme has focussed on:

- Rebuilding relatively few, smaller assets (over 20 since AMP4)
- Installing full roof membranes and drainage improvements (approximately 20 per year)
- Strategic review of large tanks/strategic storage within water supply system resilience process.

This is supported by improvements to enabling works so that all assets can be taken out of service for inspection and maintenance. We have a robust programme of asset inspections which is dynamic. It is a risk-based approach with the level of risk defining the actual inspection frequency. Consideration is given to structure, condition grade, roof type, including over burden, elevation, and surrounding land usage. We operate a range of inspection frequencies from a minimum of 6 months to a maximum of 5 years. Most inspections are undertaken by draining the service reservoir and allowing our engineers to enter the water space, usually in the context of a roof flood test. To supplement the internal inspections, regular external inspections to assess condition take place whilst the assets remain in service. These include grounds maintenance, potential for ingress (vermin/other contaminants) via overflow and air valves and hatches. As discussed in section 6.1, we have an ongoing Legal Instrument which covers the operation and maintenance of clean water tanks and associated assets. This is due to complete in 2025 and will further inform base maintenance investment in AMP8 and AMP9 through a risk-based approach.

Reduction of leakage means we will need to review service reservoir turnover time, utilising both winter and summer profiles. We plan to replace our regional telemetry system (RTS) and install more real-time monitoring as part of our smart networks programme in AMP8,

to ensure we can maintain stable chlorine and turbidity levels on the outlet of Service Reservoirs, with a view to linking to live hydraulic models in AMP9. We intend to prevent ingress on the inlet or outlets to service reservoirs by reviewing hydraulic gradients and undertaking transient monitoring as part of our trunk main reliability programme. This will be supported by an onsite survey for all air valves on service reservoir inlet/outlet mains to ensure free draining chambers.

6.5 Lead

Historically, we have renewed lead communication pipes using a risk-based approach at DMA level. Building on our AMP7 programme, we have also looked to reduce exposure by investing to remove lead from schools and from our most vulnerable customers. In AMP8 we are again proposing a risk-based approach to investment at DMA level but also reducing customers exposure to lead by renewing the full service pipe (not just the communication pipe). We will widen our approach from schools to also target other educational establishments such as nurseries and continue to target risk reduction to our most vulnerable customers. Our full long term lead strategy will be submitted in line with DWI requirements, in March 2023.

Appendix 2 'Water quality programme decision and optioneering considerations' provides a summary of the rationale for the selection and consideration of network schemes included in the DWI Appendix A submission (January 2023).

7.0 Security and Emergency Measures Direction and Network and Information Security Directive

7.1 Network & Information Security Directive (NIS)

In contrast to water quality, cyber security is by its nature short term and reactive to rapid changes in technology, regulation, and the threat environment, hence it is difficult to predict the challenges faced beyond a single AMP cycle.

The speed and scale of these factors are captured in Figure 7.1 which lists currently known changes to:

- Regulation - with the inclusion of cyber into SEMD, NIS-2 and the possible inclusion of waste and the impact on future supplier frameworks
- Threat - the invasion of Ukraine, and the change in the behaviours of Hacktivists, Script Kiddies and cyber criminals.

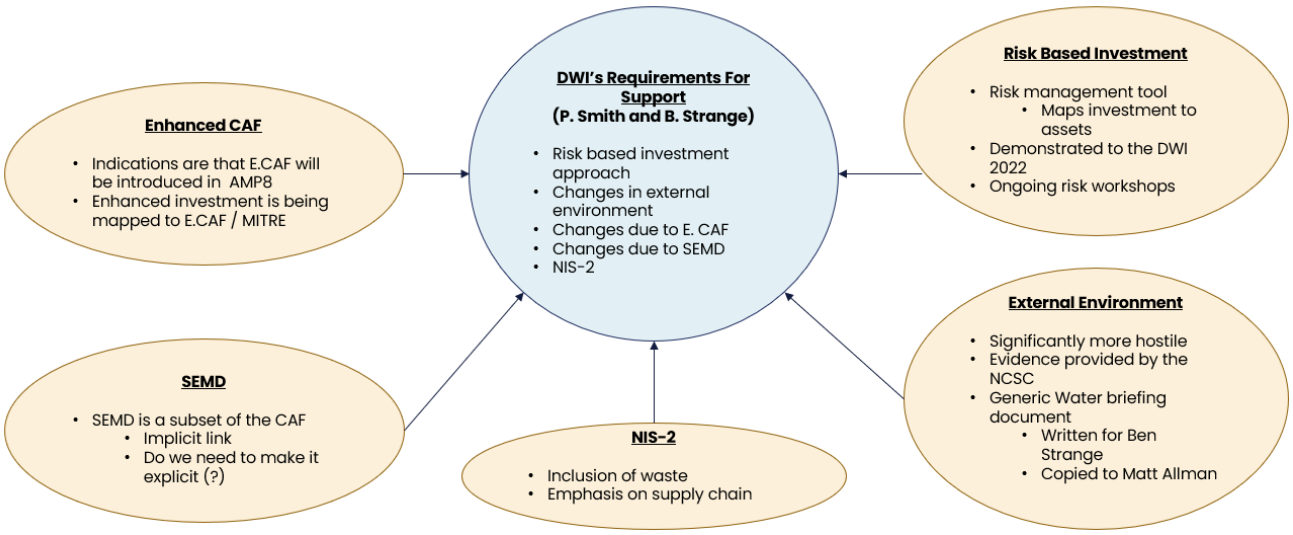


Figure 7.*1* - Changes in the security environment in AMP7 and leading into AMP8

The impact of these is compounded by concurrent, and rapid, changes across multiple cyber-physical technologies (I4.0, Digital convergence, IIoT, etc.), the nature and impact of which is still uncertain. We are constantly assessing the landscape to follow and understand these changes. We work with academic partners via government initiatives such as RITICS and PETRAS to understand changes in technology and security and with

government and industry to map changes in hostile behaviours. We engage with regulators and industry forums to understand the likely impact of regulatory changes such as the introduction of NIS-2. Furthermore, we have invested heavily in AMP7 to map and understand cyber-physical asset risks and to develop a risk based Cyber-Physical Security Management System (CPSMS) compliant with IEC 62443 and founded on the Plan Do Check Act (PDCA) model.

Central to this CPSMS is a risk modelling tool that assigns an individual risk score to each of the organisation's (circa five thousand) cyber-physical assets, while also identifying those security vulnerabilities that leave the company exposed to threat actors.

Our ambitions of cyber-physical security are informed by this risk management process and an understanding of the likely changes to the external environment facing the industry during AMP8. Not only does this ensure that the PR24 submission is defendable, and commensurate with risk (on an asset-by-asset basis), but also allows for clear allocation of funding between base and enhancement investment.

Based on this risk analysis it is apparent that our enhancement programme will need to address:

- Supply chain risk - this is an increasingly popular vector by which threat actors gain access to otherwise secure systems. It is a key tenant of NIS-2.
- Intrusion detection - credible solutions now exist, designed specifically for the cyber-physical environment
- Physical network segregation of cyber-physical systems from IT networks resulting from lessons learned from recent cyber-attacks against UK water companies.

7.2 Security & Emergency Measures Direction (SEMD)

The SEMD regulation changed in 2022 to encompass two growing elements. These are:

- Alternative Water Supplies (AWS) and the increase of the new planning assumption,
- Critical National Infrastructure (CNI) Criticalities Review recently carried out, which has resulted in an increased CNI asset base. Step 5 of the Criticalities Review is still ongoing, and this work is currently with the Cabinet Office.

Addressing the requirements for the above elements will for a key part of our Security and Emergency Planning activities in AMP8. These activities will be accompanied by a broader risk-based approach to the identification of the SEMD base maintenance programme of works which will seek to maintain our existing position, taking account of threats and vulnerabilities in applying the guidelines provided within SEMD22.

Our ambition is to continue the work already undertaken under the SEMD banner and provide a more holistic approach to this through collaborative working across multiple areas of the organisation that have a role to play in meeting the requirements of this

regulation. There will be more focus on the growing elements of the regulation to ensure these are embedded.

Appendices

Appendix 1 - Water Treatment Works benefiting from catchment management in AMP8

- There are 19 Water Treatment Works benefiting from upland restoration actions:
    - Embsay
    - Loxley
    - Langsett
    - Oldfield
    - Chellow
    - Holmbridge
    - Rivelin
    - Ewden
    - Longwood
    - Ingbirchworth
    - Kirkhamgate
    - Fixby
    - Sladen Valley
    - Graincliffe
    - Albert
    - Blackmoorfoot
    - Eccup
    - Harlow Hill
    - Thornton Steward
- There are 6 Water Treatment Works benefiting from lowland regenerative agriculture practices:
    - Tophill Low
    - Elvington
    - Ruswarp
    - Irton
    - Loftsome Bridge
    - Acomb Landing
- There are 9 Water Treatment Works benefiting from catchment actions to improve groundwater quality from saline intrusion, rural diffuse pollution including improving (and limiting) application of fertilisers, chemicals and sewage sludge to land:
    - Irton
    - Haisthorpe
    - Hutton Cranswick
    - Etton
    - Keldgate
    - Carlton Mill Lane
    - Nutwell
    - Littleworth
    - Highfield Lane

Appendix 2 – Water quality programme decision and optioneering considerations

Location / Scale / Scheme Name	**Risk that requires provision of mitigation**	**Description of decision and optioneering considerations**
East Ness WTW	Coliform and Clostridia	Increased rate of coliform and clostridia failures over last 10 years. Risk of legal instrument from the DWI. The proposed solution is closely linked to a resilience solution in the network to fully realise the benefit from additional treatment. There was no viable raw water / catchment solution identified.
Doncaster Boreholes	Nitrate	Doncaster Borehole risk was highlighted at PR19, and catchment interventions initiated. At Doncaster Boreholes and Haisthorpe nitrate trends continue to increase such that treatment options are required in addition to existing catchment activity.
Haisthorpe WTW	Nitrate	
Loxley WTW	Colour/ Trihalomethanes/ Disinfection By-products	Deteriorating raw water quality resulting in reduced WTW through put. Increased throughput is required in this system to allow flexibility, energy efficient transfer of water and additional resilience. There has been an AMP7 investigation into colour which has developed the catchment intervention plan for AMP8. A treatment scheme is also proposed for AMP8 to facilitate increased through put.
Ingbirchworth WTW	Taste and Odour	Emergence of taste and odour issues in 2021/22. Considered to be a high probability of repeat issues, so treatment option proposed as there is high certainty of success. Further investigation is on-going to determine if an alternative raw water solution is feasible.
Lead Removal	Lead	Lead removal from the water network is a challenging complex issue. Water companies are not responsible for full length of the water pipes serving a customer's property or the internal plumbing where lead can be found. Customers are not fully protected from exposure to lead if only the water company assets are replaced. For this reason, we have made the strategic decision to replace the full service pipe (including customer owned) and reduce the number of targeted Distribution Management Areas (DMAs). A high scenario has been chosen in respect of reducing risk to educational establishments – young children are one of the highest risk groups to exposure to lead. Lead exceedances will be addressed, and our free and matching service will continue (this is where a customer chooses to replace the section of lead pipe they are responsible for and the company will then replace the section they own. The chosen approach will increase the number of

		customers that benefit from reduced lead exposure to c63,000 in AMP8 (an increase from c25,000 in AMP7).
High Risk WSZ Trunk Main and DMA Discolouration Programme	Discolouration	Trunk main conditioning programme for discolouration contact reduction - the programme for AMP8 has been developed to target discolouration contact reduction in a way that will deliver the greatest benefit most efficiently. Previous investment has been made in manganese filters at WTW and large-scale flushing of DMAs to reduce the risk of discolouration. The trunk main system has had significantly less focused intervention. The discolouration contact data from 2020 to November 2022 has been used to rank and identify target zones. c1.2m customers will benefit from a reduced risk of discolouration in AMP8. DMA flushing activity will continue, but post truck main conditioning, material that can cause discolouration entering the DMA should reduce, reducing the reseeding rate in DMAs and reducing the flushing frequency.
Taste & odour investigation	Taste and Odour Algae	Proactive risk assessment and mitigation development. Due to climate change, increasing risk of algal blooms in raw water reservoirs leading to taste and odour issues. Investigation to cover six sites considered to be at risk in the future, with the development of options for mitigation.
Blackmoorfoot WTW	Colour/ Trihalomethanes/ Disinfection By-products	Catchment interventions on-going. Decision to defer treatment schemes to Amp9/10 as raw water deterioration trends slowed over past 5-10 years suggesting benefits from on-going catchment interventions. On-going operational mitigation at these sites through reduction in WTW throughput with sufficient water supply systems resilience to facilitate the reduced throughput without risk to customers (i.e. additional water is not needed at these locations and additional support to the grid from these locations is not viable).
Longwood WTW	Colour/ Trihalomethanes/ Disinfection By-products	
Hutton Cranswick WTW	Nitrate	High nitrate trend predicted to require treatment in AMP9/10, therefore catchment intervention identified in AMP8 to mitigate the increasing trend.
Other issues considered		There are other risks and mitigation requirements which could impact on water quality risk that are assessed as part of the PR24 submission, but do not meet the criteria form the perspective of the DWI water quality submission. For example, service reservoirs, where asset condition could present a water quality risk, are considered under base or other relevant categories where there are multiple drivers for intervention, such as growth to meet future capacity requirements.

B DWI Submision – Apppendix B Documents

B1 Discolouration Contacts

Appendix B: Discolouration Contacts

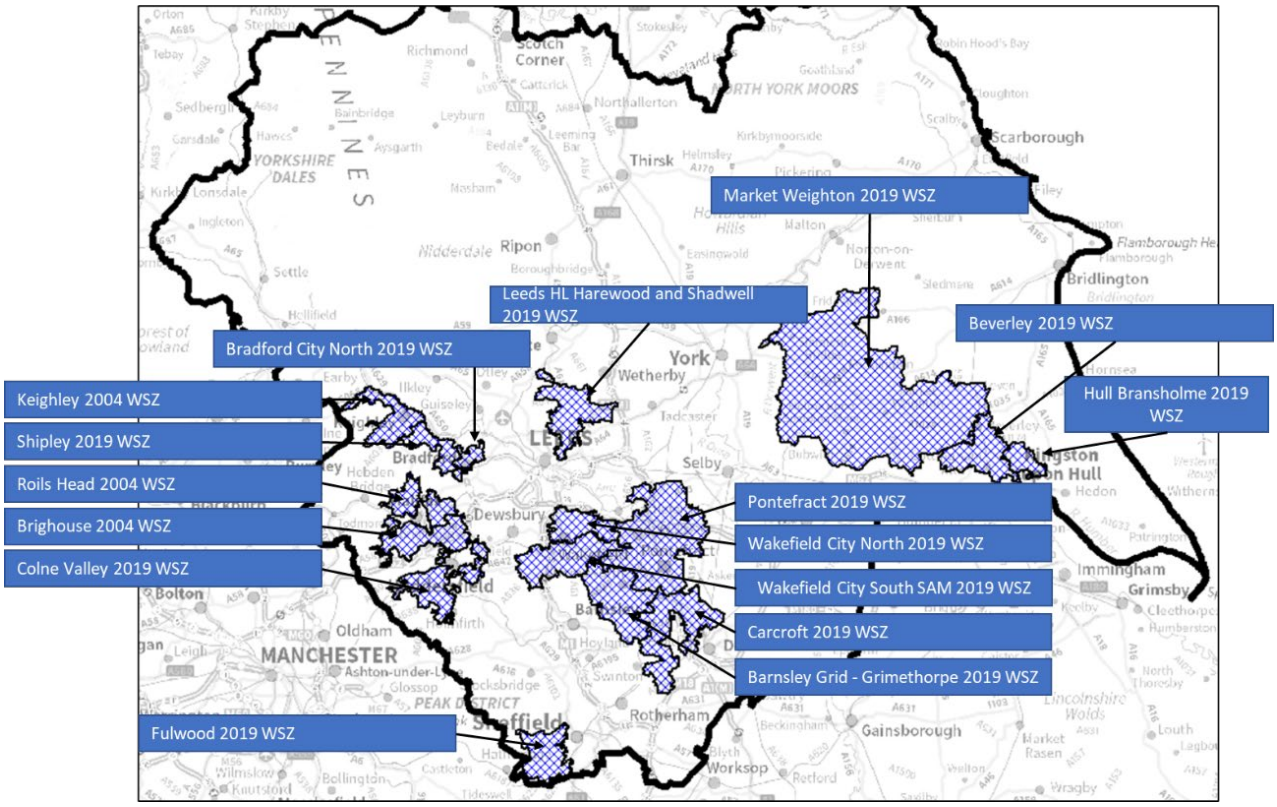
Section 1

Background information	
Water Company	Yorkshire Water
Date of submission	31st March 2023
Name of Supply System	Regional
Regulation 28 report(s) reference number(s) (Unique reference number for each report that applies):	YKS-Risk-Z3800719-03-23.csv YKS-Risk-Z2800519-03-23.csv YKS-Risk-Z4800619-03-23.csv YKS-Risk-Z4801503-03-23.csv YKS-Risk-Z3801919-03-23.csv YKS-Risk-Z4801119-03-23.csv YKS-Risk-Z3802319-03-23.csv YKS-Risk-Z2804679-03-23.csv YKS-Risk-Z4803103-03-23.csv YKS-Risk-Z1801619-03-23.csv YKS-Risk-Z2804919-03-23.csv YKS-Risk-Z1806419-03-23.csv YKS-Risk-Z4803133-03-23.csv YKS-Risk-Z4804019-03-23.csv YKS-Risk-Z1808019-03-23.csv YKS-Risk-Z1808119-03-23.csv

Background information	
Name of Water Treatment Works/ Distribution System/ Service Reservoir/ Other asset	Barnsley Grid - Grimethorpe 2019 WSZ Beverley 2019 WSZ Bradford City North 2019 WSZ Brighouse 2004 WSZ Carcroft 2019 WSZ Colne Valley 2019 WSZ Fulwood 2019 WSZ Hull Bransholme 2019 WSZ Keighley 2004 WSZ Leeds HL Harewood and Shadwell 2019 WSZ Market Weighton 2019 WSZ Pontefract 2019 WSZ Roils Head 2004 WSZ Shipley 2019 WSZ Wakefield City North 2019 WSZ Wakefield City South SAM 2019 WSZ
Water Quality hazard(s)/driver(s) identified:	Customer contacts for discolouration Iron (A022) Manganese (A023) Turbidity (A002)
Reference to outcome in company's long-term strategy: *[Any other long-term planning the company may*	See section 6. Of YWs Long Term Strategy Document (Jan 2023)

Background information	
have already published that their proposals feed into].	

Section 2

Details of water treatment works and associated supply system	
1	*Provide supply arrangements and treatment works details:*
Multiple water treatment works supply the selected Water Supply Zones.	
2	*A description and diagram of the supply system related to the treatment works*
Locations of the Water Supply Zones are shown below  	
3	*Design capacity of the water treatment works (Ml/d)*
N/A	
4	*Volume supplied:* ○ *Daily average (Ml/d)* ○ *Daily maximum (Ml/d)*

Details of water treatment works and associated supply system	
N/A	
5	*Sources of raw water (continuous/ seasonal/ standby)*
N/A	
6	*Treatment processes currently employed (including pre-treatment of raw waters) [In this case, blending is defined as treatment. This includes blending of raw waters prior to treatment. Please also indicate if bankside storage of raw water is utilised, and average retention time in the reservoir]*
Various	
7	*Service reservoirs/ booster pump details*
N/A	
8	*Water supply zones supplied and the population of each water supply zone* *[If the supply is blended with waters from other treatment works in the zone, please indicate the relative proportions (as %)]*
Table 2.8.1 2023 Populations of the impacted WSZ	

Details of water treatment works and associated supply system

Site Reference	SiteName	Population
Z1806419	Pontefract 2019 WSZ	96,020
Z2800519	Beverley 2019 WSZ	94,781
Z4804019	Shipley 2019 WSZ	93,836
Z1808019	Wakefield City North 2019 WSZ	90,214
Z3802319	Fulwood 2019 WSZ	90,019
Z4801119	Colne Valley 2019 WSZ	86,348
Z4801503	Brighouse 2004	86,197
Z3800719	Barnsley Grid - Grimethorpe 2019 WSZ	83,872
Z1808119	Wakefield City South Sam 2019 WSZ	81,052
Z2804679	Hull Bransholme 2019 WSZ	77,816
Z1801619	Leeds HL Harewood and Shadwell 2019 WSZ	76,380
Z4803103	Keighley 2004	75,124
Z4803133	Roils Head 2004	74,167
Z3801919	Carcroft 2019 WSZ	71,871
Z4800619	Bradford City North 2019 WSZ	56,787
Z2804919	Market Weighton 2019 WSZ	52,950

Section 3

Hazard identification and Risk Characterisation	
1	*Provide details of the methodology used to identify the hazard. For example:* • *Historical data,* • *Events/ incidents including near miss situations,* • *Operator knowledge,* • *Modelling and validation of modelling* • *Site visits/ technical audits*
Primarily based upon customer contact rates per 1000 population – identifying those water supply zones with the highest risk not already addressed by a legal instrument. Modified by inclusion of WSZs with relatively lower contact rates but higher numbers of contacts due to size. In addition, included a WSZ where trunk main automation work has already begun as part of work to improve resilience as a result of the drought experienced in 2022 (Keighley 2004 WSZ). Finally, adjusted in order to build an overall deliverable programme across the region and designed to ensure the population that benefits from this work (estimated to be 1.2 million) is an increase on similar work completed in AMP7. A further list of 10 WSZs is preliminarily identified for investment in AMP9.	
2	*Summary of historical data on the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the raw water source and the water entering supply from the relevant treatment works from compliance, investigative, or operational sampling*
The principal purpose of the interventions is to reduce the underlying level of latent sediments in trunk mains, and hence reduce the risk instances of discolouration impacting customers during instances of widespread discolouration. WSZs selected for improvement have been associated with previous notified WQ Events. Not all of the WSZs have suffered Events in the reference period. However, the nature of such discolouration events it that satisfactory performance can be achieved in normal operation, while the sediments represent a risk of future failure upon disturbance.	

Hazard identification and Risk Characterisation

Table 3.2.1 Number of notified WQ discolouration events per year.

Associated with an Event	2015	2016	2017	2018	2019	2020	2021	2022
Barnsley Grid - Grimethorpe 2019 WSZ	0	0	0	0	0	0	0	0
Beverley 2019 WSZ	0	0	0	1	0	0	0	0
Bradford City North 2019 WSZ	0	0	0	0	0	1	0	1
Brighouse 2004 WSZ	0	0	1	1	1	0	0	0
Carcroft 2019 WSZ	0	0	0	0	0	0	0	0
Colne Valley 2019 WSZ	1	0	0	0	1	0	0	0
Fulwood 2019 WSZ	1	0	0	0	0	1	0	0
Hull Bransholme 2019 WSZ	0	1	0	1	0	1	0	0
Keighley 2004 WSZ	0	1	0	0	0	0	0	0
Leeds HL Harewood and Shadwell 2019 WSZ	1	0	0	0	0	1	0	0
Market Weighton 2019 WSZ	0	0	0	0	0	0	0	0
Pontefract 2019 WSZ	0	0	1	0	0	0	0	0
Roils Head 2004 WSZ	0	0	0	0	0	0	0	0
Shipley 2019 WSZ	0	0	0	0	0	0	0	1
Wakefield City North 2019 WSZ	0	0	0	0	0	0	0	0
Wakefield City South Sam 2019 WSZ	0	0	0	0	0	0	0	0

3	*Details of any existing contraventions of regulatory requirements and whether they are likely to recur (at WTW, SR and/or at consumers taps)*

Research undertaken by the Company in association with Sheffield University has demonstrated the key factors associated with discolouration contacts are not the same as those predicting occurrence of iron at elevated levels.

Hence, some of the zones selected have not reported regulatory Iron sample fails since 2015.

Table 3.3.1 Number of regulatory Iron failures per year.

Hazard identification and Risk Characterisation

Asset Ref	Name	2015	2016	2017	2018	2019	2020	2021	2022
Z3800719	Barnsley Grid - Grimethorpe 2019 WSZ	0	0	0	0	0	0	1	0
Z2800519	Beverley 2019 WSZ	0	1	0	0	0	0	1	1
Z4800619	Bradford City North 2019 WSZ	0	0	0	0	0	0	0	0
Z4801503	Brighouse 2004 WSZ	0	0	0	2	0	0	0	0
Z3801919	Carcroft 2019 WSZ	0	0	0	0	1	0	0	0
Z4801119	Colne Valley 2019 WSZ	2	0	0	0	0	0	0	1
Z3802319	Fulwood 2019 WSZ	0	0	1	0	0	0	0	0
Z2804679	Hull Bransholme 2019 WSZ	1	0	1	0	3	0	1	1
Z4803103	Keighley 2004 WSZ	1	0	0	0	0	0	0	0
Z1801619	Leeds HL Harewood and Shadwell 2019 WSZ	0	0	0	0	0	0	0	2
Z2804919	Market Weighton 2019 WSZ	0	0	0	0	0	0	0	0
Z1806419	Pontefract 2019 WSZ	0	0	0	0	1	0	0	0
Z4803133	Roils Head 2004 WSZ	0	0	0	0	0	1	0	0
Z4804019	Shipley 2019 WSZ	0	0	0	0	0	0	0	0
Z1808019	Wakefield City North 2019 WSZ	0	1	2	1	3	0	0	1
Z1808119	Wakefield City South Sam 2019 WSZ	2	0	0	1	0	0	0	0

The interventions are targeted at removing sediments within trunk mains. The removal of sediments from trunk mains systems is expected to reduce the re-seeding rate within local DMAs, provide a beneficial contribution to the lowering presence of iron and improve discolouration contact rates

4	*If evidence of likely to contravene any regulatory requirement, details of when this is likely to occur (at WTW, SR and/or at consumers taps) including trend analysis & prediction modelling*

It is likely that intermittent exceedance of regulatory standards or occurrence of notified WQ events will occur across the range of the 16 WSZs selected.

5	*Details of any other data relevant to the hazard identified*

The number of notified WQ Events has fluctuated over period since the beginning of AMP6. However, there has been substantial variation in the Company's trigger levels for notification which has masked underlying improvements.

The number of 'events' against an objective trigger of 15 or 25 contacts per day (per WSZ) has shown evidence of improved resilience in the Company's networks. Limited statistical interpretation is possible due to the low number of data points, but it is considered further intervention is required to drive further benefit for customers.

Hazard identification and Risk Characterisation

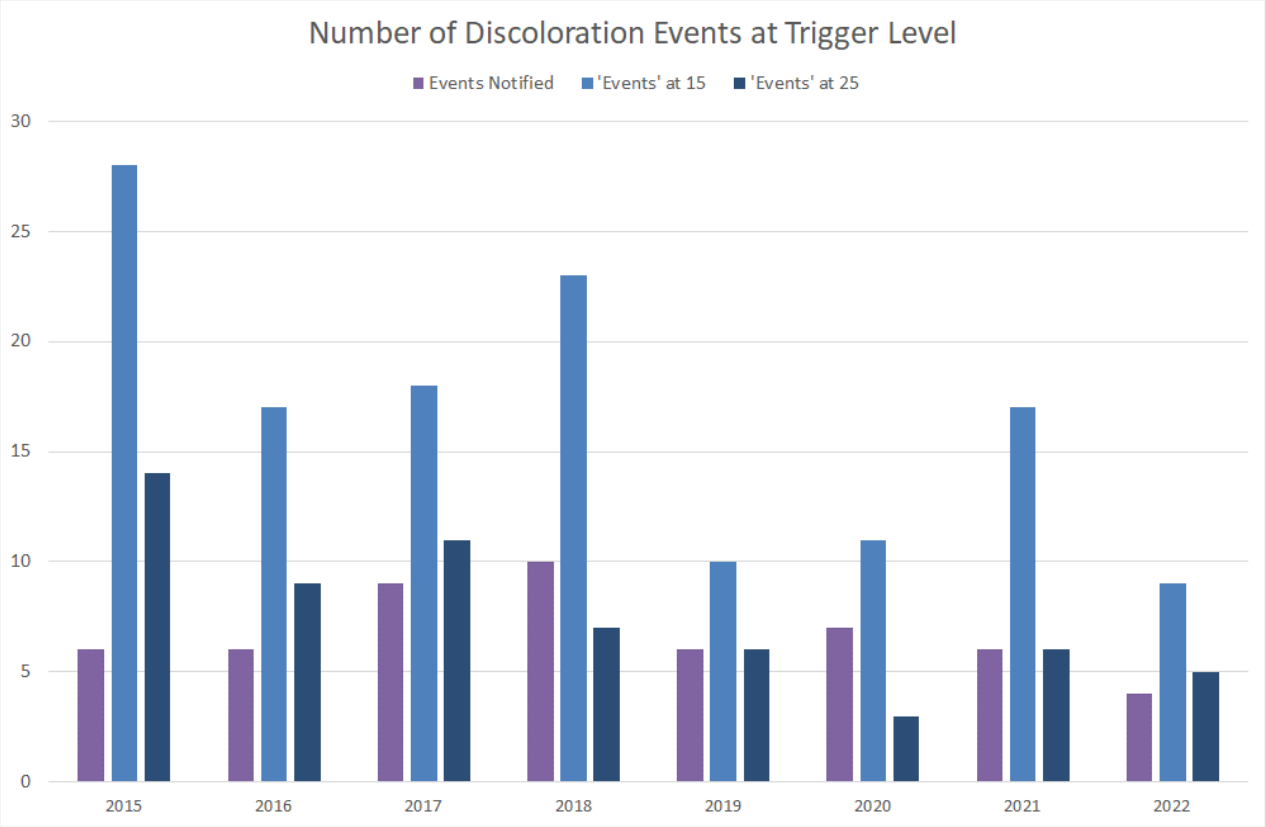


Figure 3.5.1 Number of regional discolouration events at trigger level.

Note - in the chart above each occurrence of exceedance of a defined trigger level per day in a WSZ is reported, including where there multiple WSZ associated to the same source intervention or where a single WSZ in impacted on successive days.

6	*If appropriate, summary of data/ information on consumer complaints*

There is variation in performance on a year-to-year basis. However, in general, the selected WSZs demonstrated customer contact rates for 'brown black orange' contacts per 1000 population which are above the Company average.

As discussed in the selection criteria some zones, e.g. Beverley 2019 WSZ and Shipley 2019 WSZ were selected on the basis of the total of contacts received due to their relatively larger size.

Hazard identification and Risk Characterisation

Table 3.6.1. Brown Black Orange Customer Contact rate per 1000 population.

Asset Ref	Name	Pop	2015	2016	2017	2018	2019	2020	2021	2022
Z3800719	Barnsley Grid - Grimethorpe 2019 WSZ	79013	0.61	0.73	0.53	0.70	0.42	0.99	0.44	0.80
Z2800519	Beverley 2019 WSZ	89290	1.69	1.37	0.72	0.52	0.34	0.53	0.17	0.30
Z4800619	Bradford City North 2019 WSZ	53496	0.42	0.47	0.23	0.38	0.13	1.20	0.54	0.83
Z4801503	Brighouse 2004 WSZ	81203	1.50	0.92	1.00	0.98	0.89	0.56	0.67	0.63
Z3801919	Carcroft 2019 WSZ	67707	1.33	0.54	0.48	1.39	0.35	0.87	0.44	0.53
Z4801119	Colne Valley 2019 WSZ	81345	1.00	0.80	0.79	1.20	0.59	0.65	0.51	1.03
Z3802319	Fulwood 2019 WSZ	84803	1.37	1.32	1.06	1.09	0.42	0.46	0.35	0.24
Z2804679	Hull Bransholme 2019 WSZ	73307	2.19	1.94	0.92	1.40	1.43	0.93	0.60	0.60
Z4803103	Keighley 2004 WSZ	70772	0.46	2.06	0.46	0.35	0.41	0.47	0.34	0.75
Z1801619	Leeds HL Harewood and Shadwell 2019 WSZ	71954	0.52	0.72	0.51	0.46	0.54	0.60	0.46	0.56
Z2804919	Market Weighton 2019 WSZ	49882	0.67	0.83	0.51	0.41	0.65	0.99	0.48	0.70
Z1806419	Pontefract 2019 WSZ	90456	1.08	1.32	0.63	0.78	0.74	0.49	0.46	0.52
Z4803133	Roils Head 2004 WSZ	69870	1.29	1.05	0.60	0.80	0.55	0.63	0.91	0.50
Z4804019	Shipley 2019 WSZ	88399	0.31	0.68	0.52	0.69	0.51	0.27	0.37	0.44
Z1808019	Wakefield City North 2019 WSZ	84987	1.23	0.99	1.48	0.66	1.01	0.56	0.61	0.70
Z1808119	Wakefield City South Sam 2019 WSZ	76356	0.74	0.98	0.81	0.59	0.61	0.46	0.89	0.43
	Regional Average		1.09	0.97	0.65	0.7	0.56	0.46	0.44	0.45

7	*Details of any events that have occurred in the catchment, at the treatment works and in supply that are associated with hazard identified*

As above.

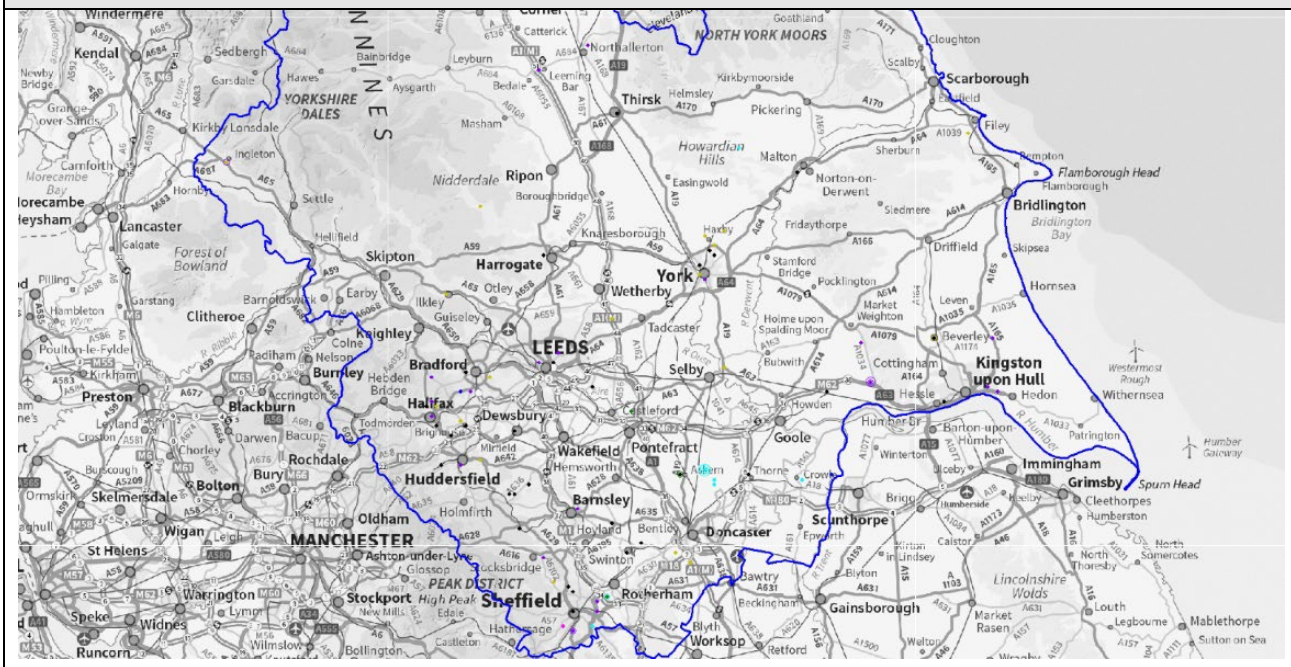
8	*Details of any existing control measure(s) that might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the catchment, in treatment and in supply*

Source risks are addressed by an appropriate design of water treatment works. All but one river or reservoir fed site will incorporate three stages of treatment by the beginning of AMP8.

During AMP7 the Company has developed processes for the assessment of trunk main related risk and is implementing mains conditioning solutions based upon Prediction of Discolouration in Distribution Systems (PODDS) philosophy.

In AMP6 and AMP7 the Company has delivered substantial improvement in the number of contacts from customers. This benefit has been substantially achieved via local within DMA flushing. This activity has reduced contacts and reduced the occurrence 'events' when compared to an objective standard.

Hazard identification and Risk Characterisation	
In addition to fundamental improvements to the mass of sediments within mains the Company has improved oversight and delivery of risk assessed activity.	
9	*Details of monitoring of the existing control measure(s) (including validation monitoring)*
All of the Company's WTW are equipped with on-line turbidity monitoring, alarms, and automate shutdown. Primarily this is designed to prevent interference with disinfection, but turbidity also acts as a proxy for the presence of insoluble particles which become incorporated into sediments. In addition, routine samples are collected for aesthetic metals from WTW outlets as part of an operational monitoring programme. The nature of aesthetic mains sediment is that much of the risk of subsequent discolouration is latent. High quality water can be supplied to customers in routine operational environments but can deteriorate rapidly in unusual circumstances. Hence, training of colleagues involved in activity, and audit of compliance with Company risk assessment procedures is vital. However, a key control is careful oversight of customer contacts on a timely basis through the control room – with rapid intervention where necessary. Our "Odyssey" mapping application visually displays the occurrence of customers in real-time. Where multiple contacts for a given contact occur in close geographical locations these appear as concentric circles of similar colours. Figure 3.9.1. Example screenshot of Odyssey mapping application	

Hazard identification and Risk Characterisation	
 The customer contact map is prominently displayed in our control room, as well as on a screen on the Duty Managers desk. The mapping system is also available to all colleagues on their computers. However, the version installed in the control is equipped with a zone flagging tool where numbers of contacts exceed certain trigger numbers in a wider operational area. This timely assessment of data is supported by longer term review of contact patterns leading to identification of risk areas for future intervention.	
10	*Details of any changes in practices or policy which might have influenced the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in water supplied to consumers, i.e., in relation to resources, blending arrangements, treatment or supply arrangements and the dates of those changes*
N/A	
11	*Details of any licensed abstraction issues which might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in raw water*
N/A	

Hazard identification and Risk Characterisation	
12	*Reasons for the presence of the hazard, if known, otherwise details of what is being done to identify the source of the hazard*

Aesthetic metals are found in all source waters but are reduced to very low concentration in WTW outlet. Albeit this may still represent many 100s of kilograms per year, which could accumulate in mains systems in the correction conditions. The proposed interventions are designed to remove the residual low levels of sediment.

Evidence suggests that even relatively low levels of manganese may act as catalysts or nucleation points for discolouration particles. However, the Company completed the construction of manganese removal facilities in previous AMP periods. It seems likely therefore that sediments currently present represent historic not current contribution from sub-optimal treatment.

13	*Outline Risk characterisation. For example, details and score arising from consequence v. likelihood matrix, where score sits in the risk profile for the supply system.*

The Company's DWSP Risk matrix incorporates a 5 x 5 scale severity and probability matrix. Our system adopts the DWI severity scores and combines this with an estimate probability (in bands of 20%) of failure within the next 12 months.

Table 3.13.1. DWSP 5x5 Scoring Matrix

		Severity				
		1 - VL	2 - L	3- M	4 – H	5 – VH
Probability	5 – VH	9	14	18	22	25
	4 – H	7	12	17	21	24
	3 – M	5	10	15	19	23
	2 – L	3	6	11	16	20
	1 - VL	1	2	4	8	13

Due to reporting requirements the risks associated with this initiative are linked to the relevant water quality parameter (iron, manganese, turbidity). However, the primary driver is in fact customer contacts for discolouration, and in particular occurrence of WQ Events due to discolouration.

Hazard identification and Risk Characterisation

In our DWSP methodology the risk scoring for a particular parameter is based on three elements:

- Flowed down risk score from upstream stage
- Overall risk of presence of parameter primarily based upon sample performance
- Any associated hazardous event that is suspected

The final score associated with the particular risk is selected from highest scoring element of these three elements.

On an individual WSZ basis, the sample data indicates the probability of exceedance of regulatory standard for each of the parameters is low from the relevant upstream treatment works / service reservoirs or indeed within the WSZ itself. Our system also incorporates customer contact data into hazardous events for risk of discolouration due to trunk mains and due to within DMA issues.

Full details of risk assessments are shown in the relevant Reg28 Reports, but a summary of the relevant risk assessments are shown below. As indicated by the scores the specific probability of an exceedance due to presence or iron, manganese, or turbidity in any one individual WSZ is not high in the next 12 months. However, as occurrence of discolouration contacts is occurring now, so the proposed work requires the risk lines to be reported at Category E due the relevant hazardous event.

Table 3.13.2. Summary of DWSP risk scoring across 16 WSZ

Hazard identification and Risk Characterisation

AssetRef	HazardRef	PreLikelihood	PreConsequence	Risk	PostLikelihood	PostConsequence	Residual Risk	DWICategory	HazardID
Z1801619	A002	2	4	16	1	4	8	E	46836
Z1801619	A022	3	3	15	2	3	11	E	47048
Z1801619	A023	3	3	15	2	3	11	E	46875
Z1806419	A002	2	4	16	2	4	16	E	42664
Z1806419	A022	2	3	11	2	3	11	E	41829
Z1806419	A023	2	3	11	2	3	11	E	42760
Z1808019	A002	1	4	8	1	4	8	E	87931
Z1808019	A022	3	3	15	2	3	11	E	41714
Z1808019	A023	3	3	15	2	3	11	E	41885
Z1808119	A002	1	4	8	1	4	8	E	88003
Z1808119	A022	4	3	17	2	3	11	E	47159
Z1808119	A023	4	3	17	2	3	11	E	46760
Z2800519	A002	1	4	8	1	4	8	E	44008
Z2800519	A022	1	3	4	1	3	4	E	42668
Z2800519	A023	1	3	4	1	3	4	E	43070
Z2804679	A002	1	4	8	1	4	8	E	45898
Z2804679	A022	1	3	4	1	3	4	E	46079
Z2804679	A023	2	3	11	2	3	11	E	45685
Z2804919	A002	1	4	8	1	4	8	E	41722
Z2804919	A022	3	3	15	2	3	11	E	41890
Z2804919	A023	1	3	4	1	3	4	E	41815
Z3800719	A002	1	4	8	1	4	8	E	51959
Z3800719	A022	4	3	17	3	3	15	E	47276
Z3800719	A023	4	3	17	2	3	11	E	40490
Z3801919	A002	1	4	8	1	4	8	E	43768
Z3801919	A022	3	3	15	2	3	11	E	42939
Z3801919	A023	1	3	4	1	3	4	E	43809
Z3802319	A002	1	4	8	1	4	8	E	47224
Z3802319	A022	3	3	15	3	3	15	E	47419
Z3802319	A023	1	3	4	2	3	11	E	47518
Z4800619	A002	2	4	16	2	4	16	E	69489
Z4800619	A022	5	3	18	4	3	17	E	41547
Z4800619	A023	5	3	18	4	3	17	E	41128
Z4801119	A002	1	4	8	1	4	8	E	41541
Z4801119	A022	1	3	4	1	3	4	E	41249
Z4801119	A023	2	3	11	2	3	11	E	41324
Z4801503	A002	1	4	8	1	4	8	E	42931
Z4801503	A022	1	3	4	1	3	4	E	42680
Z4801503	A023	4	3	17	4	3	17	E	42975
Z4803103	A002	1	4	8	1	4	8	E	43407
Z4803103	A022	1	3	4	2	3	11	E	43056
Z4803103	A023	1	3	4	1	3	4	E	42683
Z4803133	A002	2	4	16	2	4	16	E	50999
Z4803133	A022	4	3	17	2	3	11	E	43770
Z4803133	A023	4	3	17	2	3	11	E	44923
Z4804019	A002	2	4	16	2	4	16	E	58415
Z4804019	A022	4	3	17	2	3	11	E	43899
Z4804019	A023	4	3	17	2	3	11	E	43749

Section 4

Control Measures Required – Details of short, medium and long term control measures	
1	Details of short-term actions currently in place to mitigate against risk & their effect
In order to help reduce the number of discolouration contacts we receive, since the beginning of AMP6, we have built up a Distribution Maintenance team whose principal role is to carry out full DMA flushing. We currently have 42 Distribution Maintenance Technicians, supported by a back-office team who help plan the DMA flushing programme, to flush between ¼ and ⅓ of the water distribution network each year. The objective is that the whole DMA is cleaned systematically from the inlet through to its extremities to ensure that each pipe is cleaned to the same force. Turbidity is recorded during flushing and during data processing. Work is ongoing to understanding the re-seeding rates of DMAs to optimise the time for the Distribution Maintenance Team to return to the DMA to carry out another flush. We believe the trunk main conditioning programme will enable us to increase the length of time between DMAs being flushed as conditioning the upstream assets will reduce the sediment being transferred into the distribution mains.	
2	Details of mid to long term control measures identified for any residual risk: o Options the company has considered which should, where appropriate, include catchment management controls, or communications controls in association with other stakeholders o Timescale for delivery of each option o Capital costs and net additional operating costs of each option considered o Summary of costs and benefits of each option o Reasons for choosing the preferred option o Specific supporting evidence that the preferred option will address risk of hazard within the required timescale
Within AMP8 we propose to address discolouration risk in our large diameter mains by carrying out trunk main conditioning, and where it is appropriate, to automate this. We have trialled this in AMP6 and rolled this out on a much larger scale throughout AMP7 in 16 WSZs. This gives a benefit to stopping those large scale 'one off' incidents', as well as reducing the amount of sediment transferred from our trunk main system into the DMAs,	

Control Measures Required – Details of short, medium and long term control measures

where any future changes in flow (mainly from a mains burst) could result in a customer impact.

Based upon the work carried out as part of the Legal Instruments for 10 WSZs in AMP7, we developed a costing methodology per WSZ and applied this to the work in AMP8. It involved assumptions based upon traditional capital activity (mains renewal, cross connections and ancillary installations), purchase of equipment, and costs associated with flushing DMAs and trunk mains. Based upon this work we estimate a required expenditure of £558k per WSZ, resulting in a total of £8.93M for the selected 16 WSZs.

We have developed scenarios for delivering this programme of work for 10 WSZs and 16 WSZs. The 16 WSZ scenario was based upon >150 contacts per WSZ from the observation period, and then included Keighley 2004 WSZ due to the automation work we have completed as a result of the dry summer of 2022, and then a further 2 WSZs that had less contacts, but allowed a balanced approach to work across the region, so all areas of Yorkshire get a similar benefit.

A further programme of trunk main conditioning is provisionally planned for AMP9 of a similar scale.

3	Full details of how the company intends to assess and measure the benefits delivered (the outcome), including details of proposed sampling programme, number of samples to be taken over the specified period and parameters to be monitored.

The key measure for success on this project is the reduction in risk of discolouration due to sediments in trunk mains. We believe the most appropriate way of measuring this is by reducing the number of discolouration events caused by the mobilisation of sediment from trunk mains.

The target we have set is a reduction in the number of 'near miss' reportable events where the threshold has been set at >15 customer contacts related to discolouration per day as a result of a trunk main event. The historic results for the 16 proposed WSZs can be seen below.

Table 4.3.1. Near miss reportable events for 16 proposed WSZs

16 WSZ	2020	2021	2022	2023 (to date)
>10 per day	3	6	3	1

Control Measures Required – Details of short, medium and long term control measures

>11 per day	3	6	2	1
>15 per day	3	5	2	1
>20 per day	2	4	2	1

As we plan a delivery programme similar to how we have delivered the AMP7 work related to the Legal Instruments (10 WSZ regionally and 6 WSZ in Sheffield), we aim to carryout the AMP8 work in two phases of 8 WSZs each. Therefore, the target being set of only one event of >15 contacts per day associated with a trunk main discolouration incident, per phase in a reference year.

As part of providing regular updates to the DWI, we will provide updates on the following at agreed dates:

- Investigation to confirm discolouration risk status in the trunk mains of the agreed WSZs
- Investigation to confirm discolouration risk status in the DMAs of the agreed WSZs
- A detailed action plan
- Remedial activities carried out
- Annual progress reports
- Completion reports

B2 Doncaster Boreholes

Appendix B: Doncaster Boreholes

Section 1

Background information	
Water Company	Yorkshire Water
Date of submission	31st March 2023
Name of Supply System	Clifton Water Supply System
Regulation 28 report(s) reference number(s) (Unique reference number for each report that applies):	YKS-Risk-A3610450-03-23.csv YKS-Risk-A3612700-03-23.csv YKS-Risk-T3690600-03-23.csv YKS-Risk-T3692700-03-23.csv
Name of Water Treatment Works/ Distribution System/ Service Reservoir/ Other asset	Austerfield WTW Highfield Lane WTW
Water Quality hazard(s)/driver(s) identified:	Coliforms (C001), *E. coli* (C002) Nitrate (A012)
Reference to outcome in company's long-term strategy: *[Any other long-term planning the company may have already published that their proposals feed into].*	See sections 4 and 5 in YWs Long Term Strategy document (Jan 2023)

Section 2

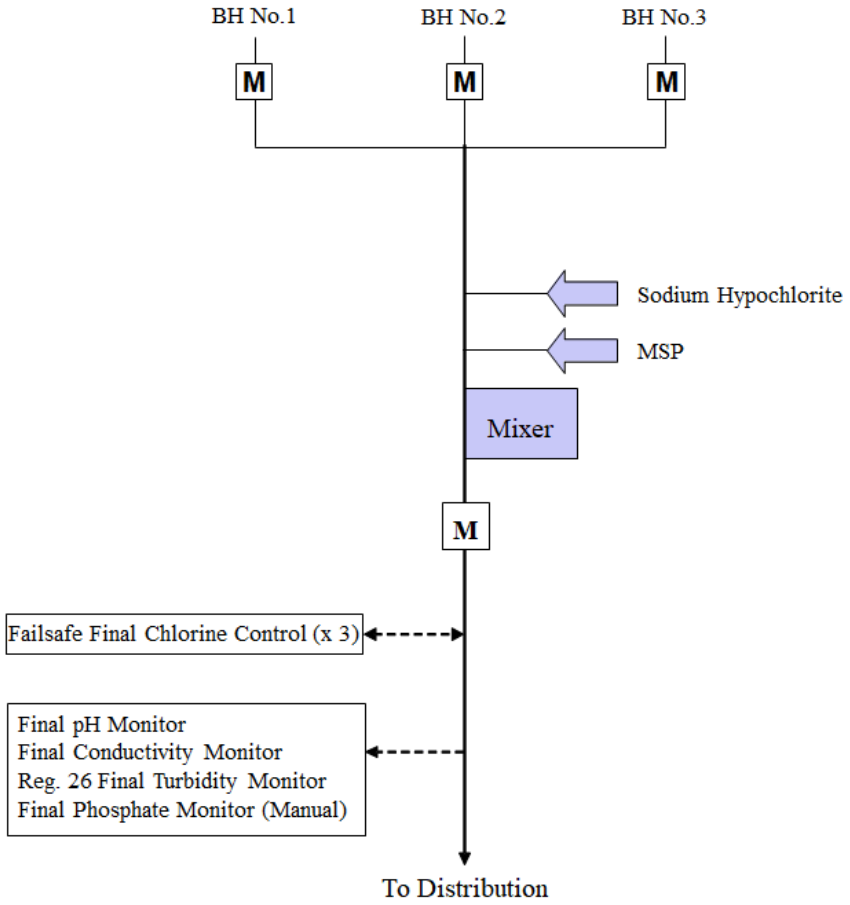
Details of water treatment works and associated supply system	
1	Provide supply arrangements and treatment works details:

Both sites have been historically considered “pristine” and currently employ simple chlorination, as Class 4 WTW under the company’s disinfection classification.

Addition of sodium hypochlorite is controlled by flow and residual chlorine concentration. There are fail-safe systems to prevent the release of unchlorinated water into the supply system.

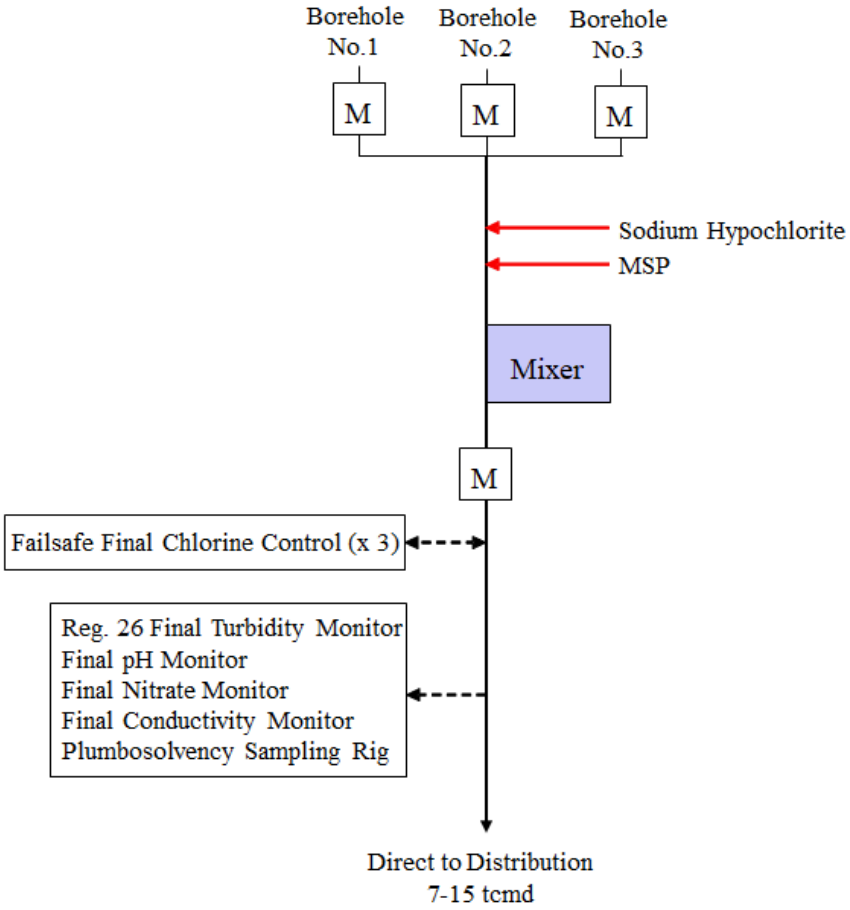
Both sites represent a mixture of low and high nitrate sources. Blending of sources ensures a compliant level of nitrate is provided to customers.

Figure 2.1.1. Austerfield WTW Schematic



Details of water treatment works and associated supply system

Figure 2.1.2. Highfield Lane WTW Schematic

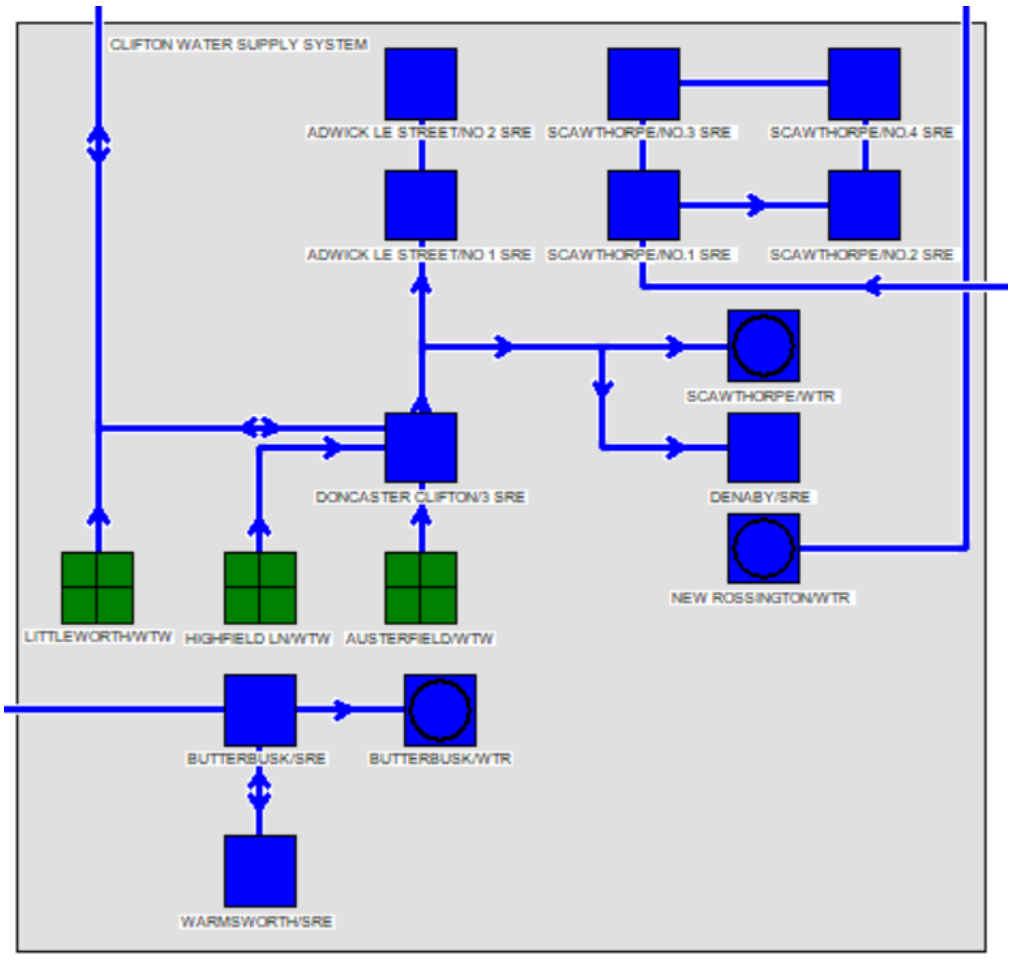


2	A description and diagram of the supply system related to the treatment works

Highfield Lane WTW and Austerfield WTW feed into the Clifton WSS, which in turn forms part of the larger Doncaster supply system, although connectivity between The Clifton and other Doncaster WSS's is limited.

A grid feed into Clifton is available and utilised during periods when peak daily demand exceeds available supply.

Importantly, there are 16 DMAs, representing a population of 36,427, which are supplied directly from either Austerfield WTW or Highfield Lane WTW prior to any mixing with other sources in Doncaster Clifton SRE.

Details of water treatment works and associated supply system	
Figure 2.2.1. Clifton Water Supply System Schematic  	
3	Design capacity of the water treatment works (Ml/d)
Highfield Lane WTW – 16.2 Austerfield WTW – 14.6	
4	Volume supplied: ○ Daily average (Ml/d) ○ Daily maximum (Ml/d)

Details of water treatment works and associated supply system	
	[Please include a commentary if there are any constraints on deployable output due to limitations associated with any part of the treatment process. E.g. constraints in relation to blend water or seasonal constraints]
Daily average (Ml/d): Austerfield WTW – 11, Highfield Lane WTW – 12 Daily maximum (Ml/d): Austerfield WTW – 13, Highfield Lane WTW – 15	
5	Sources of raw water (continuous/ seasonal/ standby) Individual sources are currently blended to minimise nitrate concentrations. *[Include names of each individual source, nature of the source (eg, surface direct abstraction; surface impounding reservoir; borehole; spring; type of aquifer). Where appropriate include detail of any existing raw water optimisation / control measure(s) that are in place (e.g. artificial mixing; selective withdrawal depths for abstraction; raw water monitoring; water column profiling; etc.)]*
Highfield Lane BHS 1, 2 & 3 (Borehole) Austerfield BHS 1, 2 & 3 (Borehole) All boreholes abstract from the Sherwood Sandstone Group aquifer. For Highfield Lane Bh3 is the duty borehole as it has low nitrate and must be operational for the site to run. If Bh3 is offline site shuts down under normal operation.	
6	Treatment processes currently employed (including pre-treatment of raw waters) *[In this case, blending is defined as treatment. This includes blending of raw waters prior to treatment. Please also indicate if bankside storage of raw water is utilised, and average retention time in the reservoir]*
See 2.1.	
7	Service reservoirs/ booster pump details

Details of water treatment works and associated supply system	
N/A	
8	Water supply zones supplied and the population of each water supply zone *[If the supply is blended with waters from other treatment works in the zone, please indicate the relative proportions (as %)]*

Table 2.8.1. WSZs supplied by Austerfield & Highfield Lane WTWs

Site Reference	SiteName	Population
Z3800819	Doncaster - Haxey 2019 WSZ	79,741
Z3801919	Carcroft 2019 WSZ	71,871
Z3801519	Doncaster - Armthorpe 2019 WSZ	66,246
Z3801419	Doncaster - Wadworth 2019 WSZ	62,943

Section 3

Hazard identification and Risk Characterisation	
1	Provide details of the methodology used to identify the hazard. For example: • Historical data, • Events/ incidents including near miss situations, • Operator knowledge, • Modelling and validation of modelling • Site visits/ technical audits
Historical data of sample performance, in relation to routine operational performance and WQ Events. This has been supplemented by investigation of asset condition.	
2	Summary of historical data on the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the raw water source and the water entering supply from the relevant treatment works from compliance, investigative, or operational sampling

Table 3.2.1. Detections of coliform bacteria at raw water sources and works outlets.

Sample Point	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
AUSTERFIELD NO 1 BHS	0	0	0	0	0	0	0	0	0	1	0	0	0	0
AUSTERFIELD NO 2 BHS	0	0	0	0	0	0	0	1	1	0	0	0	0	0
AUSTERFIELD NO 3 BHS	0	1	0	0	0	0	0	0	0	0	0	0	0	0
AUSTERFIELD WTW	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Sample Point	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
HIGHFIELD LANE 1 BHS	0	0	0	0	0	0	0	0	0	0	0	1	0	0
HIGHFIELD LANE 2 BHS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HIGHFIELD LANE 3 BHS	0	0	0	0	1	0	0	0	0	0	0	0	0	0
HIGHFIELD LANE WTW	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3.2.1. Austerfield WTW Nitrate levels

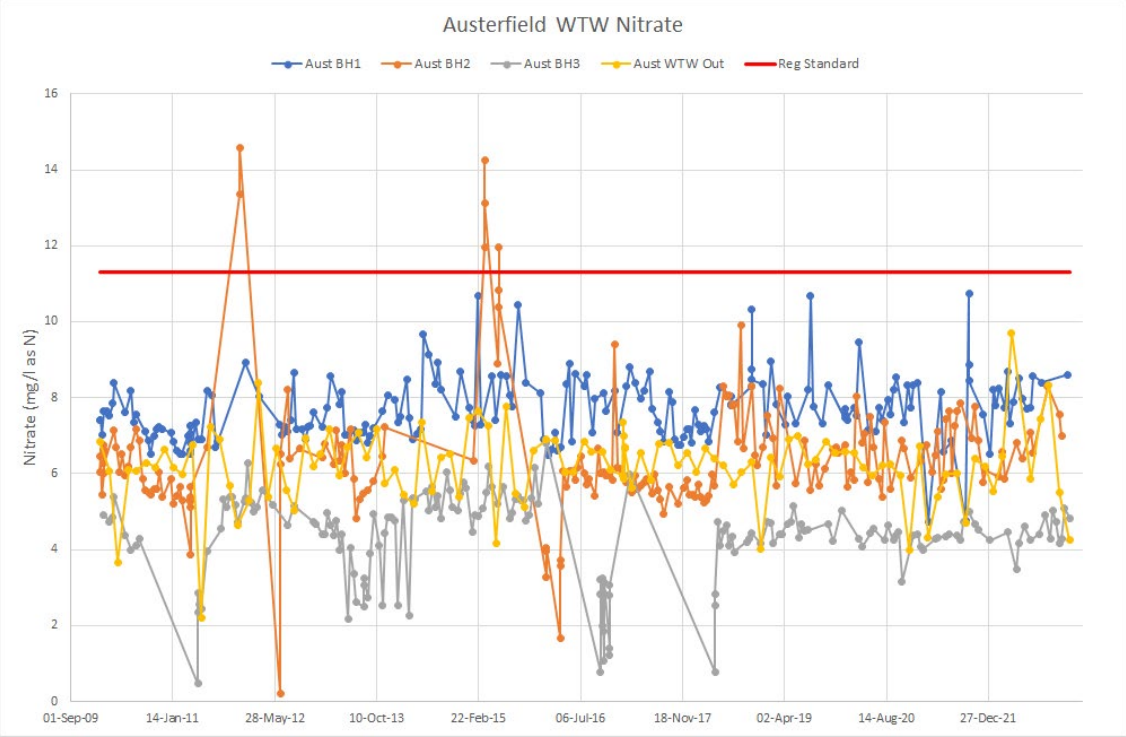
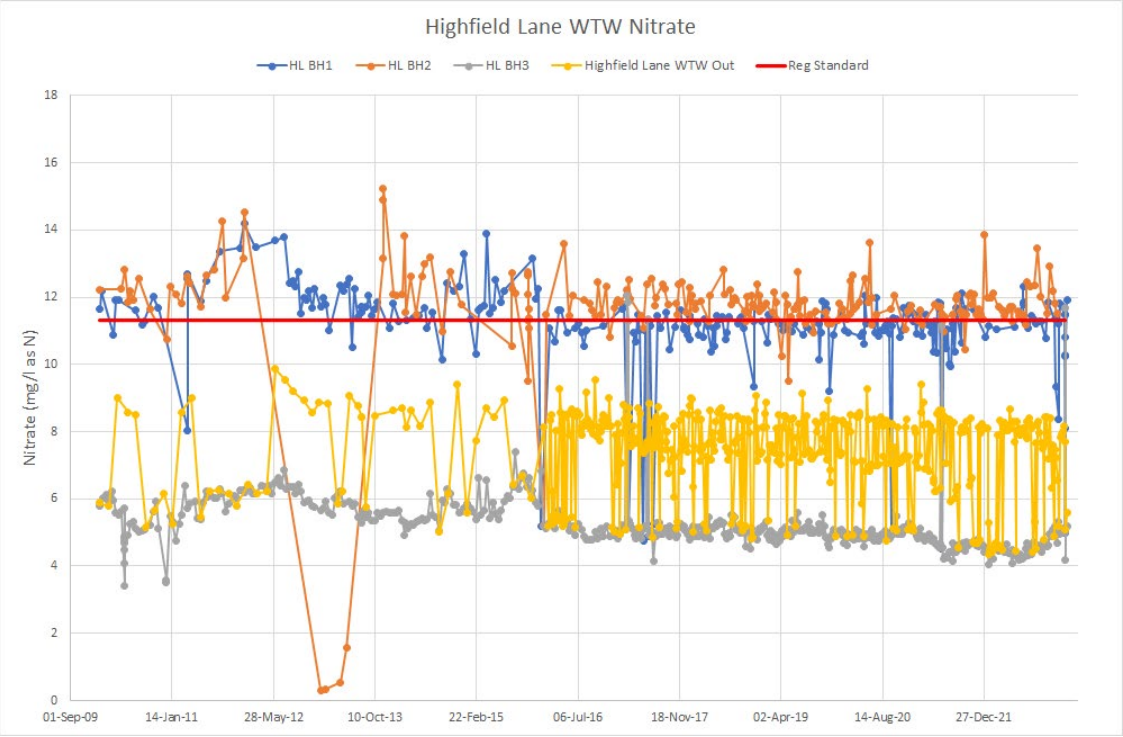


Figure 3.2.2. Highfield Lane WTW Nitrate levels



Hazard identification and Risk Characterisation	
3	Details of any existing contraventions of regulatory requirements and whether they are likely to recur (at WTW, SR and/or at consumers taps)

Since 2010:

15/10/2010: Detection of coliform bacteria at Austerfield WTW. No recurrence of bacteria at the WTW outlet. No conclusive cause was identified.

No detections have been reported at Highfield Lane WTW outlet

There have been no exceedances of the regulatory standard for nitrate at WTW outlets on downstream distribution in the regulatory sampling programme.

5/8/2013: Event 2013/4081 Elevated Nitrate at Highfield Lane WTW

Short term electrical power fluctuation caused the low nitrate borehole (BH No.3) to end a "stopped" condition. Upon works start up the site continued to operate without BH No.3 available. Nitrate levels in excess of 50 mg/l as NO3 were found in samples collected from two directly supplied DMAs.

Interlocks in PLC coding were improved to prevent recurrence.

27/9/2013: Event 2013/4169 Interruption to Chlorine Dosing at Austerfield WTW

Failure of switch-over between chlorine gas dosing systems resulted in a minimal level of chlorine dose into supply, marginally above the automated shutdown value. The shutdown trigger was raised to prevent recurrence. The Company has subsequently removed all chlorine gas dosing systems in favour of sodium hypochlorite dosing.

1/6/2017: Event 2017/6071 Raised Turbidity at Austerfield WTW

Short term spike in turbidity associated with a changeover of in-service boreholes. Raw water quality was impacted as the turn-over of boreholes was being achieved manual not via automated operation. Improvements to site PLCs and return to full automation were implemented.

Hazard identification and Risk Characterisation	
4	If evidence of likely to contravene any regulatory requirement, details of when this is likely to occur (at WTW, SR and/or at consumers taps) including trend analysis & prediction modelling

In their current operational design both WTWs are capable of supplying compliant water to customers. However, both sites are at risk of shutdown due to raw water conditions.

At both sites further minor deterioration in raw water microbiological quality could overwhelm disinfection capability. In addition, both sites are partly or wholly dependent upon a single low nitrate borehole to ensure output is below the regulatory standard for nitrate

It is not possible to provide an accurate prediction of point of failure. However, the current arrangement of independent sites is inherently non-resilient.

The Company's Water Resource Management Plan (WRMP) resource modelling indicates that on a regional basis there will be a deficit of supply by 2025. We are experiencing ever more frequent supply and demand pressures in the area, particularly in the summer, requiring grid support. Hence, a further loss of deployable source cannot be tolerated.

5	Details of any other data relevant to the hazard identified

Historically raw water from source water at both sites is considered to be "pristine". This has allowed chlorination at these sites to be carried out on a "precautionary" basis. The Company's disinfection policy defines Class 4 sites as those where there have been two or less detections of in a rolling 5-year period

Figure 3.5.1 Excerpt from Company Disinfection Policy

5.26 Class 4 Water Treatment Works – Pristine Ground Water Sources

5.27 These sources are of excellent microbiological quality and are not deemed to be at risk of pathogenic microbiological organisms. For inclusion in this category, there must be no more than two detections of coliform bacteria from individual source boreholes for a minimum period of 5 years (based on a minimum of 100 samples).

5.28 All such sources require precautionary chlorination or UV disinfection only.

5.29 Monitoring of the treated water for *Cryptosporidium* is not required for Class 4 WTWs.

However, a review of historical data indicates an intermittent presence of indicator bacteria. The tables below demonstrate the 5-year rolling occurrence of coliform bacteria in routine operational monitoring. Where more than one detection in a 5-year period has occurred, this is highlighted in red text

Table 3.5.1. 5-year rolling occurrence of coliform bacteria 2010-2023

Sample Point	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
AUSTERFIELD NO 1 BHS	0	0	0	0	0	0	0	0	0	1	1	1	1	1
AUSTERFIELD NO 2 BHS	0	0	0	0	0	0	0	1	2	2	2	2	1	0
AUSTERFIELD NO 3 BHS	0	1	1	1	1	1	0	0	0	0	0	0	0	0
AUSTERFIELD All BH	0	1	1	1	1	1	0	1	2	3	3	3	2	1

Sample Point	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
HIGHFIELD LANE 1 BHS	0	0	0	0	0	0	0	0	0	0	0	1	1	1
HIGHFIELD LANE 2 BHS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HIGHFIELD LANE 3 BHS	0	0	0	0	1	1	1	1	1	0	0	0	0	0
HIGHFIELD LANE ALL BH	0	0	0	0	1	1	1	1	1	0	0	1	1	1

Where data collected during borehole run-to-waste (for example after a period of isolation of the borehole) is additionally included then this demonstrates that the underlying risk of the presence of coliform bacteria is much greater.

Table 3.5.2. Individual coliform occurrences in all samples 2010-2023

Row Labels	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
AUSTERFIELD NO 1 BHS	0	0	0	0	0	0	0	0	0	1	0	0	0	0
AUSTERFIELD NO 2 BHS	0	2	15	0	0	0	0	1	1	0	0	0	0	0
AUSTERFIELD NO 3 BHS	0	3	0	0	0	0	9	0	0	0	0	0	0	0
HIGHFIELD LANE 1 BHS	0	0	0	0	0	0	0	0	0	0	0	1	0	1
HIGHFIELD LANE 2 BHS	0	0	0	0	0	2	0	0	0	0	0	0	0	0
HIGHFIELD LANE 3 BHS	7	0	0	0	1	0	0	0	0	0	0	0	0	0

Under the Company's current Disinfection Policy Austerfield WTW and Highfield Lane WTW are the final two sites to be considered Class 4 WTW's requiring chlorination only. Class 4 sites are not required to meet a defined CT target.

This purpose of this submission is to implement controlled disinfection in the form of a chlorine contact tank (or other form of disinfection). Implementing dedicated disinfection would allow removal of the Class 4 categorisation from the Company's policy.

The Company has implemented an operational monitoring plan for flow cytometry parameters at all WTWs. Although direct linkage to pathogenic organisms or indicator bacteria is not well demonstrated, flow cytometry data is well understood to represent the background level of all microorganisms. It is also well understood from international research and the Company's own monitoring that even relatively

low levels of CT due to contact with chlorine cause a significant reduction in ICC (intact cell count) and TCC (total cell count).

It is notable at Austerfield WTW and Highfield Lane WTW that there is little differentiation between ICC between raw water sources and the works outlet.

Figure 3.5.2. Austerfield WTW Flow Cytometry Monitoring

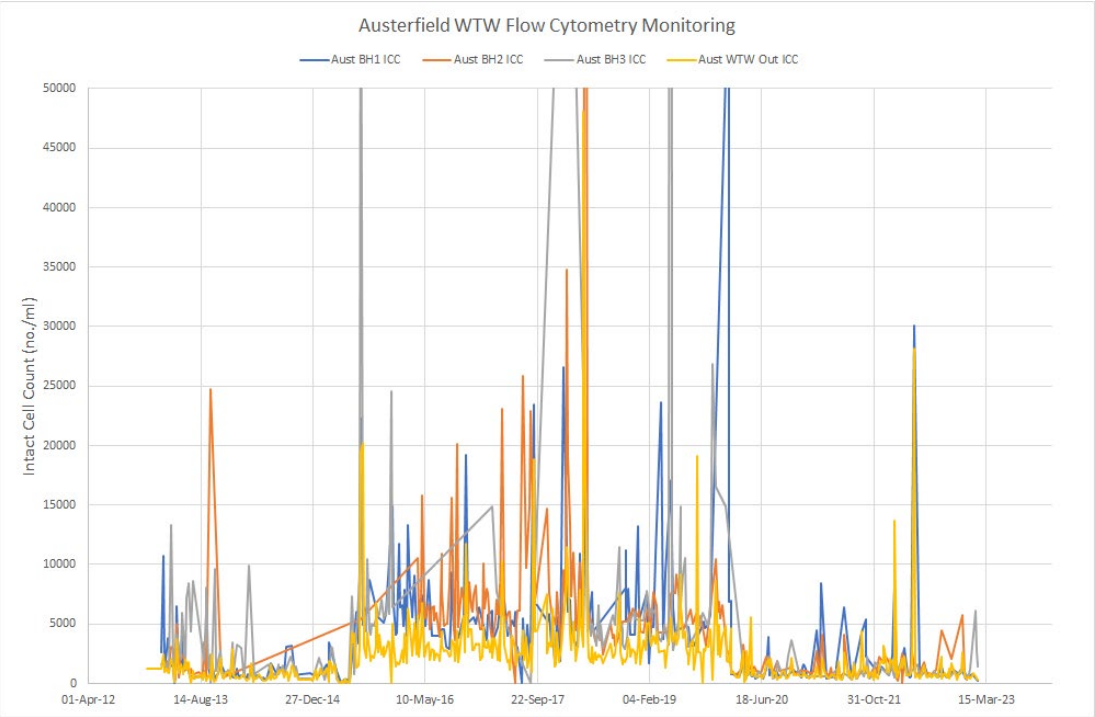
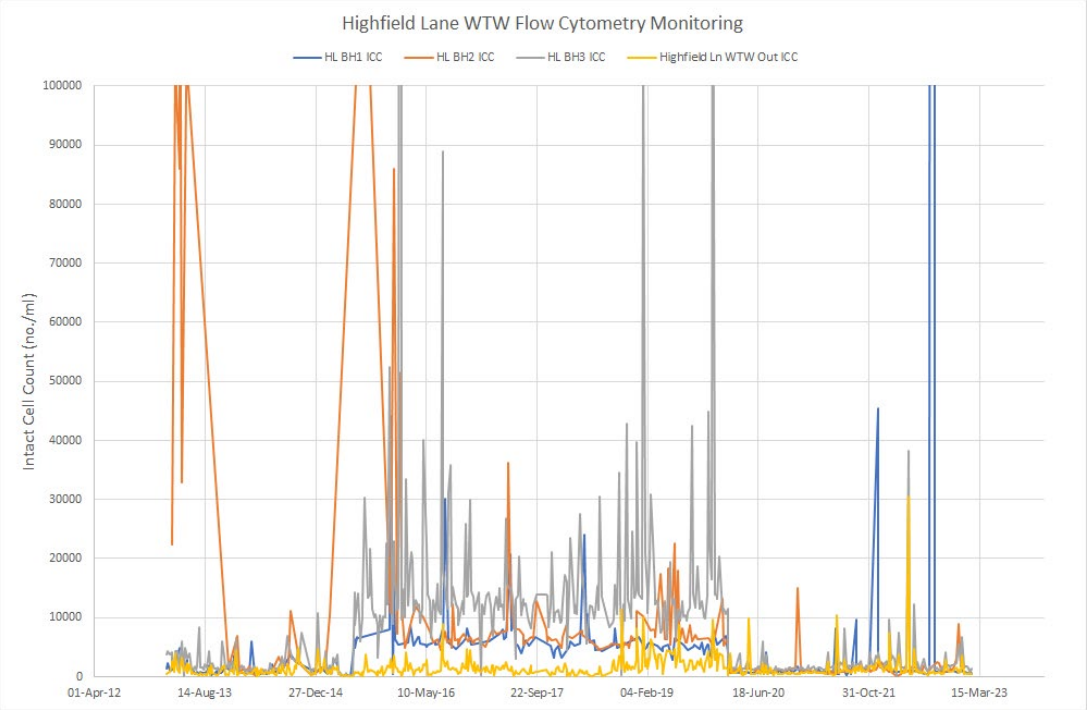


Figure 3.5.3. Highfield Lane WTW Flow Cytometry Monitoring

Hazard identification and Risk Characterisation	
	
6	If appropriate, summary of data/ information on consumer complaints
n/a	
7	Details of any events that have occurred in the catchment, at the treatment works and in supply that are associated with hazard identified
No events known.	
8	Details of any existing control measure(s) that might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the catchment, in treatment and in supply
The area is predominately agricultural with some industry. Yorkshire Water does not own the catchment for Doncaster boreholes. The agricultural landowners will follow various regulations to reduce water and air pollution such as the Farming Rules for Water Regulation. The area is also within a nitrate vulnerable zone which has further regulations around nutrient applications and is regulated by the Environment Agency. The area is also covered by Catchment Sensitive Farming (CSF). This enables farmers to have access to DEFRAs Countryside Stewardship schemes and water grants. The services include grants to improve farm infrastructure, 121 advice	

Hazard identification and Risk Characterisation
and best practice workshops and events to improve the water and air environment. The Company attended the local agricultural show (Sykehouse Show) in 2022 to help spread awareness of local water quality and offer advice on farming best practice, this was in partnership with CSF. Additionally, our contractors have started farmer engagement which involved a meeting at the local Rugby club in October 2022 in partnership with CSF and local farmers. Continuation of the stakeholder engagement is proposed for WINEP in AMP8. In addition to the farming regulation and improving best practice in the catchment through partnership with CSF, the boreholes have casings to prevent surface water infiltration and therefore prevent surface bacteria entering the borehole. • Furthermore, there has been an AMP7 Water Industry National Environment Programme (WINEP) scheme in the Doncaster area focusing on nitrate catchment characterisation, investigating the links between nitrate usage and nitrate in the aquifer. There is a specific investigation underway for Highfield Lane where the risk is greatest. This investigation will report in 2024. The investigations main objectives are: • Engagement – set up local group with land users to share the problem; make formal approach for collaborative working with existing catchment based groups; farm visits; attend meetings and events • Gather relevant data (such as cropping and nutrient use information) to enable focusing of resources and engagement with land users. • Monitoring – water quality, land use, cropping, nitrate use The conceptual understanding of the catchment and groundwater flows will be updated as well. As a result of work to date agricultural use of nitrate is the most likely source of the rising nitrate. Enhanced catchment investigation and monitoring are likely to be recommended to manage the problem. Both sites are designed with integral “interlocks” that prevent operation of the site when the relevant low nitrate borehole is not available. This is supported by site specific operating procedures and flags on telemetry systems. Both sites are designed with on-line telemetry for flow, pH, turbidity, and residual chlorine concentration, with appropriate alarms in place. And in common with all of the Company’s sodium hypochlorite dosing sites they are equipped with disinfection failsafe system triggered upon a number of criteria including raised turbidity, loss of sodium hypochlorite dose, and low residual chlorine concentration.

Hazard identification and Risk Characterisation	
9	Details of monitoring of the existing control measure(s) (including validation monitoring)
Alarms raised at both sites are flagged for investigation or action as appropriate by the Company's 24-hour control room. Fail-safe shutdown systems are subject to annual test of range of shutdown parameters. Operation of the sites is assured by collection of samples for coliform and *E. coli* bacteria. Austerfield Boreholes x52 per year when in service Austerfield WTW outlet x208 per year Highfield Lane boreholes x52 per year when in service Highfield Lane WTW outlet x365 per year This is supplemented by collection of Flow Cytometry parameters x 52 per year at borehole and WTW outlet	
10	Details of any changes in practices or policy which might have influenced the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in water supplied to consumers, i.e., in relation to resources, blending arrangements, treatment or supply arrangements and the dates of those changes
N/A	
11	Details of any licensed abstraction issues which might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in raw water
N/A	

Hazard identification and Risk Characterisation	
12	Reasons for the presence of the hazard, if known, otherwise details of what is being done to identify the source of the hazard

The geology of the Doncaster boreholes comprises of Sherwood Sandstone which has slow travel times, there is a very thin permeable drift cover and there are sand and gravel pits within source protection zone two which may increase pathways.

These groundwaters have historically been assessed as "pristine", which was based upon the absence of indicator organisms. Development of molecular identification techniques now indicates that this assessment was limited and that groundwater has higher background bacterial (although not necessarily pathogenic bacteria) counts than previously thought. We are also increasingly seeing the presence of indicator bacteria in standard culture-based analysis.

Rising and high nitrate levels are almost certainly due to application of nitrate fertilisers for agricultural production. Further testing will likely confirm this.

13	Outline Risk characterisation. For example, details and score arising from consequence v. likelihood matrix, where score sits in the risk profile for the supply system.

The Company's DWSP Risk matrix incorporates a 5 x 5 scale severity and probability matrix. Our system adopts the DWI severity scores and combines this with an estimate probability (in bands of 20%) of failure within the next 12 months.

Table 3.13.1. DWSP Risk Matrix

		Severity				
		1 - VL	2 - L	3- M	4 – H	5 – VH
Probability	5 – VH	9	14	18	22	25
	4 – H	7	12	17	21	24
	3 – M	5	10	15	19	23
	2 – L	3	6	11	16	20
	1 - VL	1	2	4	8	13

Hazard identification and Risk Characterisation
Full details of risk assessments are shown in the relevant Reg28 Reports, but in summary there is reasonably high probability of presence in the raw water supplying Austerfield WTW and Highfield Lane WTW, but relatively lower probability of detections of indicator organisms in outlet supply in the next 12 months. On a longer timescale we consider that there is a high risk of fails at some point in the future. The assessment for the risk of nitrate is nuanced. Both sites are only individually sustainable due to continued operation of low nitrate boreholes. The timeframe over which this will become unsustainable is less clear – but is a foreseeable risk.

AssetRef	HazardRef	PreLikelihood	PreConsequence	Risk	PostLikelihood	PostConsequence	Residual Risk	DWICategory	HazardID
A3610450	A012	3	5	23	3	5	23	G	45786
A3610450	A012	3	5	23	3	5	23	I	45786-F
A3610450	C001	1	5	13	1	5	13	G	58508
A3610450	C002	1	5	13	1	5	13	G	42736
T3690600	A012	3	5	23	2	5	20	E	43701
T3690600	A012	3	5	23	3	5	20	I	43701-F
T3690600	C001	1	5	13	1	5	13	E	58692
T3690600	C001	3	5	23	3	5	23	I	58692-F
T3690600	C002	1	5	13	1	5	13	E	40692
T3690600	C002	3	5	23	3	5	23	I	40692-F
A3612700	A012	5	5	25	3	5	23	G	42299
A3612700	A012	5	5	25	3	5	23	I	42299-F
A3612700	C001	1	5	13	1	5	13	G	58571
A3612700	C002	3	5	23	1	5	13	G	48053
T3692700	A012	5	5	25	1	5	13	E	40202
T3692700	A012	5	5	25	3	5	23	I	40202-F
T3692700	C001	1	5	13	1	5	13	E	58755
T3692700	C001	3	5	23	3	5	23	I	58755-F
T3692700	C002	1	5	13	1	5	13	E	46023
T3692700	C002	3	5	23	3	5	23	I	46023-F

Section 4

Control Measures Required – Details of short, medium and long term control measures	
1	Details of short-term actions currently in place to mitigate against risk & their effect
Current performance on WTW outlet has been satisfactory.	

Control Measures Required – Details of short, medium and long term control measures	
Hence, in the short term there will be continuation of existing control measures in place.	
2	Details of mid to long term control measures identified for any residual risk: o Options the company has considered which should, where appropriate, include catchment management controls, or communications controls in association with other stakeholders o Timescale for delivery of each option o Capital costs and net additional operating costs of each option considered o Summary of costs and benefits of each option o Reasons for choosing the preferred option o Specific supporting evidence that the preferred option will address risk of hazard within the required timescale
After investigation by our strategic planning partner, it was decided that the preferred solution was the installation of a contact tank along with rationalisation for treatment of all sources at a single site. This is believed to be the best solution from a totex perspective. The preferred solution in table 4.2.1 is option 1 which includes supplies from Littleworth borehole as this maximises nitrate blending and provides wider resilience. Other potential solutions such as UV and a nitrate removal plant were discounted as part of the optioneering process due to feasibility and high totex cost associated with energy demand and requirements for new power supplies in a rural area. The catchment nitrate scheme in the WINEP programme currently running (starting AMP7, continuing into AMP8), will deliver in the medium to long term. E.g. starting to see agriculture changes in catchment, adding instrumentation to document and track changes. Twin track approach will continue (treatment and catchment management). Table 4.2.1 Costs and benefits of options considered	

Control Measures Required – Details of short, medium and long term control measures

Options Considered	Capital Costs (£m)	Net Operational Costs (£m/pa)	Delivery Timescale (yrs)	Unplanned Outage Benefit (MLD)	CRI	Preferred Solution (AMP8)
Highfield/Austerfield Lane BHS – Disinfection Scheme + Littleworth Rehab	£22.58	£0.89	5	36.50	0	Y
Austerfield & Highfield Combine Flows and Treatment – Disinfection Scheme	£16.37	£0.68	5	32.00	0	N
Highfield Lane - Pesticide & Nitrate Catchment Management	£ -	£0.12	5	N/A	N/A	Y

3	Full details of how the company intends to assess and measure the benefits delivered (the outcome), including details of proposed sampling programme, number of samples to be taken over the specified period and parameters to be monitored.

The key success of the scheme is delivery of a fully new water treatment works

The proposal is to build upon existing monitoring programmes. In Phase 1 monitoring is in place to confirm any deterioration of raw water conditions. Phase 2 monitoring is designed to confirm beneficial outcome of the scheme.

Phase 1 Prior to beneficial completion of scheme

Coliform and *E. coli* samples

Austerfield Boreholes – increased from x52 to x104 per year when in service

Highfield Lane boreholes – increased fromx52 to x104 per year when in service

This is supplemented by collection of 1L coliform/*E.coli* large volume x12 per year

Control Measures Required – Details of short, medium and long term control measures
Continuation of flow cytometry parameters x 52 per year at borehole and WTW outlet Phase 2 Following beneficial completion of scheme Borehole samples to revert to x52 per year when in service, 1L monitoring is removed New site WTW outlet - Coliform and *E. coli* samples x365 per year New site WTW outlet - 1L coliform/*E.coli* large volume x12 per year Continuation of flow cytometry parameters x 52 per year at borehole and WTW outlet In both phases N group monitoring at WTW outlets x52 per year.

B3 East Ness

Appendix B: East Ness WTW

Section 1

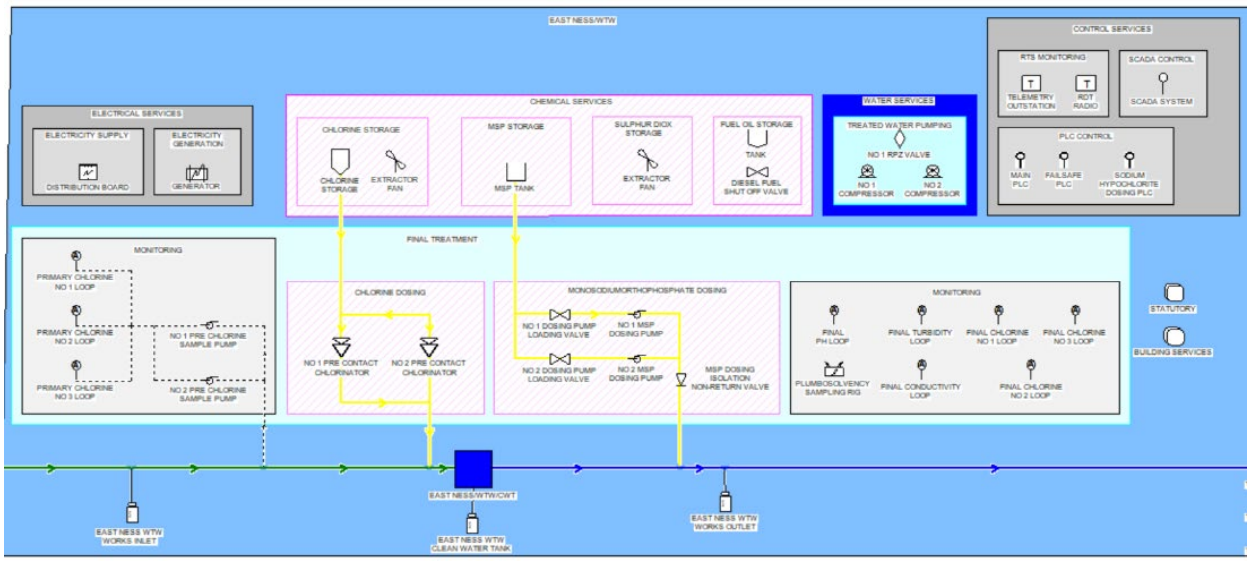
Background information	
Water Company	Yorkshire Water
Date of submission	31st March 2023
Name of Supply System	East Ness Howe Hill / Water Supply System
Regulation 28 report(s) reference number(s) (Unique reference number for each report that applies):	YKS-Risk-A2612750-03-23.csv YKS-Risk-T2692750-03-23.csv
Name of Water Treatment Works/ Distribution System/ Service Reservoir/ Other asset	East Ness WTW
Water Quality hazard(s)/driver(s) identified:	Coliforms (C001), *E. coli* (C002), *Clostridia perfringens* (C004)
Reference to outcome in company's long-term strategy: *[Any other long-term planning the company may have already published that their proposals feed into].*	See sections 4 and 5 in YWs Long Term Strategy document (Jan 2023)

Section 2

Details of water treatment works and associated supply system	
1	Provide supply arrangements and treatment works details:

Treatment consists of chlorination with contact tank and MSP dosing. A temporary cartridge type filter unit is also currently in place to mitigate WQ risks associated with the boreholes prior to delivery of the proposed scheme.

Figure 2.1.1 East Ness WTW Schematic.

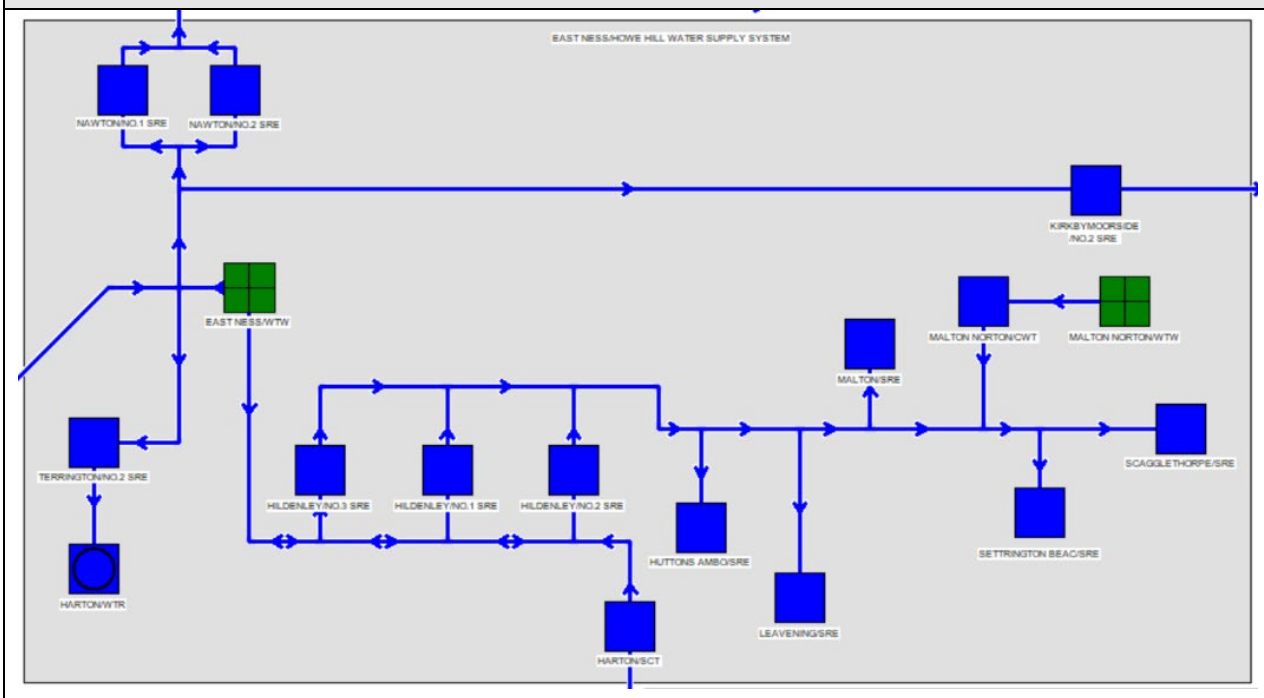


2	A description and diagram of the supply system related to the treatment works

East Ness WTW along with Malton Norton WTW supply the East Ness WSS system. East Ness provides the majority of the supply to the reservoirs in the system at a ratio of around 3:1.

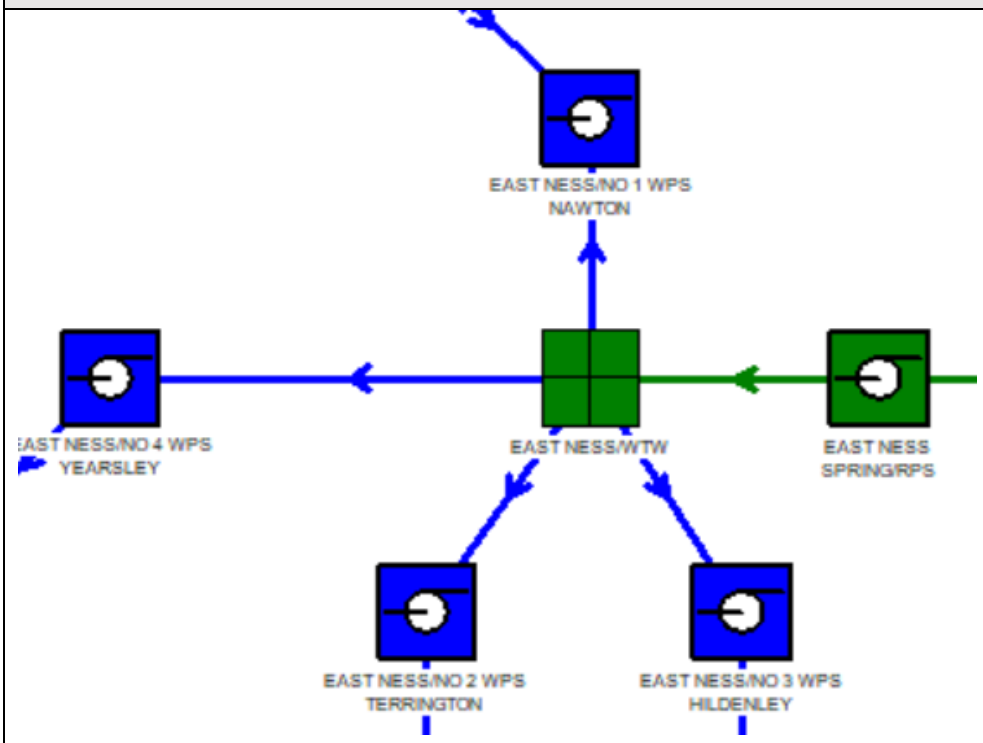
It also exports to neighbouring WSS's via Kirkbymoorside SRE, Nawton SRE and Yeasley SRE. When the adjacent Huby/Yearsley WSS is in deficit due to a prolonged unplanned outage at Huby WTW, East Ness can in theory provide a back-up supply. However, currently at East Ness flow is restricted to prevent unacceptable water quality, and hence support to other areas is limited.

Figure 2.2.1 Supply System Schematic related to East Ness WTW

Details of water treatment works and associated supply system	
	
3	Design capacity of the water treatment works (Ml/d)
11.2 Ml/d	
4	Volume supplied: ○ Daily average (Ml/d) ○ Daily maximum (Ml/d) *[Please include a commentary if there are any constraints on deployable output due to limitations associated with any part of the treatment process. E.g. constraints in relation to blend water or seasonal constraints]*
Daily average (Ml/d): 9 Ml/d Daily maximum (Ml/d): 12.5 Ml/d Max flow is usually restricted to 9.5 Ml/d due to temporary filters in place to mitigate *C. Perfringens* risk. Flows above this level can only be achieved with a time-limited production risk assessment (PRA) in place.	

Details of water treatment works and associated supply system	
5	Sources of raw water (continuous/ seasonal/ standby) *[Include names of each individual source, nature of the source (eg, surface direct abstraction; surface impounding reservoir; borehole; spring; type of aquifer). Where appropriate include detail of any existing raw water optimisation / control measure(s) that are in place (e.g. artificial mixing; selective withdrawal depths for abstraction; raw water monitoring; water column profiling; etc.)]*
East Ness BHS 1 (borehole) East Ness BHS 1A (borehole)	
6	Treatment processes currently employed (including pre-treatment of raw waters) *[In this case, blending is defined as treatment. This includes blending of raw waters prior to treatment. Please also indicate if bankside storage of raw water is utilised, and average retention time in the reservoir]*
See 2.1 above.	
7	Service reservoirs/ booster pump details
Four booster pumping stations are located on site which supply various Service Reservoirs in the area; East Ness No.1 WPS/Nawton East Ness No.2 WPS/Terrington East Ness No.3 WPS/Hildenley East Ness No.4 WPS/Yearsley Figure 2.7.1 Pumping Arrangements from East Ness WTW	

Details of water treatment works and associated supply system



8	Water supply zones supplied and the population of each water supply zone *[If the supply is blended with waters from other treatment works in the zone, please indicate the relative proportions (as %)]*

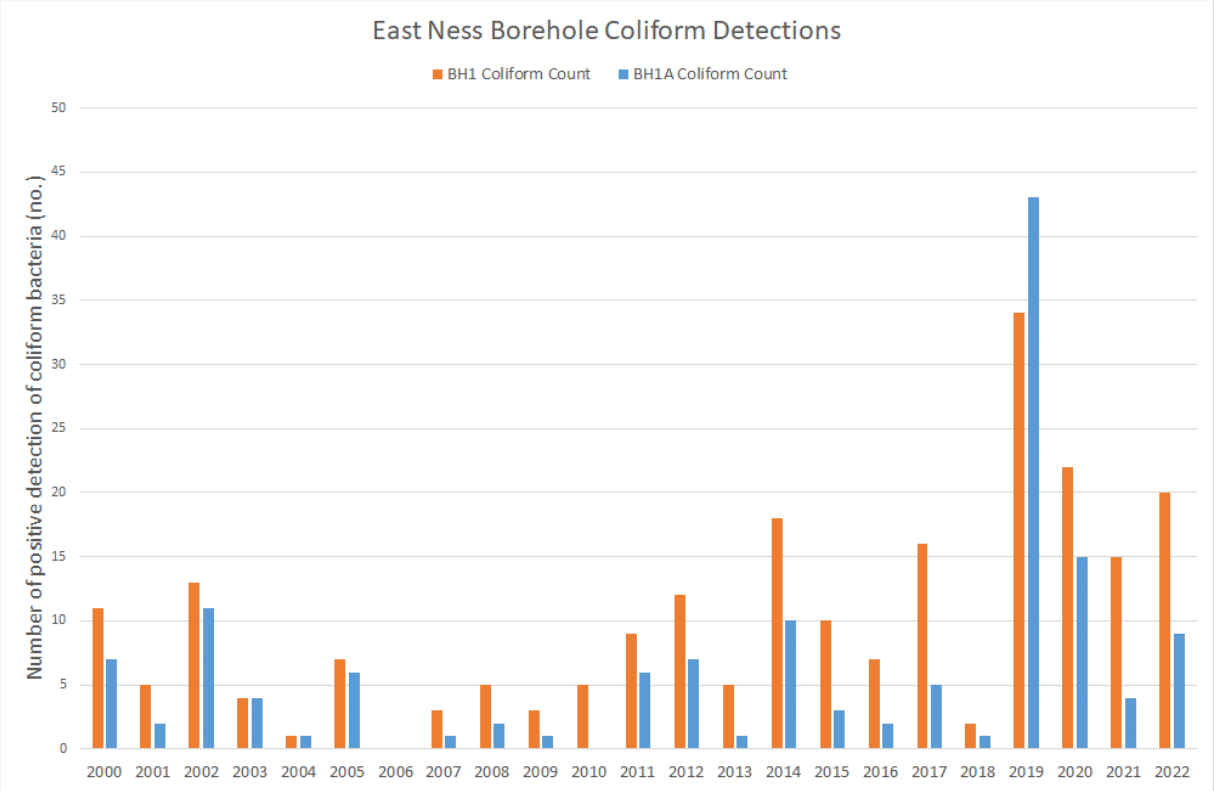
Table 2.8.1 2023 Populations of the impacted WSZs

Site Reference	SiteName	Population
Z2804819	Malton 2019 WSZ	36,793
Z2801719	Easingwold 2019 WSZ	22,057

Section 3

Hazard identification and Risk Characterisation	
1	Provide details of the methodology used to identify the hazard. For example: • Historical data, • Events/ incidents including near miss situations, • Operator knowledge, • Modelling and validation of modelling • Site visits/ technical audits
Historical data of sample performance, in relation to routine operational performance and WQ Events. This has been supplemented by investigation of asset condition. Assessment of the contribution to overall water supply resilience.	
2	Summary of historical data on the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the raw water source and the water entering supply from the relevant treatment works from compliance, investigative, or operational sampling
Source waters for East Ness WTW have historically been known to contain indicator bacteria on an intermittent basis. Consequently, controlled disinfection by chlorine within a defined contact tank is an element of the treatment process. Recent data has indicated an increased occurrence of coliform bacteria in raw water sources. The number of positive detections in samples collected from each of the boreholes supplying the site is shown below. Figure 3.2.1 East Ness Borehole coliform detections	

Hazard identification and Risk Characterisation

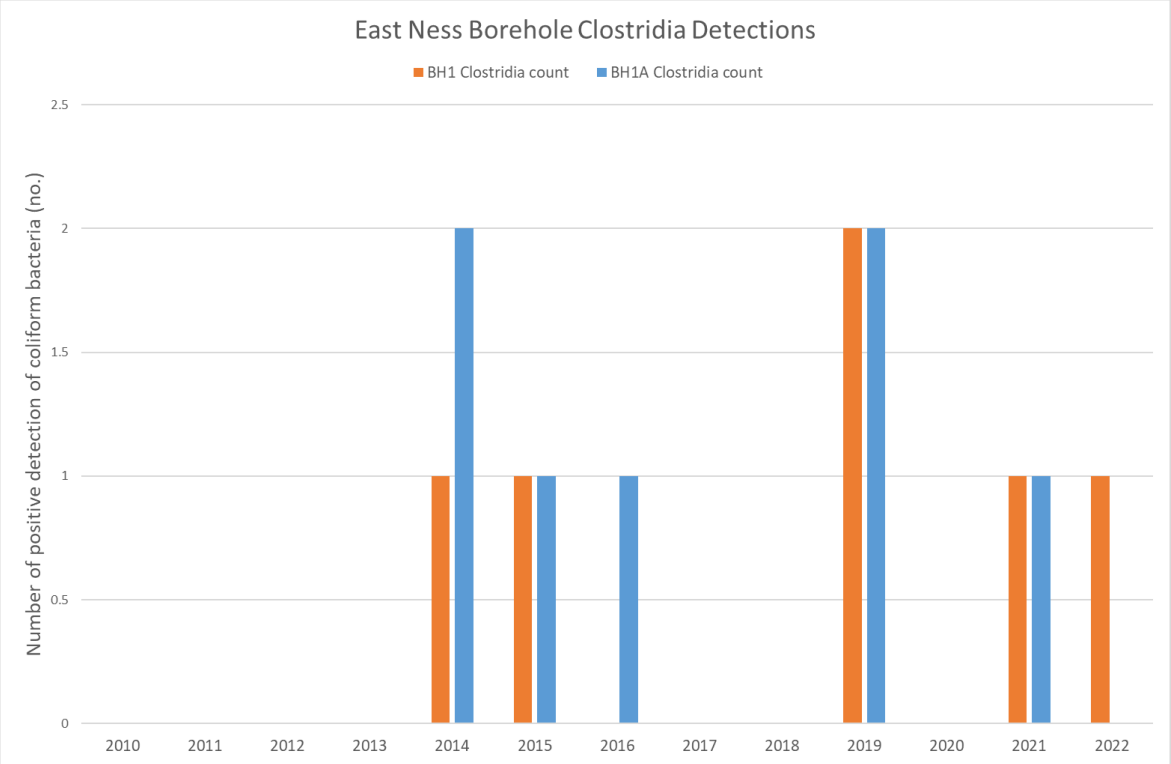


The data demonstrates an increased challenge to the existing disinfection process.

Similar monitoring data since 2010 for *C. perfringens* indicates an intermittent occurrence of this chlorine insensitive organism.

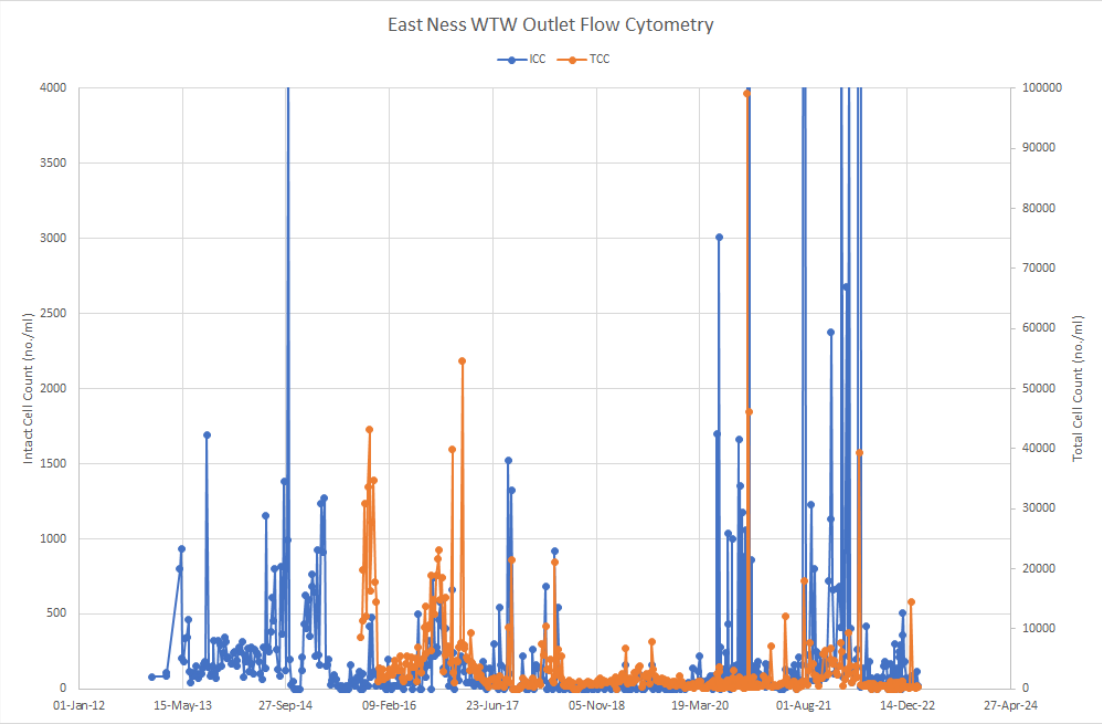
Figure 3.2.2 East Ness Borehole *C. perfringens* detections

Hazard identification and Risk Characterisation



This traditional culture sample data is consistent with data obtained as part of the Company's operational flow cytometry sample monitoring

Figure 3.2.3 East Ness Borehole flow cytometry monitoring



Hazard identification and Risk Characterisation	
Notably, sample data demonstrates an absence of indicator bacteria detections during the low rainfall periods of 2018. Following the detection of *E. coli* in a regulatory sample at East Ness WTW it was concluded that rapid recharge of groundwater following a sustained period of dry weather was a contributory factor to the raw water challenge.	
3	Details of any existing contraventions of regulatory requirements and whether they are likely to recur (at WTW, SR and/or at consumers taps)
12th September 2022. Event 2022/8734 *E. coli* at East Ness WTW Detection of coliform and *E. coli* bacteria in a regulatory sample. Notified as an Event, although subsequently classified as 'Not an Event' and assessed under Sept 2022 Compliance. The site was found to be operating above the minimum level of disinfection required for the site - I.e. CT due to freely available chlorine achieving 2 log10 inactivation of Coxsackie A2 virus. The cause was found to be related to rapid recharge of ground aquifer after an extended period of dry weather. This was exacerbated by the arrangement and condition of borehole No.1A, which has been indicated by CCTV survey to require maintenance on the borehole casing. Boreholes No.1 and No.1A are hydraulically linked.	
4	If evidence of likely to contravene any regulatory requirement, details of when this is likely to occur (at WTW, SR and/or at consumers taps) including trend analysis & prediction modelling
Expectation is that under similar circumstance to those occurring in 2022, i.e. rapid recharge of ground water after an extended period of dry weather, it is likely there could be recurrence of bacteria in water supplied to customers. Drier and hotter summers are expected to occur more frequently in national climate forecast models.	

Hazard identification and Risk Characterisation	
5	Details of any other data relevant to the hazard identified
Borehole surveys have identified Borehole 1 has a short casing with no other signs of damage or contamination. Borehole 1A has a short casing and signs of extensive tree root damage.	
6	If appropriate, summary of data/ information on consumer complaints
N/a	
7	Details of any events that have occurred in the catchment, at the treatment works and in supply that are associated with hazard identified
Groundwater movement in the Corallian Limestone Group is dominated by fissure flow, with water able to move rapidly through dissolution features along joints and bedding planes. In places the limestones are known to be karstic with significant voids and conduits. This allows water to move significant distances in a short time and can result in short residence times in the aquifer between recharge and abstraction. During heavy rainfall events, bypass recharge may occur, particularly where soils and superficial deposits are thin or absent. This effect may be exaggerated where rain falls onto very dry ground due to poor absorption in the soil. Where rapid recharge occurs, bacteria from the surface may be washed into the aquifer and these may be rapidly transported to the point of abstraction.	
8	Details of any existing control measure(s) that might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the catchment, in treatment and in supply.
The source protection zone (SPZ) for East Ness boreholes is predominately agricultural. Most of the farming in the SPZ is arable with some mixed farming towards the North of the SPZ near to the River Rye. There are five villages within the SPZ with the small village of West Ness within SPZ1. Yorkshire Water does not own	

Hazard identification and Risk Characterisation	
the catchment for East Ness boreholes. The landowners will follow various regulations to reduce water and air pollution such as the Farming Rules for Water Regulation. There is also a small section towards the South in SPZ2 that is a SSSI. This land will have restrictions to what activities can occur in order to protect the environment. The East Ness SPZ is within the River Rye catchment which is a high priority area for Catchment Sensitive Farming (CSF). This enables farmers to have access to DEFRAs Countryside Stewardship schemes and water grants. The services include grants to improve farm infrastructure, one to one advice, best practice workshops and events to improve the water and air environment. In addition to the farming regulation and improving best practice in the catchment through partnership with CSF, the boreholes have casings. This is to prevent surface water infiltration and therefore prevent surface bacteria entering the borehole. The current WTW arrangement includes a satisfactory sodium hypochlorite dosing system, which meets the Company's standard requirements for CT at a surface water influenced ground water site. It is expected that this system remains adequate to meet normal raw water challenge. However, the Company is currently investigating the possibilities of installing a medium term super-chlorination and de-chlorination arrangement to boost applied CT for recurrence of extreme events. Filtration systems capable of removing *C. perfringens* have been installed at East Ness WTW since 2020. However, the original system restricted flow through the site to a maximum 10.5 Ml/d. The abstraction license capacity of the site is 17Ml/d. An upgraded filtration system rated at 17 Ml/d is due for commissioning in Summer 2023. This will allow the site to meet the current site throughput capacity of 12 Ml/d The intention is to increase total site capacity to meet the abstraction license as part of this scheme.	
9	Details of monitoring of the existing control measure(s) (including validation monitoring)
Water quality samples are collected on the in-service borehole at time of visit: coliform/*E. coli*, *C. perfringens* – including 1L large volume, Enterococci – 104 per year. Flow cytometry – 52 per year	

Hazard identification and Risk Characterisation	
In addition to regulatory requirements, water quality samples are collected from the WTW outlet: Flow cytometry – 52 per year	
10	Details of any changes in practices or policy which might have influenced the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in water supplied to consumers, i.e., in relation to resources, blending arrangements, treatment or supply arrangements and the dates of those changes
N/A.	
11	Details of any licensed abstraction issues which might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in raw water
N/A.	
12	Reasons for the presence of the hazard, if known, otherwise details of what is being done to identify the source of the hazard
N/A	
13	Outline Risk characterisation. For example, details and score arising from consequence v. likelihood matrix, where score sits in the risk profile for the supply system.
The Company's DWSP Risk matrix incorporates a 5 x 5 scale severity and probability matrix. Our system adopts the DWI severity scores and combines this with an estimate probability (in bands of 20%) of failure within the next 12 months. Table 3.13.1 DWSP Risk Matrix	

Hazard identification and Risk Characterisation

		Severity				
		1 - VL	2 - L	3- M	4 – H	5 – VH
Probability	5 – VH	9	14	18	22	25
	4 – H	7	12	17	21	24
	3 – M	5	10	15	19	23
	2 – L	3	6	11	16	20
	1 - VL	1	2	4	8	13

Full details of risk assessments are shown in the relevant Reg28 Reports, but in summary in water supplied to customers the likely presence of coliform, *E. coli* or *Clostridia* are considered low in the next 12 months. However, in the context of increased likelihood of weather patterns seen in 2022 (very dry, and then very wet weather) the likely future presence of indicator organisms is considered a red risk.

Table 3.13.2 Summary of DWSP Risks

AssetRef	HazardRef	PreLikelihood	PreConsequence	Risk	PostLikelihood	PostConsequence	Residual Risk	DWICategory	HazardID
A2612750	C001	5	5	25	5	5	25	G	59830
A2612750	C002	5	5	25	5	5	25	G	42880
A2612750	C004A	5	4	22	5	4	22	G	43108
T2692750	C001	5	5	25	1	5	13	E	40017
T2692750	C001	5	5	25	3	5	23	I	40017-F
T2692750	C002	4	5	23	1	5	13	E	44759
T2692750	C002	4	5	23	3	5	23	I	44759-F
T2692750	C004A	5	4	22	2	4	16	E	44446
T2692750	C004A	5	4	22	3	4	21	I	44446-F

Section 4

Control Measures Required – Details of short, medium and long term control measures	
1	Details of short-term actions currently in place to mitigate against risk & their effect
Continuation of catchment management activity. Operation of current disinfection process including filtration removal of *C. perfringens* and contact with chlorine in a defined contact tank.	
2	Details of mid to long term control measures identified for any residual risk: o Options the company has considered which should, where appropriate, include catchment management controls, or communications controls in association with other stakeholders o Timescale for delivery of each option o Capital costs and net additional operating costs of each option considered o Summary of costs and benefits of each option o Reasons for choosing the preferred option o Specific supporting evidence that the preferred option will address risk of hazard within the required timescale
A number of options have been considered to resolve the bacteriological issues at East Ness WTW. A catchment investigation has been undertaken however, no root cause or high-risk activity was identified, leading to a very low confidence in a catchment approach positively addressing the risk. Hence, the preferred option is an end of pipe, treatment solution. 1. New borehole arrangement and distribution pumping (preferred option). This option has the similar estimated capex as option 2, however, it addresses the issues with the short casings of the existing borehole (by re-lining BH1 and abandoning BH1A), and also include the drilling of a new borehole at another site to allow site throughput to be increased to the 17Ml/d allowed by the	

Control Measures Required – Details of short, medium and long term control measures

licence. Coupled with improvements to the distribution pumps on site, this solution improves water quality, resilience, and site throughput.

The above option water quality solution will be delivered in conjunction with a network resilience solution to improve security of supplies in the Huby water supply system. This resilience scheme is costed at £3.25m but these costs are not included in the table below or as part of this submission (Total DWI plus resilience scheme: £14.47m).

2. Enhanced disinfection with super- and de-chlorination. Considered in more detail than option 3, however, this would not eliminate the risk associated with the short casings, nor would it increase site flows to the current licence (17 Ml/d) to increase deployable output and improve resilience. In addition, *C. perfringens* is relatively resistance to chlorine.
3. Abandonment of East Ness WTW, new supply from Elvington WTW. This option was quickly discounted due to high cost (estimated twice the capex of other options) and the fact it would mean the abandonment of a viable water resource at the same time the WRMP is identifying the need for new resources due to a supply/demand deficit.

Table 4.2.1 Comparison of cost and benefits of options

Options Considered	Capital Costs (£m)	Net Operational Costs (£m/pa)	Delivery Timescale (yrs)	Unplanned Outage Benefit (MLD)	CRI	Preferred Solution (AMP8)
East Ness WTW - New BH Arrangement & Distribution Pumping	£11.22	£0.28	4	4.5	0.13	Y
East Ness WTW - Enhanced Disinfection Process and Throughput improvements	£10.15	£0.08	4	0	0.13	N
East Ness WTW - Abandonment and Supply from Elvington WTW	£23.63	£0.09	4	-12.5	0.13	N

Control Measures Required – Details of short, medium and long term control measures	
3	Full details of how the company intends to assess and measure the benefits delivered (the outcome), including details of proposed sampling programme, number of samples to be taken over the specified period and parameters to be monitored.

The measure of success for the proposed scheme, is the absence of indicator bacteria in water supplied to customers from East Ness WTW.

Evidence suggests that the risk is greatest when a combination of specific conditions occur.

The proposal is to build up existing monitoring programmes. In Phase 1 monitoring is in place to confirm any deterioration of raw water conditions. Phase 2 monitoring is designed to confirm beneficial outcome of the scheme.

Phase 1 prior to beneficial delivery of scheme

In-service borehole at time of visit:
coliform/*E. coli*, *C. perfringens,* Enterococci – increase from 104 to 208 per year.
Coliform/*E. coli* 1L large volume, *C. perfringens* 1L large volume – 52 per year
Flow cytometry – 52 per year
WTW Outlet
Regulatory programme - Coliform/*E. coli* 208 per year +
Flow cytometry – 52 per year

Phase 2 for 12 months following beneficial completion of scheme
In-service borehole at time of visit:
coliform/*E. coli*, *C. perfringens,* Enterococci – 104 per year.
Coliform/*E. coli* 1L large volume, *C. perfringens* 1L large volume – 52 per year
Flow cytometry – 52 per year

WTW Outlet :
Coliform/*E. coli*, *C. perfringens,* Enterococci – 208 per year.
Coliform/*E. coli* 1L large volume, *C. perfringens* 1L large volume – 52 per year

Control Measures Required – Details of short, medium and long term control measures
Flow cytometry – 52 per year

B4 Haisthorpe

Appendix B: Haisthorpe WTW

Section 1

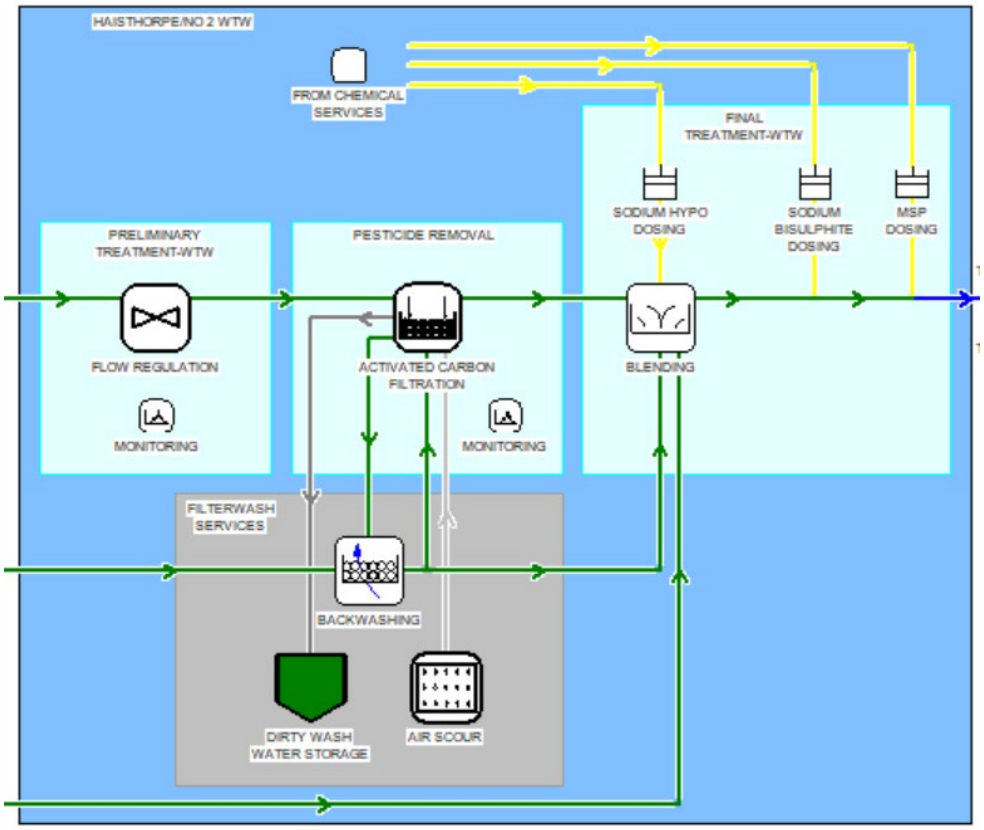
Background information	
Water Company	Yorkshire Water
Date of submission	31st March 2023
Name of Supply System	Bridlington Water Supply System
Regulation 28 report(s) reference number(s) (Unique reference number for each report that applies):	YKS-Risk-A2611150-03-23.csv YKS-Risk-A2611250-03-23.csv YKS-Risk-A2612900-03-23.csv YKS-Risk-A2614100-03-23.csv YKS-Risk-A2615450-03-23.csv YKS-Risk-T2694270-03-23.csv
Name of Water Treatment Works/ Distribution System/ Service Reservoir/ Other asset	Haisthorpe WTW
Water Quality hazard(s)/driver(s) identified:	Nitrate (A012) Security of Supply
Reference to outcome in company's long-term strategy: *[Any other long-term planning the company may*	See sections 4 and 5 in YW's Long Term Strategy document (Jan 2023)

Background information	
have already published that their proposals feed into].	

Section 2

Details of water treatment works and associated supply system	
1	Provide supply arrangements and treatment works details:

Figure 2.1.1. Haisthorpe WTW Schematic

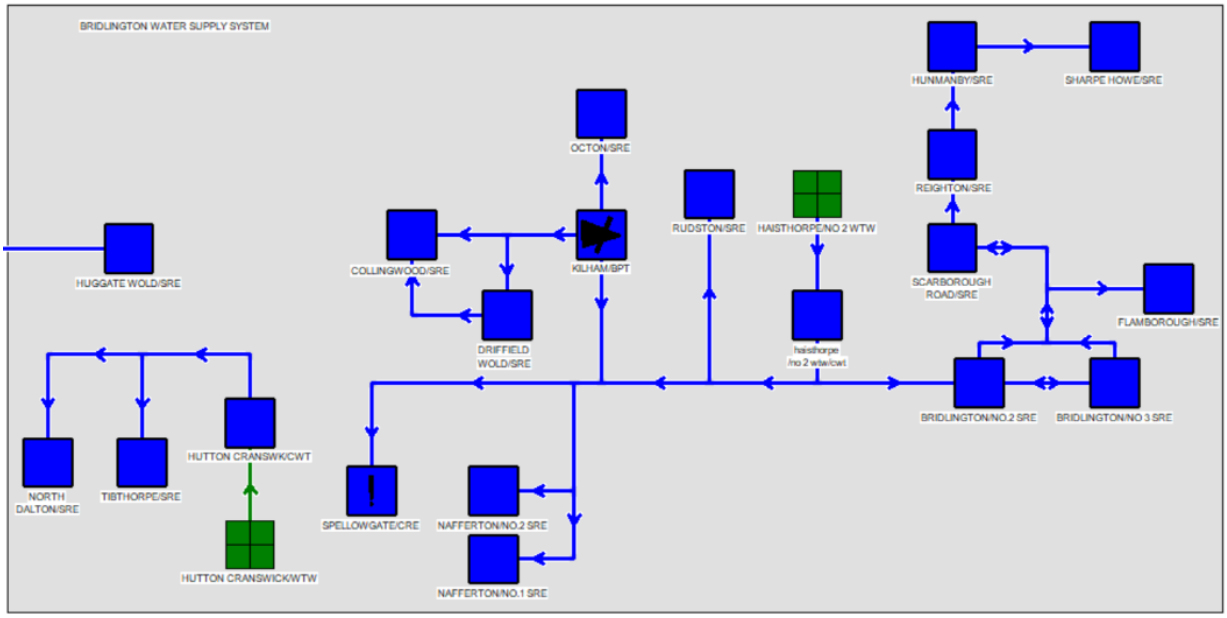


2	A description and diagram of the supply system related to the treatment works

Haisthorpe WTW along with the smaller Hutton Cranswick WTW supply the Bridlington Water Supply System (WSS). This system is largely isolated from neighbouring systems with no reliable imports, with the exception of a 2 Ml/d import from the East Coast Pipeline to Reighton CRE.

Figure 2.2.1. Haisthorpe WTW Supply System Schematic

Details of water treatment works and associated supply system



3	Design capacity of the water treatment works (Ml/d)

33 Ml/d

4	Volume supplied: ○ Daily average (Ml/d) ○ Daily maximum (Ml/d) *[Please include a commentary if there are any constraints on deployable output due to limitations associated with any part of the treatment process. E.g. constraints in relation to blend water or seasonal constraints]*

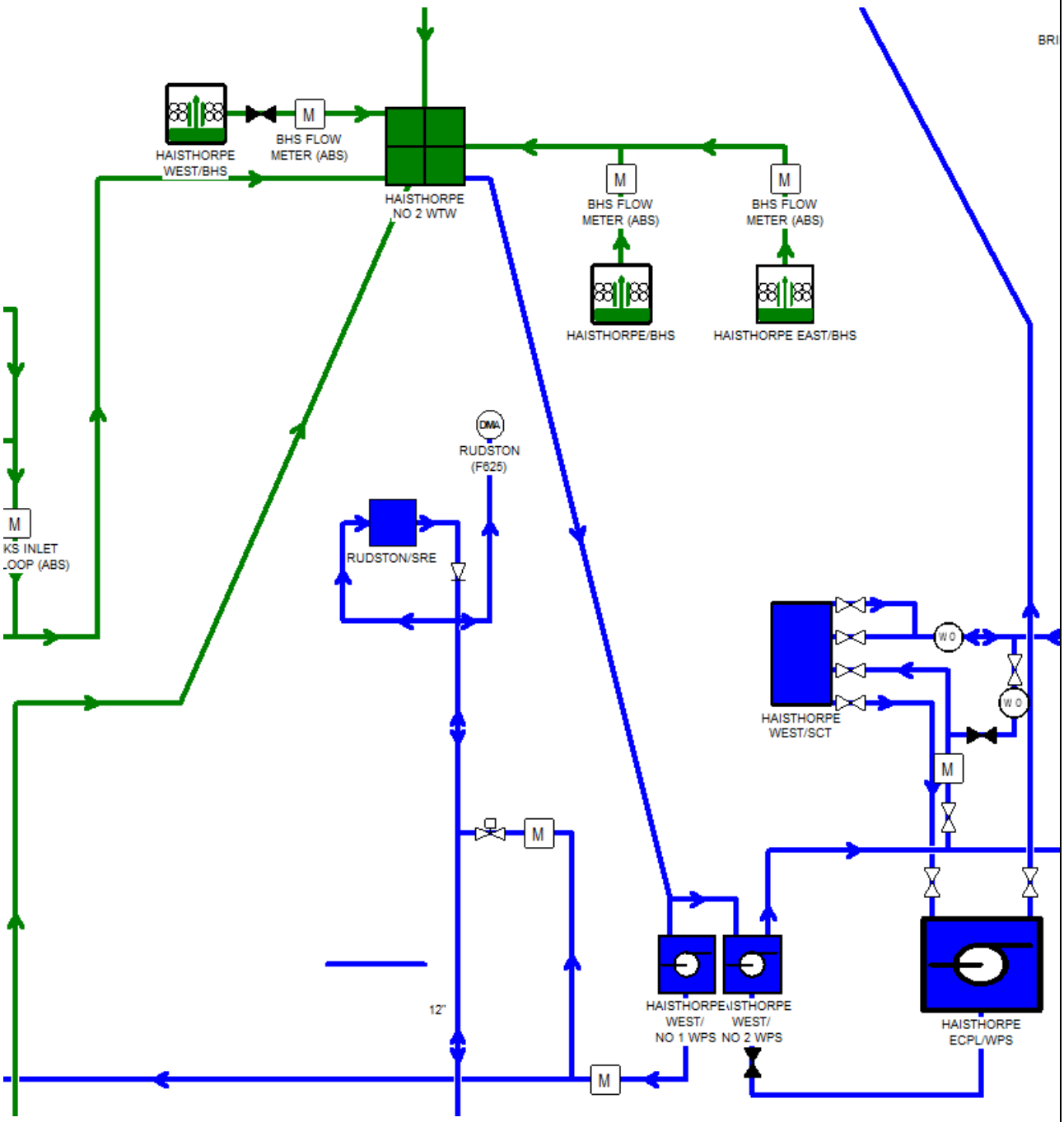
Daily average: 21 Ml/d

Daily maximum: 25.5 Ml/d

Based upon sample results current theoretical max flow is estimated at 28.6 Ml/d to avoid unacceptable nitrate levels and assumes all raw water sources are available. Should any of the low nitrate sources suffer an outage, max daily flow will be reduced.

For example, by 2025, the loss of Haisthorpe Central BH for any reason is expected to limit site flows to 20 Ml/d in order to remain within nitrate limits.

Details of water treatment works and associated supply system	
Further, based on the historic nitrate levels, site flows are forecast to be capped at 24 Ml/d by 2030 due to increasing nitrate levels.	
5	Sources of raw water (continuous/ seasonal/ standby) *[Include names of each individual source, nature of the source (eg, surface direct abstraction; surface impounding reservoir; borehole; spring; type of aquifer). Where appropriate include detail of any existing raw water optimisation / control measure(s) that are in place (e.g. artificial mixing; selective withdrawal depths for abstraction; raw water monitoring; water column profiling; etc.)]*
The source water for Haisthorpe WTW is a combination of borehole sources which are blended on site. Bridlington BHS (borehole) Burton Agnes BHS (borehole) Haisthorpe West BHS (borehole) Haisthorpe Central BHS (borehole) Haisthorpe East BHS (borehole) Kilham BHS (borehole) Elmswell BHS (borehole)	
6	Treatment processes currently employed (including pre-treatment of raw waters) *[In this case, blending is defined as treatment. This includes blending of raw waters prior to treatment. Please also indicate if bankside storage of raw water is utilised, and average retention time in the reservoir]*
Water from Bridlington and Burton Agnes boreholes are subject to GAC filtration before blending with the remaining sources and being dosed with sodium hypochlorite.	
7	Service reservoirs/ booster pump details
Haisthorpe WTW in turn supplies Haisthorpe West WPS No.1 and No.2.	

Details of water treatment works and associated supply system	
Figure 2.7.1 Supply from Haisthorpe WTW.  	
8	Water supply zones supplied and the population of each water supply zone *[If the supply is blended with waters from other treatment works in the zone, please indicate the relative proportions (as %)]*

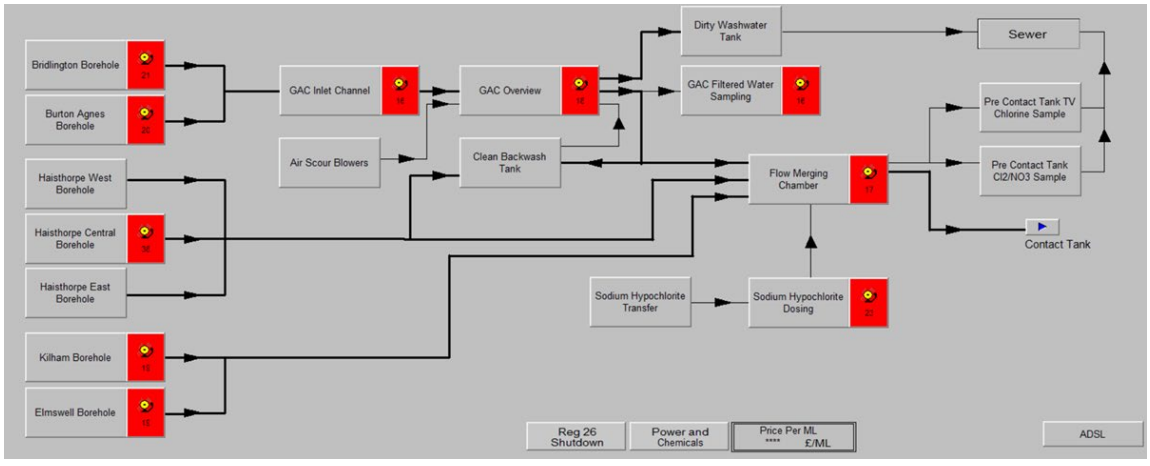
Details of water treatment works and associated supply system

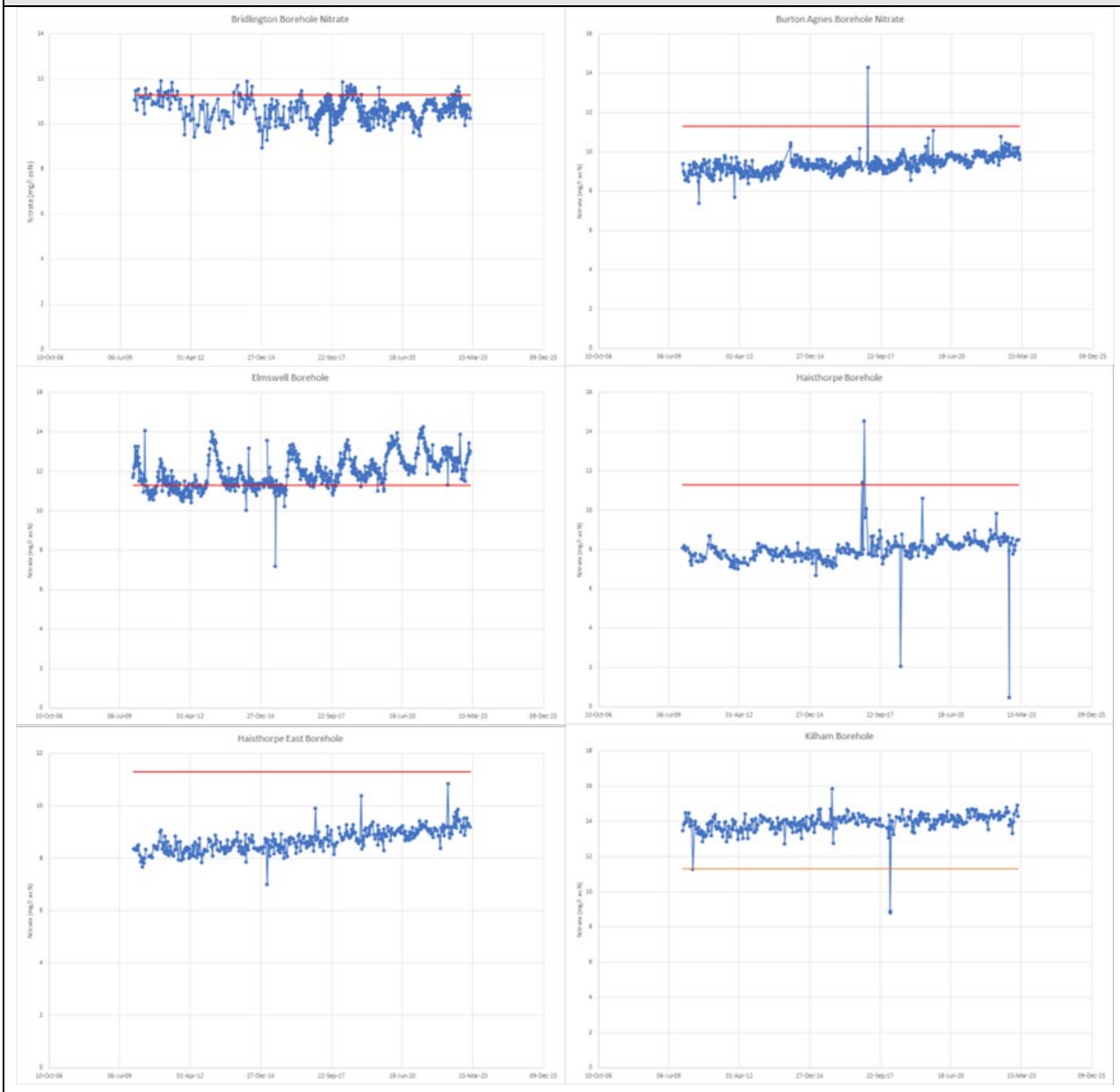
Haisthorpe WTW acts as the source for two WSZs as shown below

Table 2.8.1. Water Supply Zones fed by Haisthorpe WTW and population

Site Reference	SiteName	Population
Z2807119	Filey 2019 WSZ	32,640
Z2801519	Driffield 2019 WSZ	28,587

Section 3

Hazard identification and Risk Characterisation	
1	Provide details of the methodology used to identify the hazard. For example: • Historical data, • Events/ incidents including near miss situations, • Operator knowledge, • Modelling and validation of modelling • Site visits/ technical audits
Historical Sample data, and predictions of future deterioration of raw water quality. Operating practice at Haisthorpe WTW, with regard to current blending practice in the context of customer demand data.	
2	Summary of historical data on the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the raw water source and the water entering supply from the relevant treatment works from compliance, investigative, or operational sampling
Nitrate levels are monitored at each of the supplying borehole groups: Bridlington, Burton Agnes, Elmswell, Haisthorpe, and Kilham. Figure 3.2.1. Haisthorpe WTW borehole group schematic  Figure 3.2.2. Nitrate levels at borehole groups feeding Haisthorpe WTW	

Hazard identification and Risk Characterisation	
 The supplies from Elmswell and Kilham boreholes currently exceed the permitted level of nitrate. A wholesome supply is maintained by blending high nitrate sources with lower nitrate sources.	
3	Details of any existing contraventions of regulatory requirements and whether they are likely to recur (at WTW, SR and/or at consumer's taps)

Hazard identification and Risk Characterisation	
No history of exceedance of the standard for nitrate at the WTW outlet or in downstream areas. Site is operated to ensure standard is not exceeded, which may not be sustainable into AMP8 and beyond.	
4	If evidence of likely to contravene any regulatory requirement, details of when this is likely to occur (at WTW, SR and/or at consumers taps) including trend analysis & prediction modelling
The current operation of Haisthorpe WTW maintains a compliant supply to customers. Water from all sources is monitored and blended to achieve a supply to customers that is less than 46 mg/l as NO3. The Company's approach has been to implement this lower trigger in order to provide a safe dead-band for this health impacting parameter. A deterioration in the levels of nitrate has been noted previously as part of our long-term monitoring programmes. It was considered possible that catchment management activities could arrest this increase – as has occurred at other sites. However, evidence is now available that there is a foreseeable risk of a dilemma between either loss of supply, or supply of non-compliant water within the next AMP period. Ave Daily Demand on Haisthorpe – 20-23 Ml/d (summer/winter peak 25.5Ml/d). Instantaneous demand – max 28.6 Ml/d. The table below illustrates the projected nitrate levels (mg/l NO3) at each of the raw water sources until the end AMP8 (based upon the increase in the last 5 years). The table also shows the maximum available flow (Ml/d) that can be achieved whilst maintaining the operational constraint of ensuring mixed nitrate does not exceed 46 mg/l NO3. The projection indicates that demand on the site may exceed the peak demand of 26 Ml/d by 2027. Table 3.4.1. Available flow at projected nitrated levels at borehole groups feeding Haisthorpe WTW	

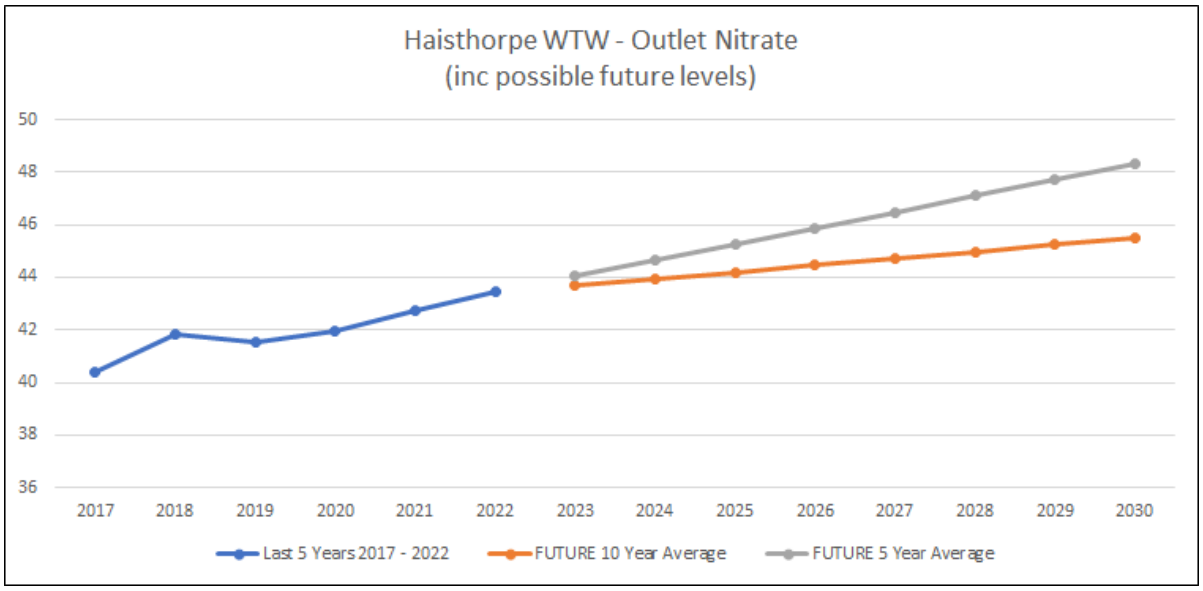
Hazard identification and Risk Characterisation

	Future potential based on **5 year average** change							
	2023	2024	2025	2026	2027	2028	2029	2030
Haisthorpe WTW Outle	44.04	44.65	45.26	45.87	46.48	47.09	47.70	48.31
Kilham	63.92	64.25	64.59	64.92	65.25	65.58	65.91	66.24
Elmswell	58.03	59.09	60.15	61.21	62.27	63.33	64.39	65.45
Haisthorpe Central	38.95	39.14	39.33	39.52	39.71	39.90	40.09	40.28
Haisthorpe East	41.40	41.88	42.36	42.84	43.32	43.80	44.28	44.76
Burton Agnes	43.64	44.00	44.36	44.72	45.08	45.44	45.80	46.16
Brid Mill Lane	47.56	47.75	47.94	48.13	48.32	48.51	48.70	48.89
Available Flow (Ml/d	28.63	27.94	27.28	26.49	25.8	25.2	24.67	24.19

A further risk exists that should one of the low nitrate sources suffer an outage, throughput would be capped at c.20 Ml/d, which would be insufficient to meet average daily demand.

The figure below shows the projected nitrate levels at Haisthorpe WTW based on the historic 5 year nitrate levels (grey) and 10 year nitrate levels (orange).

Figure 3.5.1. Forecast nitrate levels at Haisthorpe WTW outlet



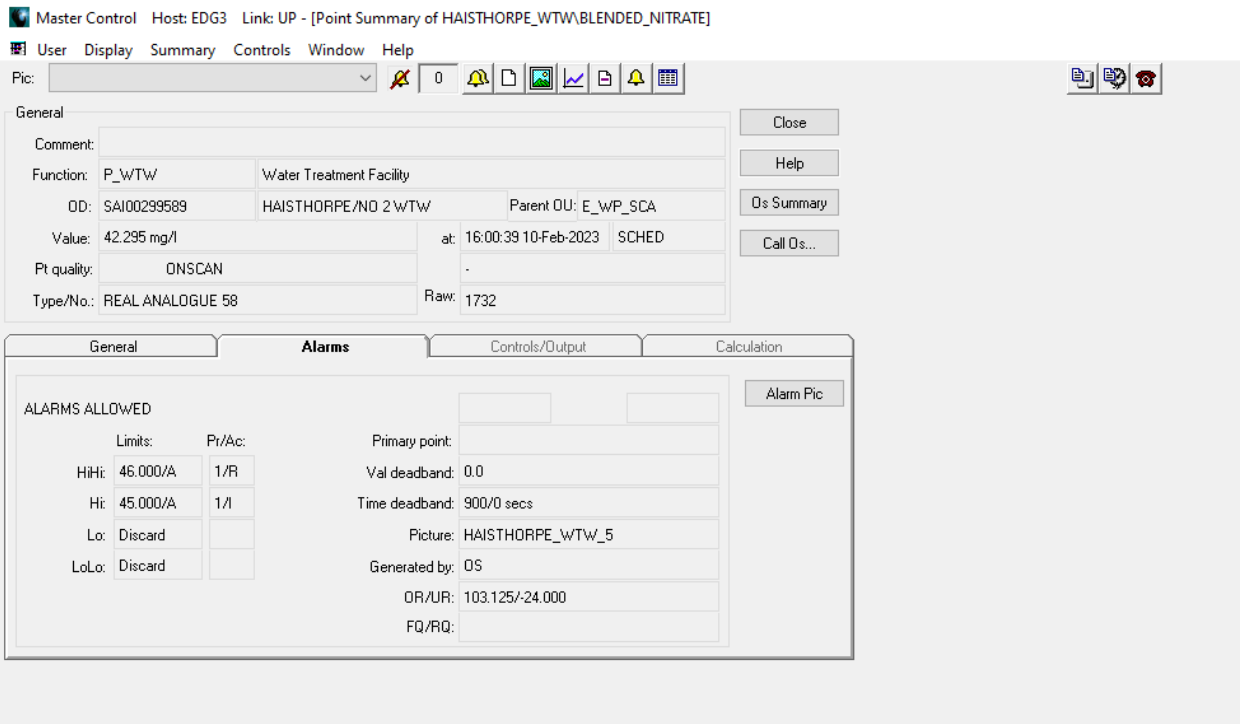
5	Details of any other data relevant to the hazard identified
N/A	
6	If appropriate, summary of data/ information on consumer complaints

Hazard identification and Risk Characterisation	
N/A	
7	Details of any events that have occurred in the catchment, at the treatment works and in supply that are associated with hazard identified
No specific events are known.	
8	Details of any existing control measure(s) that might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the catchment, in treatment and in supply
The geology of the Haisthorpe boreholes comprises chalk which has rapid travel times and around six metres of sandy soil and boulder clay which offers some aquifer protection. The area is predominately agricultural and nitrate applications are very likely. Yorkshire Water does not own the catchment for Haisthorpe boreholes. The agricultural landowners follow various regulations to reduce water and air pollution such as the Farming Rules for Water Regulation. The area is also within a nitrate vulnerable zone which has further regulations around nutrient applications and is regulated by the Environment Agency. The area is also covered by Catchment Sensitive Farming (CSF). This enables farmers to have access to DEFRAs Countryside Stewardship schemes and water grants. The services include grants to improve farm infrastructure, one to one advice, best practice workshops and events to improve the water and air environment. In addition to the farming regulation and improving best practice in the catchment through partnership with CSF, the boreholes have casings to prevent surface water infiltration. The source protection zones have also been part of a Water Industry National Environment Programme (WINEP) in AMP7 to reduce nitrate leaching from the catchment. An innovation group as part of the Sustainable Landscapes programme ran by our contractors Future Food Solutions was established in 2021. The group focusses on nitrogen efficiency, soil health and improvements in the wider environment as well as exploring more sustainable and more profitable ways of producing crops for the food and drink supply chain. The impact of the above control measures is not sufficient to adequately assure compliance hence an end of pipe treatment solution is proposed for AMP8.	

Hazard identification and Risk Characterisation	
The current treatment process at Haisthorpe blends the low and high nitrate sources. The blended supply is continuously monitored for nitrate on-line with alarms in place to prevent exceedance of the standard.	
9	Details of monitoring of the existing control measure(s) (including validation monitoring)

Alarms generated by automated site systems are received and actioned via our 24-hour control room.

Figure 3.8.1. Regional Telemetry System Screenshot of monitoring alarms in place at Haisthorpe WTW



On-site monitoring is validated by Nitrogen group sample collection

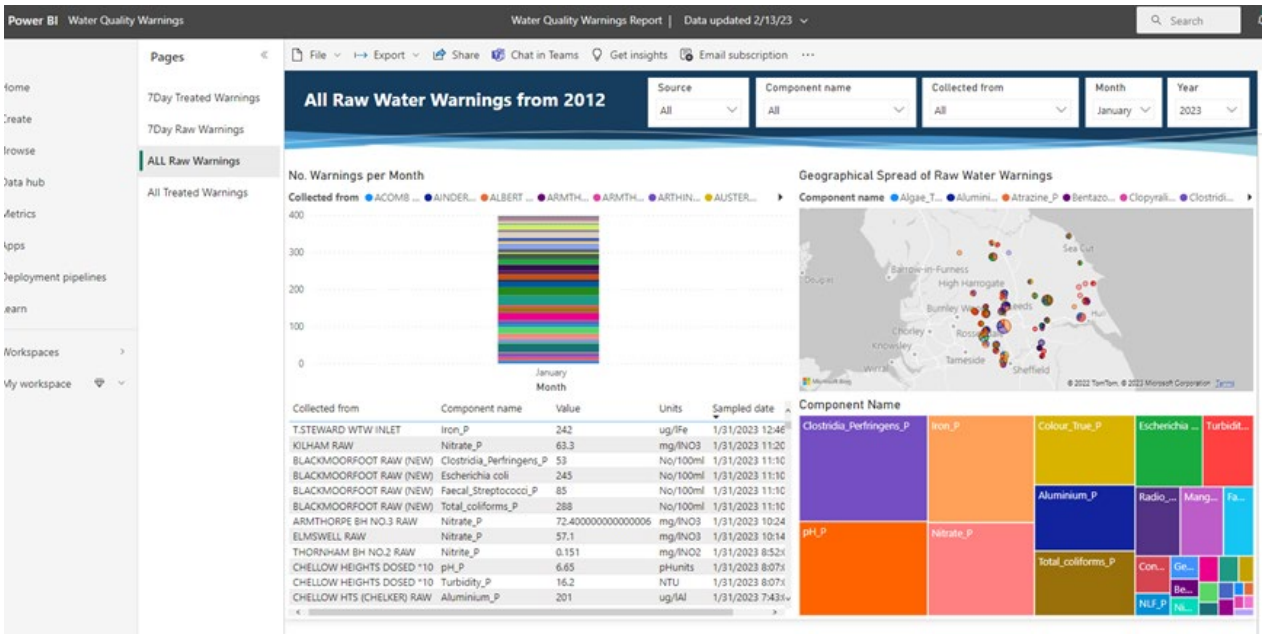
Bridlington Mill Lane BH x52 per year

Burton Agnes BH x52 per year

Elmswell Wold BH x52 per year

Haisthorpe BH x26 per year

Haisthorpe East BH x26 per year

Hazard identification and Risk Characterisation	
Kilham BH x26 per year Haisthorpe WTW Outlet x52 per year Nitrate is a fully dissolved conservative parameter and level of nitrogen identified in the mixed water provides an upper limit on the level of nitrate in downstream supply areas. Hence, no additional monitoring in distribution is necessary. Samples collected in both raw and treated water regulatory and operational sampling programmes are flagged with warning limits where these exceed expected values. This identifies unusual samples for further investigation by Water Quality Scientists. Figure 3.9.1. Example dashboard for Raw Water Warnings across the Yorkshire region  	
10	Details of any changes in practices or policy which might have influenced the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in water supplied to consumers, i.e., in relation to resources, blending arrangements, treatment or supply arrangements and the dates of those changes
N/A	

Hazard identification and Risk Characterisation	
11	Details of any licensed abstraction issues which might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in raw water
None currently.	
12	Reasons for the presence of the hazard, if known, otherwise details of what is being done to identify the source of the hazard
Nitrates in groundwater are primarily a result of agricultural runoff, primarily sourced from high nitrogen fertilisers and manures.	
13	Outline Risk characterisation. For example, details and score arising from consequence v. likelihood matrix, where score sits in the risk profile for the supply system.

The Company's DWSP Risk matrix incorporates a 5 x 5 scale severity and probability matrix. Our system adopts the DWI severity scores and combines this with an estimate probability (in bands of 20%) of failure within the next 12 months.

Table 3.13.1. DWSP Risk Matrix

		Severity				
		1 - VL	2 - L	3- M	4 – H	5 – VH
Probability	5 – VH	9	14	18	22	25
	4 – H	7	12	17	21	24
	3 – M	5	10	15	19	23
	2 – L	3	6	11	16	20
	1 - VL	1	2	4	8	13

Full details of risk assessments are shown in the relevant Reg28 Reports, but in summary there are risks of nitrate at all of the supplying boreholes. It is considered that the probability of nitrate failure is currently high amber but is a future high red risk over the timeframe of AMP8.

Hazard identification and Risk Characterisation

Table 3.13.2. Summary of DWSP risk scoring across WSZs fed by Haisthorpe WTW

AssetRef	HazardRef	PreLikelihood	PreConsequence	Risk	PostLikelihood	PostConsequence	Residual Risk	DWICategory	HazardID
A2611150	A012	3	5	23	3	5	23	G	41305
A2611150	A012	4	5	24	4	5	24	I	41305-F
A2611250	A012	3	5	23	3	5	23	G	45482
A2611250	A012	4	5	24	3	5	23	I	45482-F
A2612900	A012	5	5	25	5	5	25	G	42595
A2612900	A012	5	5	25	5	5	25	I	42595-F
A2614100	A012	4	5	24	4	5	24	G	47416
A2614100	A012	4	5	24	4	5	24	I	47416-F
A2615450	A012	5	5	25	5	5	25	G	40587
A2615450	A012	5	5	25	5	5	25	I	40587-F
T2694270	A012	5	5	25	2	5	20	E	45287
T2694270	A012	5	5	25	5	5	25	I	45287-F

Section 4

Control Measures Required – Details of short, medium and long term control measures	
1	Details of short-term actions currently in place to mitigate against risk & their effect
Continuation of blending of high nitrate sources.	
2	Details of mid to long term control measures identified for any residual risk: o Options the company has considered which should, where appropriate, include catchment management controls, or communications controls in association with other stakeholders o Timescale for delivery of each option o Capital costs and net additional operating costs of each option considered o Summary of costs and benefits of each option o Reasons for choosing the preferred option o Specific supporting evidence that the preferred option will address risk of hazard within the required timescale
The WINEP programme included a nitrate scheme in AMP7 which is set to continue into AMP8, including liaison and education with the agricultural sector to adopt low nitrate farming methods in the catchment. This is expected to yield positive results in the medium/long term. However, the rate of increase in nitrate levels at Haisthorpe suggests that failures are likely in AMP8 and as such, a treatment solution is now required to ensure continued compliance. A new low nitrate borehole was considered, however, this would require amendments to the abstraction licence and there the EA are unlikely to support such a proposal. As such, the preferred option is the installation of a nitrate removal plant. Initially considerations assumed treating all sources, but subsequent analysis suggests treating the two high nitrate sources will be sufficient to reduce levels now and into the future, at reduced costs to Yorkshire Water's customers.	

Control Measures Required – Details of short, medium and long term control measures

Table 4.2.1. Summary of solution options considered for Haisthorpe WTW

Options Considered	Capital Costs (£m)	Net Operational Costs (£m/pa)	Delivery Timescale (yrs)	Unplanned Outage Benefit (MLD)	CRI	Preferred Solution (AMP8)
Haisthorpe WTW Option 1 - New Borehole	£7.5	£0.19	3	0	0.71	N
Haisthorpe WTW Option 2 - Nitrate Removal Plant - All Sources	£17.3m	£0.57	4	3.87	0.77	N
Haisthorpe WTW Option 3 - Nitrate Removal Plant - High Nitrate Sources Only	£7.96	£0.23	4	3.87	0.77	Y
Haisthorpe WTW - Pesticide & Nitrate Catchment Management	£ -	£0.61	5	N/A	N/A	Y

3	Full details of how the company intends to assess and measure the benefits delivered (the outcome), including details of proposed sampling programme, number of samples to be taken over the specified period and parameters to be monitored.

Success of the project is the continuation of supply of a compliant water to downstream customers.

Current nitrate monitoring programmes will identify the risk to customers, and maintain supply within a safe dead-band.

Bridlington Mill Lane BH x52 per year

Burton Agnes BH x52 per year

Elmswell Wold BH x52 per year

Haisthorpe BH x26 per year

Control Measures Required – Details of short, medium and long term control measures
Haisthorpe East BH x26 per year Kilham BH x26 per year Haisthorpe WTW Outlet x52 per year Further reassessment of sampling criteria and frequency will occur depending upon any future deterioration of sources.

B5 Ingbirchworth

Appendix B: Ingbirchworth WTW

Section 1

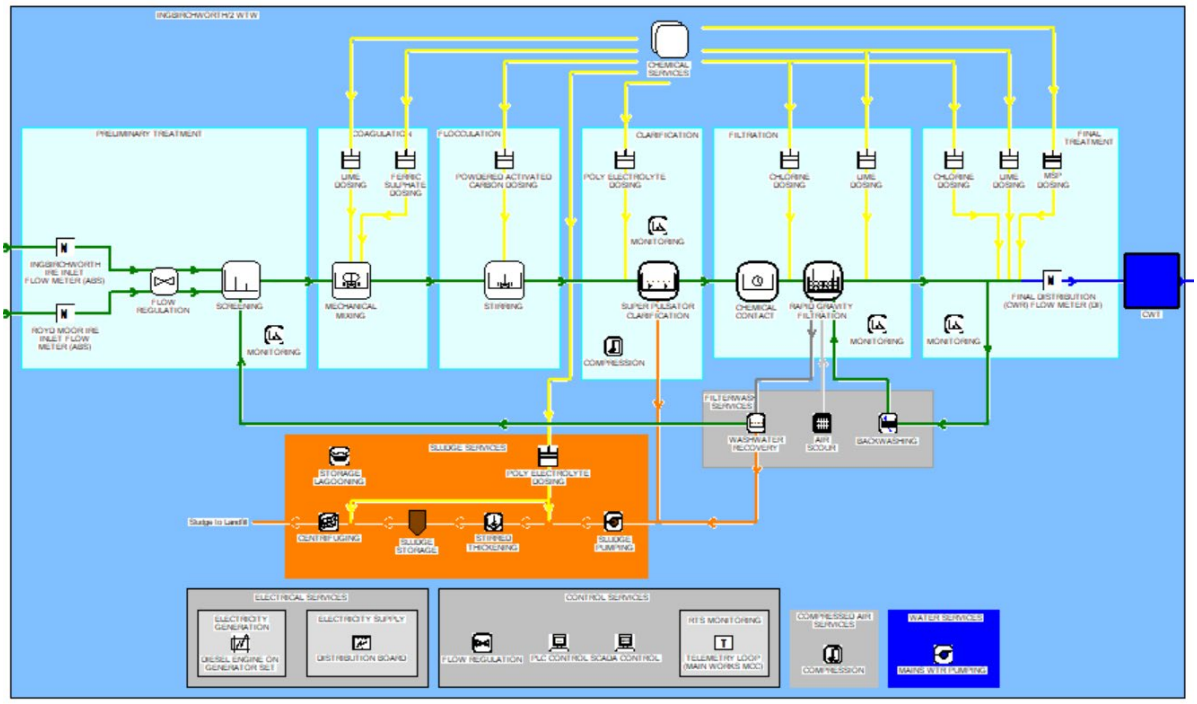
Background information	
Water Company	Yorkshire Water
Date of submission	31st March 2023
Name of Supply System	South/Barnsley Pennine WSS
Regulation 28 report(s) reference number(s) (Unique reference number for each report that applies):	YKS-Risk-A3612850-03-23.csv YKS-Risk-T3692910-03-23.csv
Name of Water Treatment Works/ Distribution System/ Service Reservoir/ Other asset	Ingbirchworth WTW
Water Quality hazard(s)/driver(s) identified:	Odour (A003) Taste Quant (A004) Manganese (A023) The reservoir solution would provide a holistic solution for Mn and Algae, where we implement the findings from the on-going "When and How to Mix" research project.
Reference to outcome in company's long-term strategy:	See sections 4 and 5 of YWs Long Term Strategy document (January 2023)

Section 2

Details of water treatment works and associated supply system	
1	Provide supply arrangements and treatment works details:

Raw waters are screened and mixed on the inlet, followed pH correction, clarification (super pulsation), filtration (rapid gravity filters), manganese contactors and chlorine dosing.

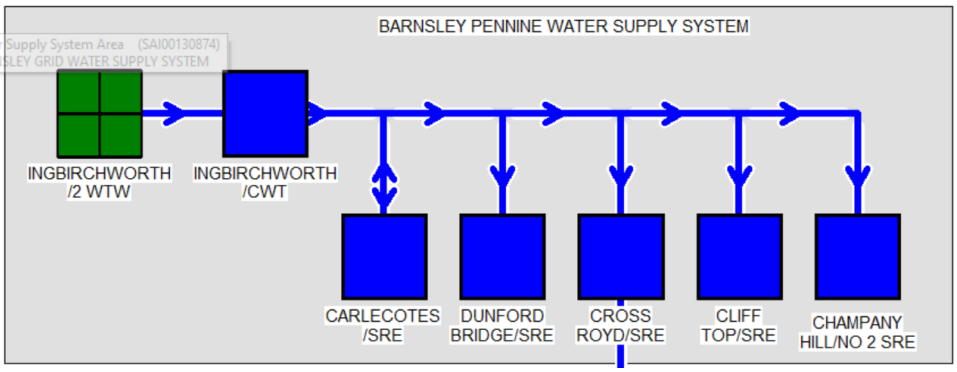
Figure 2.1.1 Ingbirchworth Process Schematic



2	A description and diagram of the supply system related to the treatment works

Historically Ingbirchworth WTW primarily served the Barnsley Pennine Water Supply System (WSS), however with the closure of Rusby Wood WTW approximately 15 years ago, it now also supplies the Rusby Wood WSS via Rusby Wood CRE, in conjunction with Holmbridge WTW via Thongsbridge WPS.

There are no other major imports/exports, and the Barnsley Pennine system is reliant on Ingbirchworth WTW for its supply.

Details of water treatment works and associated supply system	
Figure 2.2.1 Barnsley WSS Schematic  	
3	Design capacity of the water treatment works (Ml/d)
20 Ml/d	
4	Volume supplied: ○ Daily average (Ml/d) ○ Daily maximum (Ml/d) *[Please include a commentary if there are any constraints on deployable output due to limitations associated with any part of the treatment process. E.g. constraints in relation to blend water or seasonal constraints]*
Daily Ave – 17 Ml/d Daily Max – 20 Ml/d	
5	Sources of raw water (continuous/ seasonal/ standby) *[Include names of each individual source, nature of the source (eg, surface direct abstraction; surface impounding reservoir; borehole; spring; type of aquifer). Where appropriate include detail of any existing raw water optimisation / control measure(s) that are in place (e.g. artificial mixing; selective withdrawal depths for abstraction; raw water monitoring; water column profiling; etc.)]*
Raw water for the site is supplied via two impounding reservoirs; Ingbirchworth IRE and Royd Moor IRE. The preferential source of supply is Ingbirchworth IRE as it	

Details of water treatment works and associated supply system

provides a dedicated yield for Ingbirchworth WTW which cannot be supplied to any other water treatment works.

There is a bubbler in place at Ingbirchworth IRE. The reservoir has a single draw-off at the bottom of the reservoir.

Legal Instrument YKS_2022_00006 is currently in delivery at Ingbirchworth. This will provide additional data on the reservoir and water treatment works, and this output will be included development of interventions under the proposed scheme.

6	Treatment processes currently employed (including pre-treatment of raw waters) *[In this case, blending is defined as treatment. This includes blending of raw waters prior to treatment. Please also indicate if bankside storage of raw water is utilised, and average retention time in the reservoir]*

There is a bubbler in place at Ingbirchworth IRE, and there are options for selection of raw water at the WTW inlet. However, experience in 2022 indicated the current source selection options are limited in certain operational scenarios.

Please see above in section 2.1. The first stage of treatment is coagulation with ferric sulphate. The WTW also incorporates a PAC dosing system for control of earthy tastes and odours. The water is clarified in super-pulsators. This is followed by two stages of filtration.

7	Service reservoirs/ booster pump details

Ingbirchworth No.2 CWT – 10 Ml/d

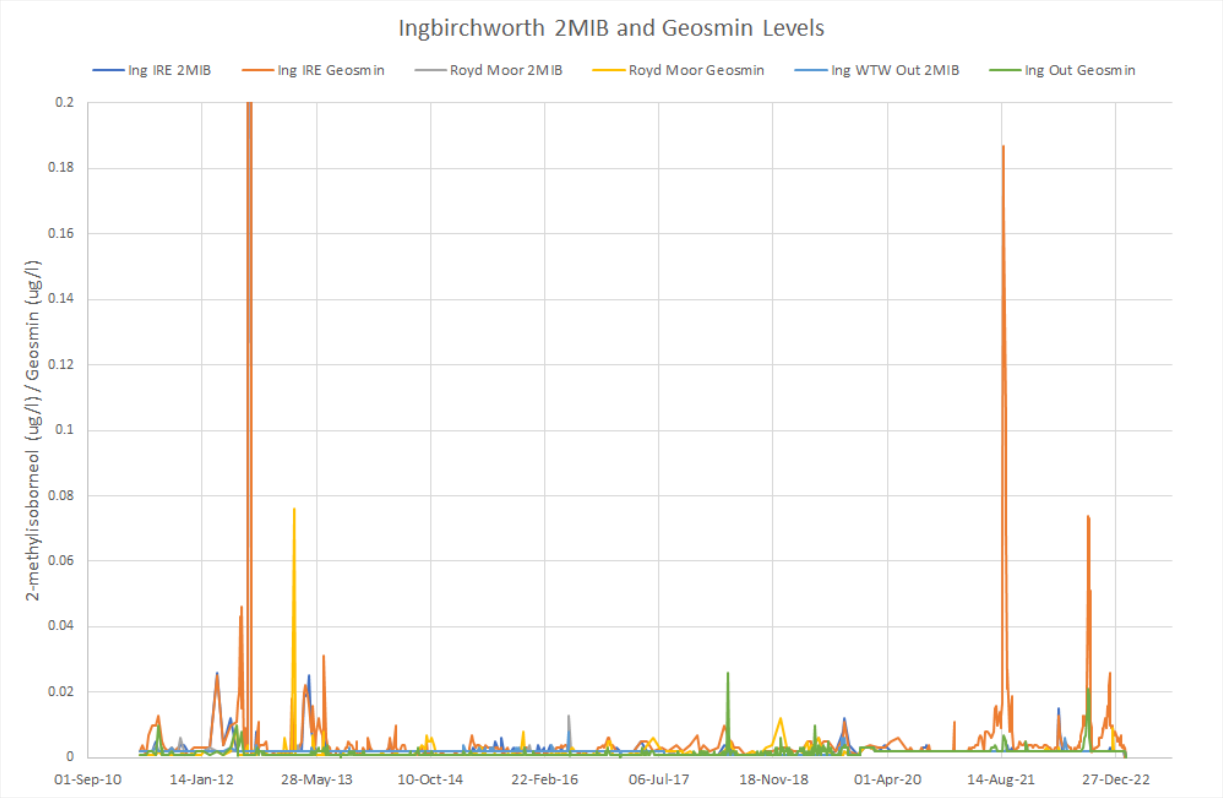
8	Water supply zones supplied and the population of each water supply zone *[If the supply is blended with waters from other treatment works in the zone, please indicate the relative proportions (as %)]*

Table 2.8.1 2023 Populations of WSZs supplied by Ingbirchworth WTW.

Site Reference	SiteName	Population
Z3800319	Barnsley - Pennine 2019 WSZ	63,360
Z4802919	Holmfirth and Emley 2019 WSZ	50,413

Section 3

Hazard identification and Risk Characterisation	
1	Provide details of the methodology used to identify the hazard. For example: • Historical data, • Events/ incidents including near miss situations, • Operator knowledge, • Modelling and validation of modelling • Site visits/ technical audits
Hazard has been identified through the existence of notified water quality events and sample data. Further information has been gained during site visits, and site audits by our framework strategic partner.	
2	Summary of historical data on the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the raw water source and the water entering supply from the relevant treatment works from compliance, investigative, or operational sampling
Geosmin and 2-methylisoborneol are monitored in the two raw water sources supplying Ingbirchworth WTW. Recent years have seen excessive levels of these earthy taste and odour causing compounds. Figure 3.2.1 Ingbirchworth 2-MIB and Geosmin Levels	

Hazard identification and Risk Characterisation	
	
3	Details of any existing contraventions of regulatory requirements and whether they are likely to recur (at WTW, SR and/or at consumers taps)
Since 2010: 7/11/2011 Manganese sample exceedance within current Holmfirth & Emley 2019 WSZ Mains sediment related exceedance of standard for manganese at dead-location location in residential cul-de-sac. Not directly related to WTW performance. 19/7/2013 Manganese sample exceedance within current Holmfirth & Emley 2019 WSZ Nearby burst main cause disturbance of mains sediment. Not directly related to WTW performance.	

Hazard identification and Risk Characterisation	
10/6/2016 Manganese sample exceedance within current Holmfirth & Emley 2019 WSZ All follow up samples indicated extremely low levels of manganese. No customer impact at time of collection. No clear cause was identified. 28/07/2021 Event 2021/8185 Denby Dale Discolouration Turnover of water within Ingbirchworth IRE led to unprecedented sustained high levels of manganese overwhelming site processes. This resulted in discolouration to customers. Investigation indicated discolouration was caused by precipitation of soluble manganese that had overwhelmed site process. Resolved by novel arrangements of raw water sources and downstream distribution supply reducing demand on Ingbirchworth WTW. 31/08/2022 Event 2022/8704 Ingbirchworth WTW Earthy Odours Seasonal increase in the levels of geosmin in raw water supplying Ingbirchworth WTW caused challenge to existing treatment processes. An error in operation led to an underdose of PAC and impact on customers. Mitigation activity was further impeded by restrictions on available supply options due to drought conditions. Associated with two regulatory sample failures 25/8/2022 Taste and Odour Detection in Holmfirth & Emley 2019 WSZ 5/9/2022 Taste and Odour Detection in Holmfirth & Emley 2019 WSZ	
4	If evidence of likely to contravene any regulatory requirement, details of when this is likely to occur (at WTW, SR and/or at consumers taps) including trend analysis & prediction modelling
Serious WQ Events have occurred in the past two calendar years, with substantial impact on customers and exceedance of regulatory standards. Novel combinations of raw water supply, ongoing enhancements to raw water monitoring, improvements to site operation, and facility for limited reduction of supply area	

provide evidence that further impact on customers can be avoided in the short term.

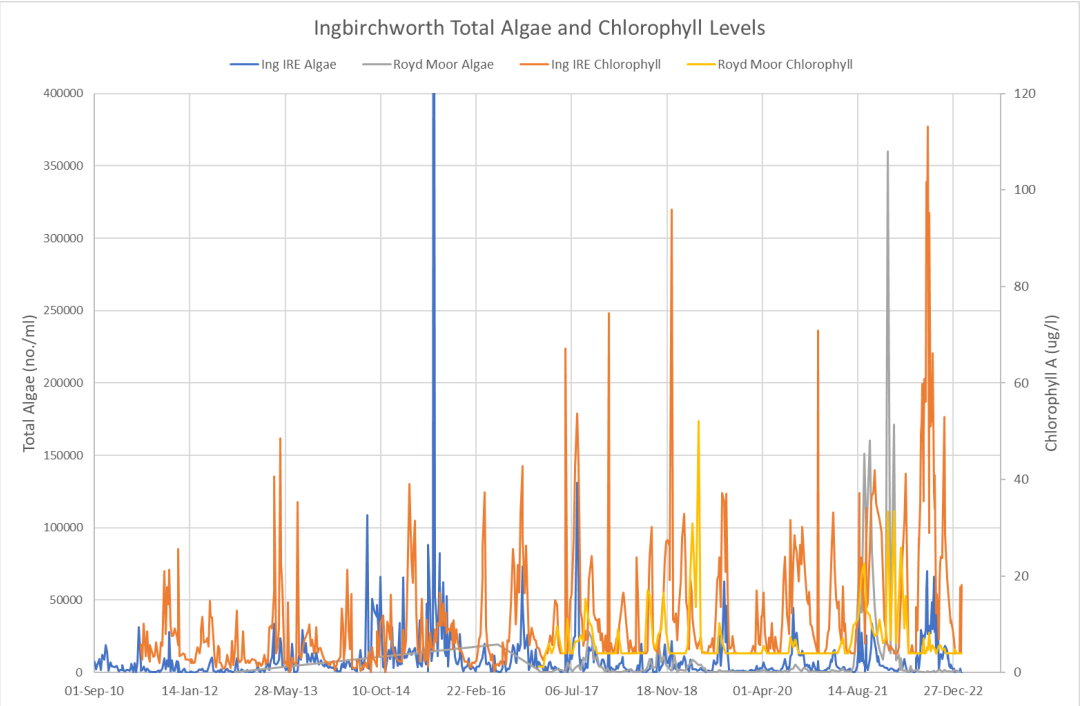
However, currently available mitigating options require unrestricted use of raw water and capacity to allow reduced site throughput. Conditions throughout 2022 were significantly unusual and so perhaps unlikely to be repeated in a short-term time frame. However, national models predicting change in climate indicate that similar conditions are likely in the future.

It is also relevant to note that on a regional basis, the Company is predicting a shortfall in treated water capacity by 2025. Hence, maintaining a resilient supply to customers is not consistent with a reduction of Ingbirchworth WTW throughput during high demand periods

5	Details of any other data relevant to the hazard identified

Sample data indicates that although total algal levels have not shown significant variation from historical performance, the level of chlorophyll A detected has increased.

Figure 3.5.1 Ingbirchworth Total Algae and Chlorophyll



Hazard identification and Risk Characterisation

Investigations into the detail of the interactions between cyanobacteria, nutrients, environmental and chemical triggers at Ingbirchworth IRE are part of an on-going legal instrument (YKS_2022_00006).

Background levels of raw water manganese remain low at Ingbirchworth WTW, with short term peaks. However, in 2021 the peak of manganese persisted for several weeks and was unprecedented.

Figure 3.5.2 Ingbirchworth Manganese Levels

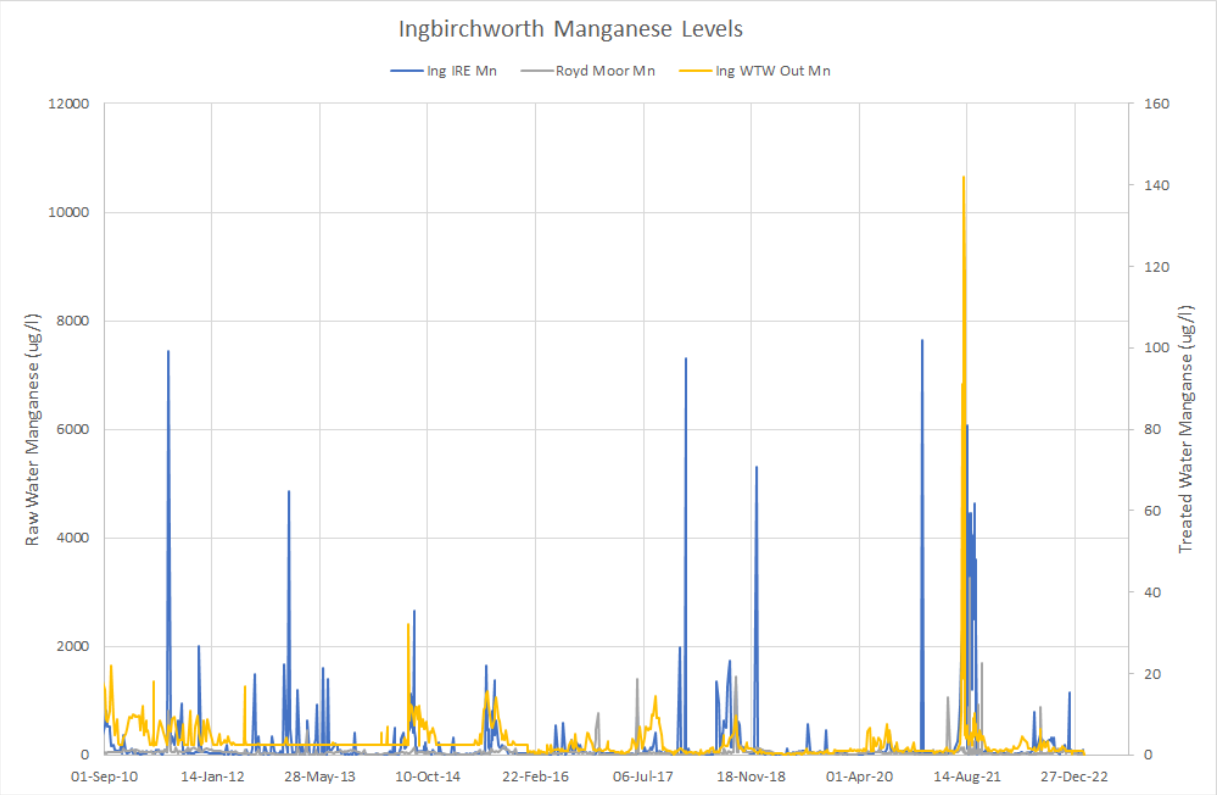


Table 3.5.1 Summary of Ingbirchworth WTW manganese performance

Hazard identification and Risk Characterisation

Year	Number	Median	Mean	95th %ile	Max
2010	51	5.70	7.62	17.00	22.00
2011	51	5.70	5.79	9.90	12.00
2012	54	2.60	2.90	4.44	5.90
2013	51	2.60	2.61	2.60	3.00
2014	51	2.60	5.05	11.85	32.20
2015	50	2.60	4.85	13.20	15.70
2016	52	1.25	1.59	4.46	5.48
2017	52	1.44	2.94	9.36	14.50
2018	52	1.08	1.74	4.98	9.56
2019	52	0.40	0.48	1.10	1.58
2020	52	1.10	1.91	5.87	7.66
2021	52	0.97	2.78	8.43	34.20
2022	53	1.41	1.68	3.54	4.43

Manganese levels in supply at customers' taps is routinely at acceptable levels. Average manganese detected in regulatory samples by year is shown below.

Table 3.5.2 Summary of manganese in regulatory sampling programme

Water Supply Zone	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
BARNSLEY PENNINE 2019 WSZ	4.20	6.20	3.23	3.04	3.23	3.03	2.62	1.75	0.86	0.71	1.92	2.11	1.12	0.62
HOLMFIRTH/EMLEY 2019 WSZ	5.21	4.45	2.86	6.56	4.46	3.51	1.35	1.34	1.20	1.52	1.61	2.00	1.45	0.69

6	If appropriate, summary of data/ information on consumer complaints

The current water supply zone structure was created in 2019. Since that point Barnsley – Pennine 2019 WSZ has performed adequately with respect to customer contacts for taste or odour per 1000 population. However, Holmfirth and Emley 2019 WSZ has demonstrated below average performance and a deteriorating trend. Values are excluding contacts received during the notified Events.

Table 3.6.1 Taste and Odour contacts per 1000 population in Impacted WSZs

	2019	2020	2021	2022
Barnsley - Pennine 2019 WSZ	0.20	0.22	0.22	0.17
Holmfirth and Emley 2019 WSZ	0.32	0.44	0.44	0.54
Company Average	0.31	0.30	0.29	0.28

Hazard identification and Risk Characterisation	
7	Details of any events that have occurred in the catchment, at the treatment works and in supply that are associated with hazard identified
No specific issues are known in the catchment, but additional stakeholder engagement is included as part of YKS_2022_00006	
8	Details of any existing control measure(s) that might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the catchment, in treatment and in supply
The reservoirs that supply Ingbirchworth WTW are Ingbirchworth and Royd Moor. The area is predominately mixed agriculture with muck and slurry applications being very likely. Yorkshire Water does not own the whole catchment for Ingbirchworth. The Yorkshire Water tenants will have set restrictions to follow regarding slurry applications on high-risk land and are part of a rolling farm audit programme lead by the Land and Property Team. Both tenants and private landowners will follow various regulations to reduce water and air pollution, such as the Farming Rules for Water Regulation which is regulated by the Environment Agency. The area is also covered by Catchment Sensitive Farming (CSF). This enables farmers to have access to DEFRAs Countryside Stewardship schemes and water grants. The services include grants to improve farm infrastructure, 121 advice and best practice workshops and events to improve the water and air environment. In AMP7 the Company has attended the local agricultural show – Penistone Show in partnership with CSF to spread awareness about the local water quality issues and farming best practice. CSF have also hosted a Nutrient Management Workshop in Penistone with the Environment Agency in November 2022 to raise awareness about the Farming Rule for Water regulation and requirements for nutrient management plans. Additionally, Ingbirchworth reservoir has a bubbler installed. A current project is in place to investigate best practise use and design of bubbling in the reservoir. Optimisation of operation could help to disperse algal blooms. The treatment works can treat a variable blend of the two water sources. Hence, preferential selection of the lower yield Royd Moor source and restriction of the	

Hazard identification and Risk Characterisation	
downstream distribution area reduces the challenge to the treatment process. This was successful in dealing with the unprecedented levels of manganese in 2021. Raw water entering Ingbirchworth WTW is monitored for light absorbance at 254nm by on-line instruments, and this represents a good measure of organic compounds entering the treatment process. This will be significantly enhanced by further parameters following installation of the column profiler at Ingbirchworth IRE. The treatment process on site includes a pre-clarification PAC dosing system, which when operated correctly is capable of addressing the normal raw water challenge. Since commissioning in AMP5, the second stage of filtration at the site has comprised a dedicated manganese removal stage with pH correction and a sodium hypochlorite dose prior to filtration. Ingbirchworth WTW is equipped with on-line monitors for LA254, flow, pH, turbidity, and chlorine with appropriate alarms or automated shutdown triggers through the treatment process. A recently installed post manganese contactor residual chlorine concentration monitor has been brought on-line to provide better evidence of increased chlorine demand.	
9	Details of monitoring of the existing control measure(s) (including validation monitoring)
Catchment activity is monitored by regular catchment investigations, and supported by a sampling programme which confirms the quality of raw water supplying the treatment works. A variable monitoring and escalation protocol has been developed as part YKS_2022_00006 and has been separately communicated to the Inspectorate in correspondence. The Company took the opportunity to incorporate steps related to risk of earthy tastes and odours even though this was not specifically required by the notice. The protocol includes triggers for enhanced level of sampling monitoring as well as additional operational site activity. The intention is to retain this monitoring programme. However, this will be reviewed following assessment of data made available by the column profiler to be installed as part of the notice.	

Hazard identification and Risk Characterisation

The base line level of monitoring is represented by

Ingbirchworth IRE – 2-MIB / geosmin x52 per year

Ingbirchworth IRE - total algae / chlorophyll A x52 per year

Ingbirchworth IRE – manganese x52 per year

Royd Moor IRE - 2-MIB / geosmin x52 per year

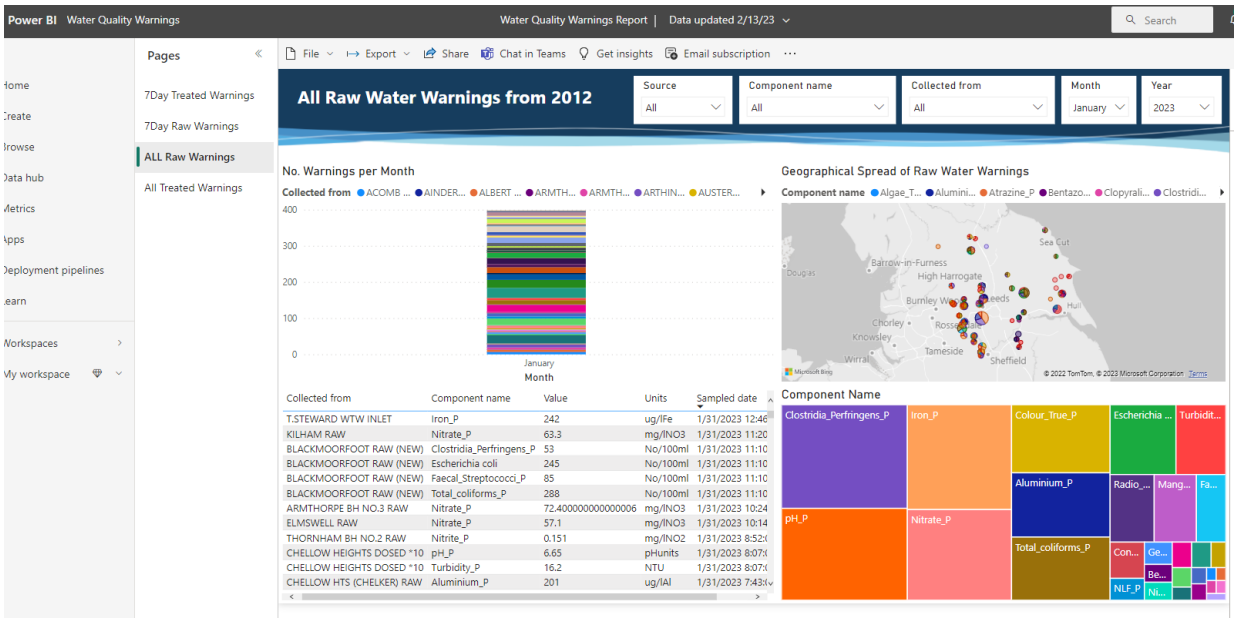
Royd Moor IRE - total algae / chlorophyll A x52 per year

Ingbirchworth WTW Outlet - 2-MIB / geosmin x52 per year

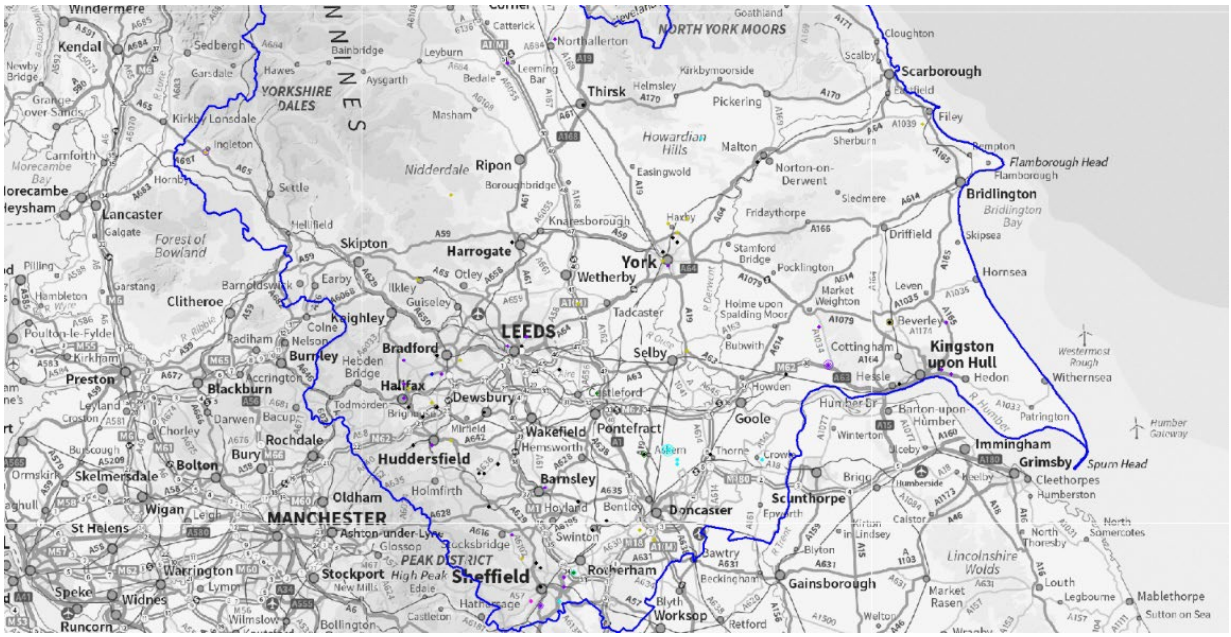
Ingbirchworth WTW Outlet – manganese x52 per year

Samples collected in both raw and treated water regulatory and operational sampling programmes are flagged with warning limits where these exceed expected values.

Figure 3.9.1 Example of Daily Raw Water Warning Dashboard.



However, the key element of validating of control measures is careful monitoring of customer contacts on a timely basis through the control room – with rapid intervention where necessary. Our "Odyssey" GIS mapping application visually displays the occurrence of customer contacts in real-time. Where multiple contacts

Hazard identification and Risk Characterisation
occur in close geographical locations, these appear as concentric circles of similar colours. Figure 3.9.2 Example of Odyssey mapping application      The customer contact map is prominently displayed in our control room, as well as on a screen on the Duty Managers desk. The mapping system is also available to all colleagues on their computers. The version installed in the control is equipped with a zone flagging tool where numbers of contacts exceed certain trigger numbers in a wider operational area.

10	Details of any changes in practices or policy which might have influenced the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in water supplied to consumers, i.e., in relation to resources, blending arrangements, treatment or supply arrangements and the dates of those changes
N/A	
11	Details of any licensed abstraction issues which might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in raw water

Hazard identification and Risk Characterisation	
N/A	
12	Reasons for the presence of the hazard, if known, otherwise details of what is being done to identify the source of the hazard

Overview of Risk

Many water companies in the UK are experiencing an increased level of risk from algal growth in raw water reservoirs. Algae are the cause of multiple water quality and treatment risks.

Under certain environmental conditions, algae release metabolites 2MIB and Geosmin that give an earthy taste and odour (T&O) to the water which is detectable by customers at very low concentrations.

High levels of algal biomass can physically overwhelm WTW processes and lead to the formation of toxic disinfection by-products.

Cyanobacteria production of T&O metabolites is a globally increasing problem that has been directly linked to climate change. Reduced summer rainfall and increased temperature favours development of warm shallow reservoirs that promote cyanobacteria abundance. Additionally, research on T&O event triggers indicates that fluctuating weather conditions and associated pulses in key nutrients (ammonium and organic forms of phosphate) from agricultural practices greatly increase T&O risk. Extreme weather events, in particular summer rainfall and storm events directly enhance this and lead to pulses of T&O metabolites.

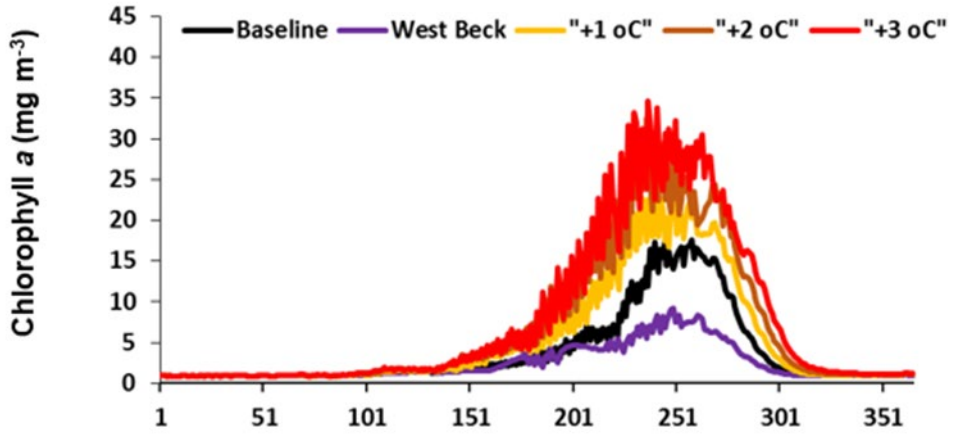
References:

OFWAT Innovation in water challenge project- Reservoir Water Community Monitoring for Algal Associated Risk Assessment. Cardiff University 2022

Blooms like it hot Hans W Paerl and Jef Huisman, Science Vol 320 2008

In summary the high levels of cyanobacteria and associated metabolites observed in raw water sources over the past few years will not subside, they are forecast to increase.

In 2020 UK CEH were asked to model different future scenarios for Tophill Low reservoirs to support an existing quality scheme. One of the scenarios considered was increased air temperature due to climate change. Figure 3.12.1 shows the

Hazard identification and Risk Characterisation
impact air temperature has on the biomass of cyanobacteria, their growth starts earlier, subsides later and reaches greater biomass during the peak season. Figure 3.12.1 Impact of air temperature on cyanobacteria **Comparison between simulated baseline cyanobacteria chlorophyll *a* concentrations (mg m^{-3}, black line) and the West Beck scenario (purple line) and three increased air temperature scenarios (+1°C yellow line; +2°C orange line; +3°C red line)**      Action is required to manage catchments and reservoirs differently to reduce or delay the need for expensive and carbon intensive capital solutions which would be required to maintain and improve drinking water quality.

13	Outline Risk characterisation. For example, details and score arising from consequence v. likelihood matrix, where score sits in the risk profile for the supply system.

The Company's DWSP Risk matrix incorporates a 5 x 5 scale severity and probability matrix. Our system adopts the DWI severity scores and combines this with an estimate probability (in bands of 20%) of failure within the next 12 months.

Table 3.13.1 DWSP Risk Matrix

Hazard identification and Risk Characterisation

		Severity				
		1 - VL	2 - L	3- M	4 – H	5 – VH
Probability	5 – VH	9	14	18	22	25
	4 – H	7	12	17	21	24
	3 – M	5	10	15	19	23
	2 – L	3	6	11	16	20
	1 - VL	1	2	4	8	13

Full details of risk assessments are shown in the relevant Reg28 Reports, but in summary there is a very high probability of the occurrence of tastes and odours in the two supplying raw waters. The risk at the WTW outlet is currently mitigated by treatment processes but further interventions are to be investigated.

AssetRef	HazardRef	PreLikelihood	PreConsequence	Risk	PostLikelihood	PostConsequence	Residual Risk	DWICategory	HazardID
A3612850	A003	5	3	15	5	3	15	F	42520
A3612850	A004	5	3	15	5	3	15	F	46046
A3612850	A023	5	3	15	5	3	15	F	41917
T3692910	A003	5	3	15	1	3	4	E	46705
T3692910	A004	5	3	15	1	3	4	E	41081
T3692910	A023	5	3	15	2	3	11	E	46662

Section 4

Control Measures Required – Details of short, medium and long term control measures	
1	Details of short-term actions currently in place to mitigate against risk & their effect
Short term actions are being implemented in line with our recently updated escalation policy under legal Instrument YKS_2022_00006.	
2	Details of mid to long term control measures identified for any residual risk: o Options the company has considered which should, where appropriate, include catchment management controls, or communications controls in association with other stakeholders o Timescale for delivery of each option o Capital costs and net additional operating costs of each option considered o Summary of costs and benefits of each option o Reasons for choosing the preferred option o Specific supporting evidence that the preferred option will address risk of hazard within the required timescale
Catchment Management Catchment management is the first line of defence for controlling water quality at source. The following paragraphs describe the recent activity in the catchments supplying Ingbirchworth WTWs. This level of activity is typical of all our agricultural catchments. Engagement with landowners and tenants has been a priority at Ingbirchworth, raising awareness of the principles contained within Farming Rules for Water. Engagement has been through attendance at the local agricultural show at Penistone (10th of September 22) in partnership with Catchment Sensitive Farming to raise awareness to water quality and offer advice to the farming community.	

Control Measures Required – Details of short, medium and long term control measures

We have also completed a catchment walkover with Natural England and Catchment Sensitive Farming which identified hazards which were brought to the attention of the Environment Agency to investigate.

There was a Nutrient Management Planning Farming event on the 8th of November 2023 held in the local area hosted by Catchment Sensitive Farming and the Environment Agency to raise awareness of the Farming Rule of Water and the requirements for a nutrient management plan.

Raw water source selection

Where reservoirs have known issues with algae, specifically T&O, seasonal use of raw water sources and blending are used to control risk. This approach has been adopted at Ingbirchworth WTW, and there is methodology in place to facilitate this.

Reservoir Management Solution

Understanding the extent to which a reservoir stratifies, the dissolved oxygen demand of the sediment layer and the impact this has on the release of soluble ions, including nutrients from the sediment can be key to understanding the root cause of Manganese and Algae risk. This allows the correct intervention to be taken.

Preventative action may be in the form of bubblers, mixers, oxygenators, blending options, alternative draw off and catchment management to control nutrient inputs. There are also some emerging nutrient stripping solutions that could be considered, although currently these are still at development stage. The starting point for any solution design is understanding the water quality in the reservoir at all depths.

YW is currently engaged in collaborative research projects with Cardiff and Bath Universities and UKCEH to understand the triggers for T&O events, and specifically how stratification and mixer selection and design could provide a holistic solution to mitigate Mn and Algae related risks.

Intense reservoir monitoring is underway at Ingbirchworth for the research project and to meet the requirements of the Legal instrument. The formal outputs from the research will be delivered in Dec 2024. This will inform whether a redesign of the bubbler system at Ingbirchworth is required.

Control Measures Required – Details of short, medium and long term control measures

Treatment Solution

The preferred solution is the treatment option of process improvements, including the installation of ozone and GAC filtration. This will be supplemented by reservoir mixing solutions as informed by our on-going investigation. This is the only solution at the present time that gives sufficient confidence in delivering the required outcomes. Further detailed investigation may confirm that a reservoir management only solution is viable.

Table 4.2.1 Comparison of cost and benefits of potential solutions

Options Considered	Capital Costs (£m)	Net Operational Costs (£m/pa)	Delivery Timescale (yrs)	Unplanned Outage Benefit (MLD)	CRI	Preferred Solution (AMP8)
Ingbirchworth WTW - Reservoir management & Treatment Solution	£22.43	£0.31	5	22	0.21	Y
Ingbirchworth WTW - Reservoir Management only	£4.22	£0.04	5	22*	0.1	N
Catchment Management - Winscar, Thurlstone, B'Stones - DrWPA_ND	£ -	£0.23	5	N/A	N/A	Y

*as detailed above, lack of confidence that the reservoir management only solution will provide full UPO benefit.

3	Full details of how the company intends to assess and measure the benefits delivered (the outcome), including details of proposed sampling programme,

Control Measures Required – Details of short, medium and long term control measures	
	number of samples to be taken over the specified period and parameters to be monitored.
It is intended to continue the existing oversight processes created as part of YKS_2022_00006 until delivery of the proposed treatment work enhancements. This includes review of triggers and appropriate steps.	

B6 Lead

Appendix B: Lead

Section 1

Background information	
Water Company	Yorkshire Water
Date of submission	31st March 2023
Name of Supply System	Regional
Regulation 28 report(s) reference number(s) (Unique reference number for each report that applies):	Initiative applies regionally for multiple aspects. However, one element of the scheme is to carry out targeted 'hot-spot' lead service pipe replacement in seven selected local areas represented by the following Reg 28 documents. YKS-Risk-Z4800619-03-23.csv YKS-Risk- Z4801219-03-23.csv YKS-Risk- Z2802719-03-23.csv YKS-Risk- Z2800519-03-23.csv YKS-Risk- Z2803019-03-23.csv YKS-Risk- Z1801219-03-23.csv YKS-Risk- Z9809719-03-23.csv
Name of Water Treatment Works/ Distribution System/ Service Reservoir/ Other asset	Regional

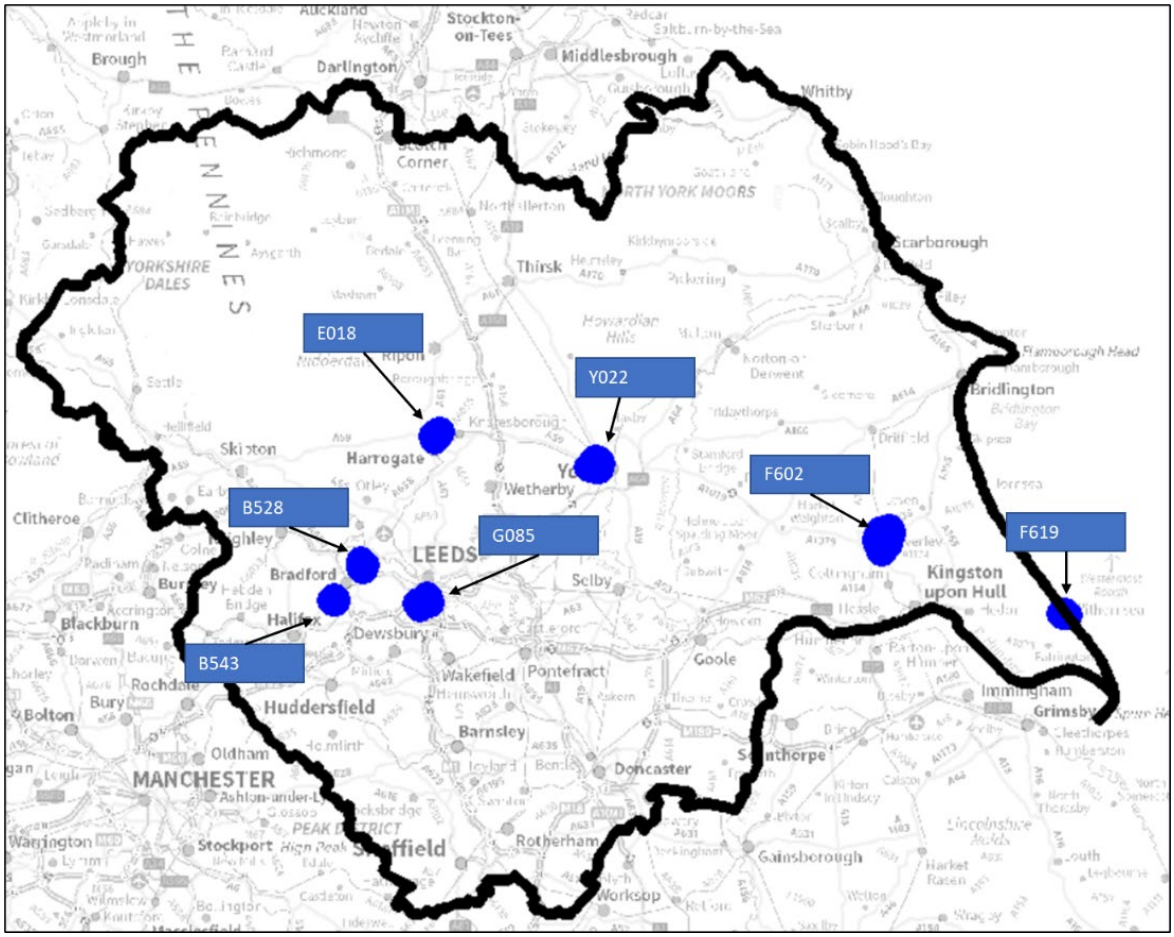
Background information	
Water Quality hazard(s)/driver(s) identified:	Lead (B007B)
Reference to outcome in company's long-term strategy:	Please see lead strategy published in March 2023 for more details.

Section 2

Details of water treatment works and associated supply system	
1	Provide supply arrangements and treatment works details:
N/A	
2	A description and diagram of the supply system related to the treatment works

Locations of the DMA hot-spot schemes are shown below. The Lead Exceedance and Free and Matching scheme locations are unknown due to the sampling process or in relation to customer requests. The Educational Establishments scheme will be investigated at the start of the scheme so the actual location of Lead Service pipe renewals is to be defined. Continued work to address lead risks to our customers on the priority services register will result in lead renewals at specific properties.

Figure 2.2.1 Location of Hotspot DMAs for supply pipe replacement



Details of water treatment works and associated supply system	
3	Design capacity of the water treatment works (Ml/d)
N/A	
4	Volume supplied: ○ Daily average (Ml/d) ○ Daily maximum (Ml/d) *[Please include a commentary if there are any constraints on deployable output due to limitations associated with any part of the treatment process. E.g. constraints in relation to blend water or seasonal constraints]*
N/A	
5	Sources of raw water (continuous/ seasonal/ standby) *[Include names of each individual source, nature of the source (eg, surface direct abstraction; surface impounding reservoir; borehole; spring; type of aquifer). Where appropriate include detail of any existing raw water optimisation / control measure(s) that are in place (e.g. artificial mixing; selective withdrawal depths for abstraction; raw water monitoring; water column profiling; etc.)]*
N/A	
6	Treatment processes currently employed (including pre-treatment of raw waters) *[In this case, blending is defined as treatment. This includes blending of raw waters prior to treatment. Please also indicate if bankside storage of raw water is utilised, and average retention time in the reservoir]*
A controlled dose of phosphate is provided into all of the Company's Water Supply Zones as part of our approach to controlling plumbosolvency.	
7	Service reservoirs/ booster pump details

Details of water treatment works and associated supply system	
N/A	
8	Water supply zones supplied and the population of each water supply zone *[If the supply is blended with waters from other treatment works in the zone, please indicate the relative proportions (as %)]*

Hotspot service pipe replacement is to be carried out in seven targeted local DMA areas.

Table 2.8.1 WSZ Populations in relation to the hotspot DMAs

DMA Ref	Water Supply Zone	WSZ Ref	2023 WSZ Population
B528	Bradford City North 2019 WSZ	Z4800619	56787
B543	Denholme and Queensbury 2019 WSZ	Z4801219	90509
E018	Harrogate North 2019 WSZ	Z2802719	39118
F602	Beverley 2019 WSZ	Z2800519	94781
F619	Holderness 2019 WSZ	Z2803019	42246
G085	Leeds LL Robin Hood 2019 WSZ	Z1801219	67389
Y022	York West 2019 WSZ	Z9809719	92222

Section 3

Hazard identification and Risk Characterisation	
1	Provide details of the methodology used to identify the hazard. For example: • Historical data, • Events/ incidents including near miss situations, • Operator knowledge, • Modelling and validation of modelling • Site visits/ technical audits

Replacement on exceedance of the 10µg/l standard - Under Regulation 17(9), we replace our pipes and fittings where a sample has exceeded the 10µg/l standard.

Method of identifying high risk DMAs - If a DMA has been subject to more than one sample per year exceeding 4µg/l within a rolling 3-year period (2019-21), it is proposed a strategic lead investigation programme be adopted to identify which properties within the DMA have a lead service.

Lead Pipe Replacement – customer request scheme - in line with the 'Lead Replacement Policy', we fund the "free and matching" replacement of the lead communication pipes at the request of the customers who have replaced all sections of lead in their supply pipe or internal plumbing system.

Educational Establishments - We acknowledge that children are particularly vulnerable to the effects of lead, and that even relatively low levels of exposure can cause serious damage. In the Yorkshire region, in order to reduce a child's potential exposure to lead we plan a programme of renewal of lead communication pipes, and where agreed, supply pipes, that supply our schools and potentially nurseries.

Customers on the Priority Services Register - The intention is to continue to work with our vulnerable customers in a targeted replacement of lead services. Where it is identified that these properties may have a lead service, our intention is to replace the communication pipe.

Hazard identification and Risk Characterisation	
2	Summary of historical data on the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the raw water source and the water entering supply from the relevant treatment works from compliance, investigative, or operational sampling

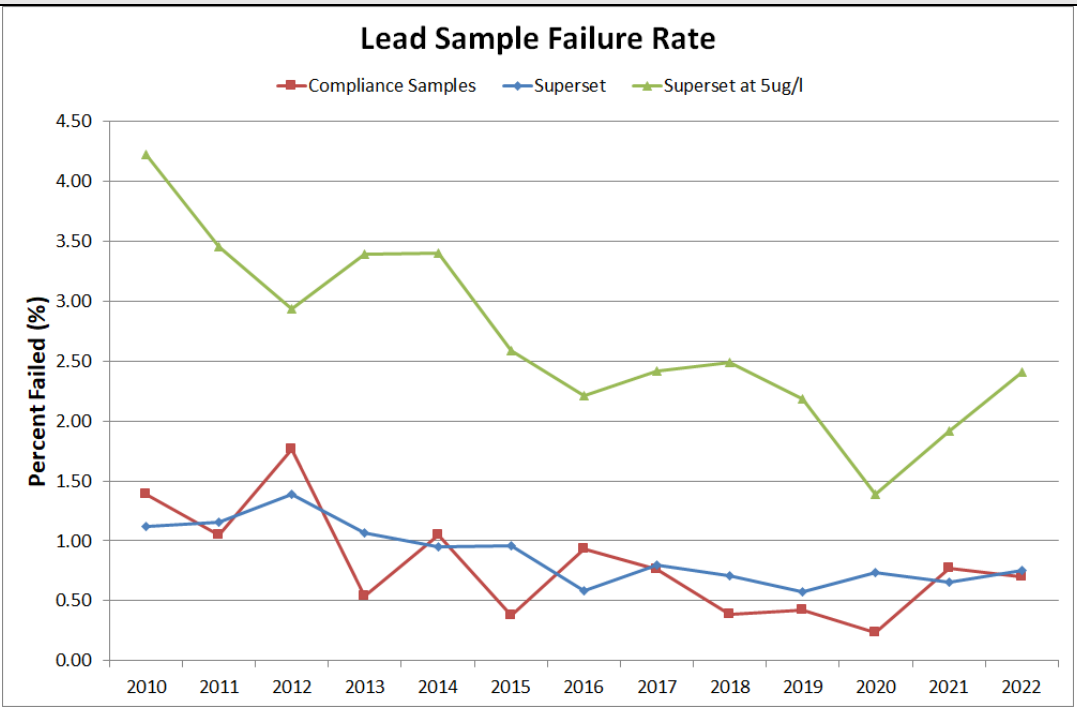
The Company collects lead samples as part of the regulatory sampling programme at a frequency of x8 per year. In addition, to those collected for regulatory purposes an additional series of operational samples are collected. Approximately 4 to 5 operational samples are collected for each regulatory sample.

Table 3.2.1 Lead Samples and Failures

	Total Samples	Total Fails	Total Fails at 5ug/l
2010	3386	38	143
2011	3387	39	117
2012	3377	47	99
2013	3363	36	114
2014	3354	32	114
2015	3127	30	81
2016	3255	19	72
2017	3269	26	79
2018	3254	23	81
2019	3985	23	87
2020	2443	18	34
2021	3650	24	70
2022	3993	30	96

Figure 3.2.1 Lead Failure Rates of sampling programmes

Hazard identification and Risk Characterisation



3	Details of any existing contraventions of regulatory requirements and whether they are likely to recur (at WTW, SR and/or at consumers taps)

A relatively small number of samples collected from customer properties on a regional basis each year as part of the compliance sampling programme fail to meet the regulatory standard.

Table 3.3.1 Numbers of regulatory fails per year

	Compliance Fails
2010	8
2011	6
2012	10
2013	3
2014	6
2015	2
2016	5
2017	4
2018	2
2019	3
2020	1
2021	5
2022	5

Hazard identification and Risk Characterisation	
4	If evidence of likely to contravene any regulatory requirement, details of when this is likely to occur (at WTW, SR and/or at consumers taps) including trend analysis & prediction modelling
A relatively small number of samples collected from customer properties on a regional basis each year as part of the compliance sampling programme fail to meet the regulatory standard. Where it is identified that these properties have a lead communication pipe, we replace it.	
5	Details of any other data relevant to the hazard identified
N/A	
6	If appropriate, summary of data/ information on consumer complaints
N/A	
7	Details of any events that have occurred in the catchment, at the treatment works and in supply that are associated with hazard identified
N/A	
8	Details of any existing control measure(s) that might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in the catchment, in treatment and in supply
A controlled dose of phosphate is provided into all of the Company's Water Supply Zones.	
9	Details of monitoring of the existing control measure(s) (including validation monitoring)

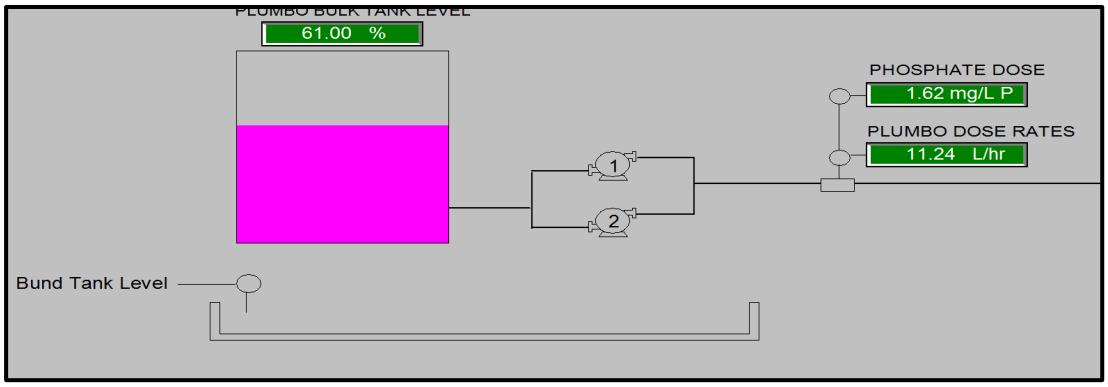
Hazard identification and Risk Characterisation

The Company's processes with regard to lead monitoring were subject to a DWI Audit in 2021 and 2022.

Routine and enhanced sampling programmes as described above are the key mechanisms to provide a good background for identification of the highest risk areas.

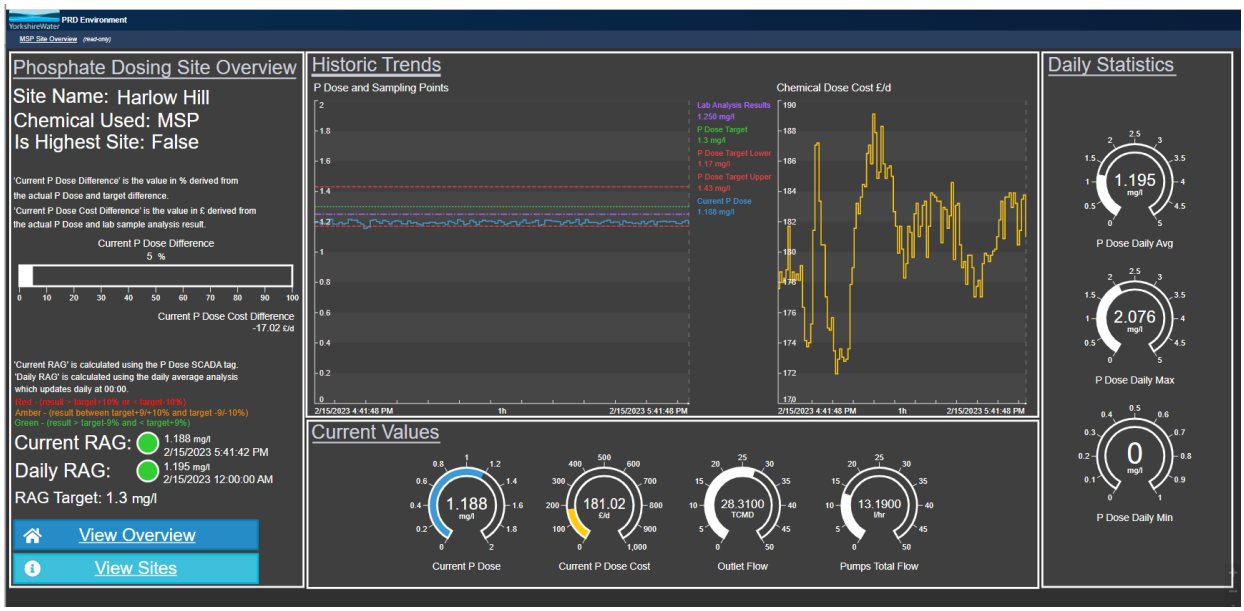
Phosphate dosing is calculated and displayed on site SCADAs. An example from Acomb Landing WTW in York is shown below.

Figure 3.9.1 Example SCADA phosphate dosing information



On a regional basis, phosphate based chemical dosing is monitored by on-line telemetry. This data is used to confirm dose rates, which is interrogated by our WQ Scientists.

Figure 3.9.2 Example Phosphate dosing Dashboard.



Hazard identification and Risk Characterisation	
On-line data is assured by collection of laboratory samples for phosphate x52 per year at WTW outlets.	
10	Details of any changes in practices or policy which might have influenced the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in water supplied to consumers, i.e., in relation to resources, blending arrangements, treatment or supply arrangements and the dates of those changes
N/A	
11	Details of any licensed abstraction issues which might influence the values and concentrations of the organism, substance(s) or parameter(s) associated with the hazard in raw water
N/A	
12	Reasons for the presence of the hazard, if known, otherwise details of what is being done to identify the source of the hazard
Lead is present in water from customers taps due to a combination of reasons: • Lead pipework installed prior to 1970s. • Leaching for new brass fittings prior to build-up of phosphate layer • Inappropriate use of lead solders However, it is relevant to note that in all cases property-by-property level local factors, such as the combination of metals involved in fittings and physical disturbance, strongly influence the level of lead occurring at a specific property.	
13	Outline Risk characterisation. For example, details and score arising from consequence v. likelihood matrix, where score sits in the risk profile for the supply system.

Hazard identification and Risk Characterisation

The Company's DWSP Risk matrix incorporates a 5 x 5 scale severity and probability matrix. Our system adopts the DWI severity scores and combines this with an estimate probability (in bands of 20%) of failure within the next 12 months.

Figure 3.13.1 DWSP Risk Matrix

		Severity				
		1 - VL	2 - L	3- M	4 – H	5 – VH
Probability	5 – VH	9	14	18	22	25
	4 – H	7	12	17	21	24
	3 – M	5	10	15	19	23
	2 – L	3	6	11	16	20
	1 - VL	1	2	4	8	13

Full details of risk assessments are shown in the relevant Reg28 Reports, but in summary, the risk of lead in water is considered to be of the highest severity. The overall probability of occurrence at any specific water supply zone is relatively low as lead issues are often concentrated in hotspot locations.

Table 3.13.1 Summary of DWSP risk details.

AssetRef	HazardRef	PreLikelihood	PreConsequence	Risk	PostLikelihood	PostConsequence	Residual Risk	DWICategory	HazardID
Z9809719	B007B	3	5	23	2	5	20	E	44124
Z1801219	B007B	4	5	24	3	5	23	E	48100
Z2800519	B007B	3	5	23	2	5	20	E	44043
Z4800619	B007B	3	5	23	2	5	20	E	41132
Z4801219	B007B	3	5	23	2	5	20	E	42554
Z2803019	B007B	3	5	23	2	5	20	E	40477

Section 4

Control Measures Required – Details of short, medium and long term control measures	
1	Details of short-term actions currently in place to mitigate against risk & their effect
Dosing of phosphate-based chemicals into all Water Supply Zones. Customer requested and sample related replacement of lead communication pipework. Opportunistic replacement of lead communication pipework in relation to other operational activity.	
2	Details of mid to long term control measures identified for any residual risk: o Options the company has considered which should, where appropriate, include catchment management controls, or communications controls in association with other stakeholders o Timescale for delivery of each option o Capital costs and net additional operating costs of each option considered o Summary of costs and benefits of each option o Reasons for choosing the preferred option o Specific supporting evidence that the preferred option will address risk of hazard within the required timescale
The table below shows the proposed investment within AMP8 of the different elements of the lead programme. The costs show the capital cost of replacement of either the communication pipe or full service pipe, depending upon the scenario. The costs are based upon the AMP7 delivery capital costs for lead pipe replacement. We do not believe there are any additional operating costs for any of the scenarios selected. The chosen approach will increase the number of customers that benefit from reduced lead exposure to c63,000 in AMP8 (an increase from c25,000 in AMP7). This is primarily due to an enhanced programme at educational establishments.	

Control Measures Required – Details of short, medium and long term control measures

Other options considered were renewing only the communication pipe but decided to renew the service pipe to maximise the health benefit and avoid possibly having to return to replace supply pipe at a future date.

Table 4.2.1 Costs of Proposed Interventions

PR24 Lead Programme Scenarios	AMP8 Proposed Investment	Estimated No. Of Renewals	Estimated No. of people to benefit	Timescales for delivery
Lead Exceedance	£607,497	434	1,041	AMP8 year 1-5
Lead Free & Matching	£2,934,477	2,096	5,031	AMP8 year 1-5
Lead DMA Hot Spot Medium Scenario (7 DMAs) Full Service Pipe	£15,061,694	8,285	19,883	AMP8 year 1-3
Lead Education Establishment High Scenario Full Service Pipe	£1,000,000	100	35,929	AMP8 year 1-5
Lead Helping Hands/Vulnerable Customers	£804,338	575	1,379	AMP8 year 1-3
	£20,408,005	**11,489**	**63,263**	
Assumes an average of 359 pupils per education establishment and 2.4 people per property				

3	Full details of how the company intends to assess and measure the benefits delivered (the outcome), including details of proposed sampling programme, number of samples to be taken over the specified period and parameters to be monitored.

The scheme has a number of elements which will each require their own measure. However, the key success criteria will be completion of planned activity in the seven selected DMA areas, and replacement of other pipework. It is identified in the lead exceedance, free and matching, vulnerable customer, and educational establishment elements of the scheme. Estimated numbers of pipes are provided in table 4.2.1.

Underlying this activity, the Company intends to continue its operational lead monitoring programme. Lead samples are scheduled in all zones at the equivalent frequency to aesthetic mains scheduling. Eight of the samples are created as regulatory with the remaining as operational. Sampling officers and laboratory process are entirely the same, and indeed only colleagues reporting regulatory result are aware which samples have been scheduled as regulatory.

All exceedances of standards or Company trigger levels will enter the appropriate replacement programmes.

C Lead Strategy

Lead Strategy

Yorkshire Water

March 2023

YorkshireWater

1.0 Introduction

This document outlines the Yorkshire Water (YW) long term lead removal strategy – it outlines our previous and current asset strategy, our plans for Asset Management Plan (AMP) 8 in 2025 – 2030, and future lead strategies. The lead removal strategy builds on and aligns with YWs wider Long-Term Statement on Drinking Water Quality submitted to the Drinking Water Inspectorate (DWI) in January 2023.

2.0 Previous Strategies

The YW strategy for lead was previously set out in the 2018 Long Term Delivery Strategy, this section will summarise the activities completed, the learnings and performance.

2.1 Summary of Activities

During the past two AMP periods we have delivered a **Hotspot Programme** focused on proactively removing or relining (Rotherham trial) lead pipes from the region using a risk-based approach. We have continued to focus on **vulnerable customers**[1] with targeted replacement of lead services to those who are most at risk. We continued replacement **under regulation 17(9)** where a lead sample has exceeded the 10µg/l standard. As well as the "**free and matching**" replacement of lead communication pipes at the request of customers who have removed all sections of lead in their supply pipe or internal plumbing system.

2.1.1 Lining Trial: Rotherham Case Study

We have previously trialled the use of lining techniques in the Rotherham region, lining the entire service pipe. The trial focused on c1000 social housing properties and the use of rapid setting polymeric lining. The delivery of the trial was challenging and the delivery team had to overcome issues such as health and safety within gardens, access to properties and local disruption. The findings from the trial were positive from a lead removal perspective. With the lining however, not being a permanent solution and the costs not being significantly lower than full replacement, we are not proposing lining techniques in our future strategy.

[1] Throughout AMP6 and AMP7 we have carried out service pipe renewal to our most vulnerable customers from a water quality perspective. Where a customer has informed us that they are on dialysis or require a constant supply of water in the event of a planned interruption, we have renewed their service where we have found it to be lead.

Children are particularly vulnerable to lead exposure. As such we have focused on removing lead connections to **education establishments** in the region. In AMP7 this has provided learnings that will inform our future strategies, including how to focus investigations and communication with schools and nurseries to deliver lead removal schemes.

2.2 Phosphate Dosing Cessation

Dosing of phosphate-based chemicals is one of the mitigation activities credited with supporting the significant reduction in the number of exceedances for lead over the last 20 years. However, it is also understood that the worldwide resource of available phosphate is limited. Some water companies have followed a pathway of removing known lead pipework with the intention of ceasing phosphate dosing. Unfortunately, we have not been able to cease dosing.

Our Yorkshire Grid network is designed to provide substantial resilience in supply options to customers. This is achieved by constructing a supply system that incorporates multiple interconnections between water supply systems. We are committed to delivering safe, wholesome water to our customers and because there is flexibility in the journey treated water will take on a day-to-day basis from the water treatment works to the customer tap, we continue to monosodium phosphate (MSP) dose all our water supplies in order to mitigate the lead risk. In addition, where customers internal pipes are still lead, removing MSP could put those customers at a health risk, therefore a full lead removal approach is required.

However, we are keeping the current arrangements under review. We will consider opportunities for future interventions to sustainably allow phosphate-free supply areas.

2.3 Investigation into Lead Data in Yorkshire Network

As part of a lead replacement project in AMP7, we have gained better intelligence on the occurrence of lead pipes remaining in Yorkshire. Estimates of numbers of service pipes of specific materials were made across the region including lead, galvanised iron and steel. This information will be used in the future to target hotspots of lead replacement as well as indicating the estimated scale of removal required.

As part of the project, service pipe material was estimated directly from a single variable of property build period. The dataset used was a breakdown of the dwelling stock down to a lower geographic level 'Lower layer Super Output Area' (LSOA), categorised by the property build period. The counts are calculated from domestic property data for England and Wales, extracted from the Valuation Office Agency's administrative database on 31 March 2015. This data has been corroborated by its use in the DWI and WRC publication 'Long-term Strategies to Reduce Lead Exposure from Drinking Water'.

As well as this, data collected as part of repair & maintenance of communication pipes provides us with valuable insight into material types in specific areas, which helps inform our Lead Strategy.

2.4 Summary of previous WQ performance and enhanced monitoring programme / Drinking Water Safety Plans

The Company carries out monitoring for lead in both regulatory and operational surveillance sampling programmes. All 89 of the Company's WSZ require sampling for lead at the higher frequency of 8 samples per year in the regulatory programme. The Company supplements this programme by collection of further samples at the frequency dictated by the requirements for aesthetic metals.

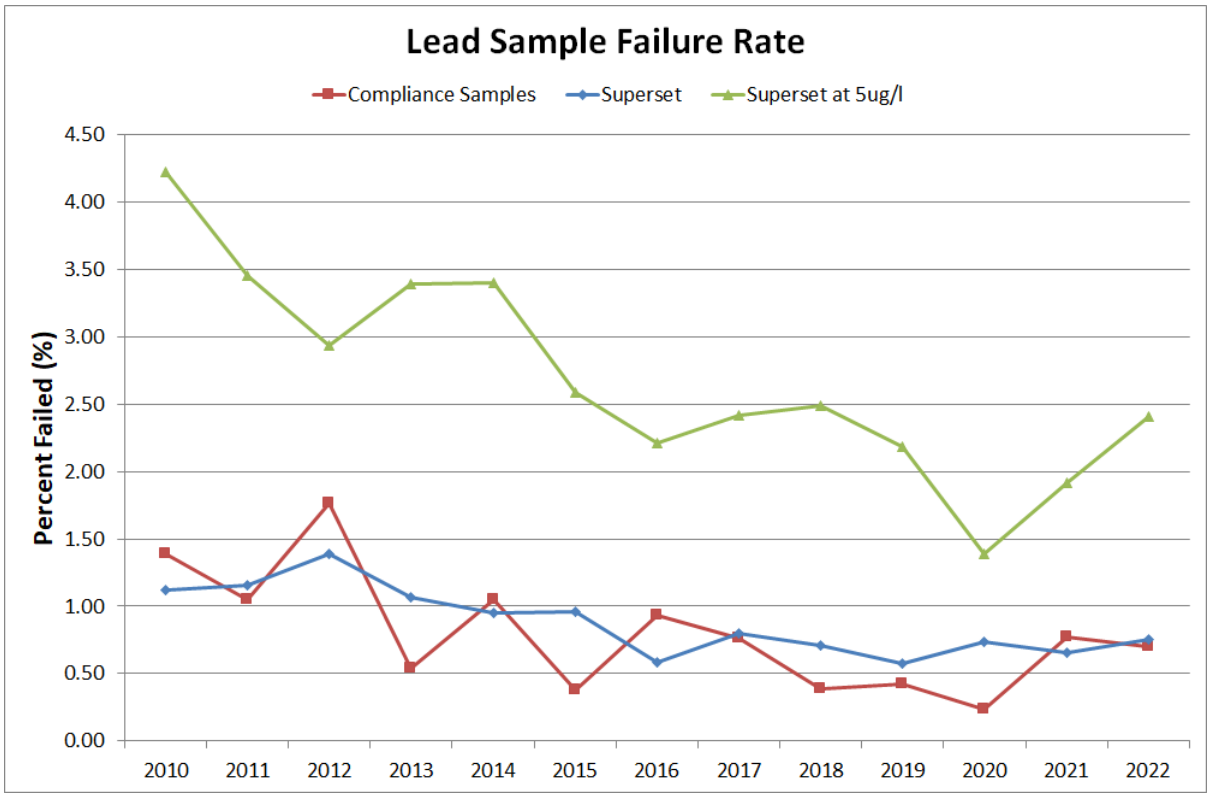
All samples are collected by UKAS accredited Water Quality Sampling officers. The occurrence is defined as a 'compliance' or 'non-compliance' event at the point of prescheduling. However, this information is not available to the Sampling Officer or laboratory – ensuring all samples are processed identically.

Table 2.4.1. Total lead Exceedances

	Total Samples	Total Fails	Total Fails at 5ug/l
2010	3386	38	143
2011	3387	39	117
2012	3377	47	99
2013	3363	36	114
2014	3354	32	114
2015	3127	30	81
2016	3255	19	72
2017	3269	26	79
2018	3254	23	81
2019	3985	23	87
2020	2443	18	34
2021	3650	24	70
2022	3993	30	96

In line with data from elsewhere in the UK, sample results (shown in 2.4.1 & 2.4.2) indicate that there has been a reduction in the rate of failure for lead. This is apparent at the 10 ug/l Pb regulatory standard and at the 5 ug/l Pb trigger level.

Figure 2.4.2 Lead sample failure rate



The Company has chosen to incorporate the DWI's parameter risk scores into its 5 x 5 risk matrix in our Drinking Water Safety Plan risk assessments. As such the parameter lead is assessed at the highest priority of 5 (very high) on the severity scale. Sample data is incorporated into probability calculation in the Company's Drinking Water Safety Planning risk assessments. Details are updated on a regular basis in our Reg28 report submissions.

3.0 AMP8 and Beyond

This section will outline the programme of works to be completed in AMP8, detailing changes from our previous strategies and where further investigation is required. The chosen approach will increase the number of customers that benefit from reduced lead exposure to c63,000 in AMP8 (an increase from c25,000 in AMP7). See table 3.1 for full details of the lead associated activities planned for AMP8.

Table 3.1 AMP8 Programme - proposed Scenarios

PR24 Lead Programme Likely Scenarios	AMP8 Cost (£m)	% Increase no. of pipes replaced	No. of people benefited
Lead Exceedance	£0.61	67%	1041
Lead Free & Matching	£2.93	4%	5031
Lead DMA Hotspot - Full Service Pipe (7 DMAs)	£15.06	78%	19883
Lead Education Establishment High Scenario	£1.00	426%	35929
Lead Vulnerable Customers support	£0.80	14%	1379
Total	**£20.41**	**54%**	**63,263**

3.1 Lead Exceedance and Free & Matching

As part of our sampling programme if a customer has a result above a trigger of 7.5µg/l Pb and it is confirmed that the communication pipe material is lead, we will renew the communication pipe as part of our 'Lead Exceedance' programme of work. For sample results between 5 and 7. 5µg/l Pb, we write to the customer and advise they may wish to consider replacing lead pipework. Where a customer is renewing their lead supply pipe, and we confirm they have a lead communication pipe, we will renew it free of charge.

3.2 Hotspot Programme

In AMP8 we are again proposing a risk-based approach to investment at Distribution Management Area (DMA) level.

Lead removal from the water network is a challenging and complex issue. Water companies are not responsible for full length of the water pipes serving a customer's property or the internal plumbing where lead can be found. Customers are not fully protected from exposure to lead if only the water company assets are replaced. For this reason, we have made the strategic decision to replace the full service pipe (including customer owned, up to the boundary of the property) and reduce the number of targeted DMAs in comparison with previous AMPs.

In the long term, we propose to continue this targeted replacement of lead in hotspot DMAs. We use a risk based approach to target these DMAs using the number of times our enhanced sampling programme has exceeded a specific value. For AMP6, AMP7 and AMP8, this has been 4μg/l Pb. This approach has the potential to be modified in the future, as we learn from internal and external findings, in order to reduce risk to customers.

3.3 Educational Establishments

In AMP8 we will widen our approach from schools to also target other educational establishments such as nurseries. We believe this approach helps us target those most at risk from the issues associated with lead. In AMP7 we renewed 19 service pipes that supplied water to 17 schools and plan to take the learning from this work so that our AMP8 programme can be delivered as efficiently as possible. The challenges associated with delivering a programme of work directed towards schools and nurseries is identifying the pipe material type that supplies the building. The logistics around renewing a service pipe that supplies a school also means that the work needs to take place in the holiday period (mainly summer), as often the renewal takes place within the boundary of a school (playground) which can pose a Health & Safety risk to both the contractors and the students as well.

The work carried out in AMP7 will inform how we will identify lead in schools. In AMP8 and beyond, we will also widen the scope of educational establishments to include other communal buildings such as sports and recreation halls and medical businesses. This strategy will allow us to provide benefit to a higher number of vulnerable customers and establishments than focusing purely on hotspot replacement for private customer properties.

3.4 Vulnerable Customers

Throughout AMP6 and AMP7 we have carried out service pipe renewal to our most vulnerable customers from a water quality perspective. Where a customer has informed us that they are on dialysis or require a constant supply of water in the event of a planned interruption, we have renewed their service where we have found it to be lead. As our list of vulnerable customers is constantly changing, we will review those that are added to the priority services register and where we find there is a lead service supplying these properties, we will seek consent to renew the service pipe. Table 3.2 shows the different reasons why a customer may be on the register.

Table 3.2 Categories of vulnerable customers

Categories	Registered
Additional presence preferred	2,771
Blind	986
Careline/telecare system	1,114
Chronic/serious illness	12,407
Dementia(s)/Cognitive impairment	2,106
Developmental condition	2,027
Dialysis, feeding pump and automated medication	577
Families with young children 5 or under	3,391
Hearing impairment (inc. Deaf)	3,916
Heart, lung & ventilator	1,625
Medically dependent showering/bathing	5,359
Medicine refrigeration	3,110
Mental health	5,683
Nebuliser and apnoea monitor	1,303
Oxygen concentrator	249
Oxygen Use	498
Partially sighted	2,481
Pensionable age	14,281
Physical impairment	9,601
Poor sense of smell/taste	1,128
Restricted hand movement	3,518
Speech impairment	931
Stair lift, hoist, electric bed	2,143
Temporary - Life changes	34,705
Temporary - Post hospital recovery	466
Temporary - Young adult householder (<18)	207
Unable to answer door	1,610
Unable to communicate in English	344
Water dependent	8,471
Total	127,008

3.4 Phosphate Dosing

We will investigate what is required to remove dosing in specific areas. However, until this is feasible in our networks, we will continue with our current dosing of phosphate-based chemicals.

3.5 Asset replacement: Mains Renewal / relining and communication pipe renewal for leakage purposes

- **Mains renewal / relining programme** – In order to continue to improve our asset health in AMP8 we are planning on increasing the level of mains renewal or relining (where appropriate). The primary driver for this is to reduce the number of mains

repairs and consequently interruptions to customer supplies. We will include assessment of lead risk potentially related to galvanised steel mains. One of the other benefits of doing this work is the visibility of our underground assets: A substantial mains renewal programme gives us an understanding of the services we are connecting our mains into. Where a connection into a main occurs, a record will be held of this material and consideration will be given to renewing the service whilst renewing the main.

- **Communication Pipe Renewal** – As part of our drive to reduce leakage, we have increased the number of communication pipe renewals we carry out. Although leakage levels associated with lead as a material are generally low, on occasion there will be lead communication pipe renewals carried out for leakage and low pressure purposes.

4.0 Future Lead Strategies

The final section of this document will outline the scale of the challenge for the full removal of lead, the affordability for customers and YWs support of national initiatives.

In table 4.1 we have summarised the current forecast position to remove lead entirely from the Yorkshire network. Unit rates for communication pipes, full service pipe and end to end (including internal plumbing) have been estimated based on industry data to outline the scale of the programme required from both a cost and activity perspective. In comparison to our proposed AMP8 programme, these figures are orders of magnitude larger showing the step change that is required in the future.

Table 4.1 Indicative full network lead replacement cost scenarios

		25 Year Plan		40 Year Plan		60 Year Plan	
		Annual	**AMP**	**Annual**	**AMP**	**Annual**	**AMP**
Lead Scenario Types	No. of pipes	48,000	240,000	30,000	150,000	20,000	100,000
Communication Pipe Only	Cost (millions)	£67	£336	£42	£210	£28	£140
Full Service Pipe		£91	£456	£57	£285	£38	£190
End to End (Incl. internal plumbing)		£154	£768	£96	£480	£64	£320

YW is committed to the removal of lead for our customers, but several obstacles need to be overcome to implement a strategy in our networks.

- **Affordability**: The costs involved in delivering a lead-free Yorkshire would significantly increase customer bills. Water companies must balance the priorities based upon customer expectations of quality and cost. We will be flexible to changes in customer need.
- **Pipe ownership**: We have committed in AMP8 to focus on replacing lead pipes up to the property wall but delivery for all customers can be problematic due to the disruption it can cause and this can influence a customer's choices about interventions on their pipework.
- **Regulation**: It is likely that a change in legislation is required to initiate full lead removal with consideration of inter-generational fairness for affordability and customer bills.

We would welcome policy change in this area in the future and will include these 'lead-free' adaptive pathway scenarios in our Long Term Delivery Strategy (LTDS) submission as part of the wider AMP8 Business Plan submissions.

Further engagement with the DWI and wider water industry would be welcomed to identify how best to overcome the challenges identified. YW will continue to work on nationwide lead initiatives to reduce the health risk of lead to customers.