Asset health: our approach

Chapter 4: Supplementary document

Document Reference: S4001

This document summarises our current and expected asset health across our regulated business. It demonstrates that we have the data, tools and capability to assess asset health to inform risk-balanced investment decisions.

United Utilities Water Limited

United
Utilities

helping life flow smoothly

Contents

1   Executive summary

This document demonstrates that we have the data, tools and capability to assess asset health and to make risk balanced decisions that manage the health of our assets in a controlled way, with this analysis being integrated throughout the business from our operational process to our corporate risk management framework.

The document also sets out how we have engaged with customers to understand their views of asset health and their appetite for investment to maintain asset health. Our planned approach for AMP7 broadly aligns to customer expectations by including financially incentivised performance commitments for maintaining asset health. It also summarises our current and expected asset health across our regulated business.

We have commissioned a comprehensive review of our understanding and management of asset health by the same team in Jacobs who carried out the horizontal audit for Ofwat[1]. Our company specific audit by Jacobs confirmed that we had good to leading-edge performance across all measures, see supplementary T9035. Jacobs found that the concept of asset health was extremely well embedded across our business with excellent customer engagement and use within our business as usual decision-making processes.

Table 1: Summary asset health assessments from independent audit

Assessment Category	Assessment
Understanding of asset health	Best in class
Measurement of asset health (physical)	Performing
The link between asset health, performance, service and outcomes	Performing
Influence of asset health on investment planning and decision making	Leading
Communication and the views of the customer	Leading
Asset health assurance	Leading
Innovation and collaboration	Performing

We have used a number of methods to understand customer views on asset health, including engaging with our online customer community 'WaterTalk' about asset health and have used quantitative and qualitative research to engage customers in meaningful discussions around asset health and the health of our asset base.

The results showed that customers generally understand the traditional measures of asset health, and how they might impact current and future service. With the research demonstrating that increased investment targeting changes to asset health was widely supported, particularly for measures with a clear environmental service benefit. We believe that this conclusion helps to support our plan to target both the least healthy assets and the potential service impacts associated with asset health issues.

We have complemented the well-established measures of asset health widely used within the water industry with our Base Asset Health indicator (BAH), which is a standard measure of asset health that has been applied across our whole asset base, taking account of the various existing asset health data streams, which are now well embedded across our business.

The health of our assets underpins their ability to deliver our services to customers and the environment and helps us to focus our maintenance appropriately. During AMP7 we will focus on more cost effective and innovative operational strategies to deliver the required service performance and target investment on unhealthy assets, which in certain parts of our business will allow 'average' asset health to deteriorate in a managed way, as indicated in Figure 1 below.

---

[1] 'Targeted Review of Asset Health and Resilience in the Water Industry' 14th September 2017
https://www.ofwat.gov.uk/publication-targeted-review-asset-health/

Figure 1: The effect of underlying asset health deterioration on performance with targeted operational strategies to improve performance

PERFORMANCE FAILURES
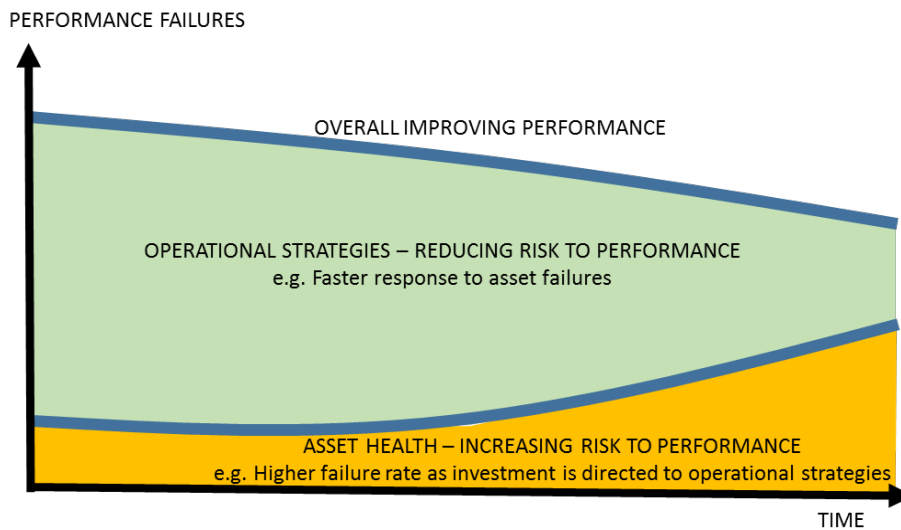
Examples of operational interventions that have limited effect upon asset health, but that can improve service performance include:

- customer awareness campaigns, such as our 'what not to flush' series, highlighting sewer misuse,
- alternative supply vehicles that help to ensure water supplies are retained during a water pipe burst or repair, and
- better and more pervasive instrumentation that improves recognition and response to incidents, reducing their effects upon our service delivery.

The AMP7 approach is driven by our innovative system thinking approach to operating and maintaining our asset base and should allow us to meet the substantial commitments for environmental improvements, whilst minimising investment requirements. In the longer term, we will need to ensure that we continue to invest in innovative and efficient ways to maintain the overall health of our asset base as a greater proportion of our asset base ages.

We will focus our maintenance investment on those assets in poor health, which have the largest potential risk of failure leading to service impacts. The longer that healthy assets are operated the more value they deliver for customers and the environment. Ensuring that our assets are operated and maintained to maximise their period of long, healthy, performance is central to our asset management strategy, requiring a careful balance between an increasing risk of failure against efficient investment and enabling us to meet our performance commitments with efficient and effective investment.

This approach should deliver stable performance for asset health across our regulatory measures and deliver our performance commitments. Figure 2 illustrates this approach to asset health for AMP7.

Figure 2: Targeting maintenance at the most unhealthy assets
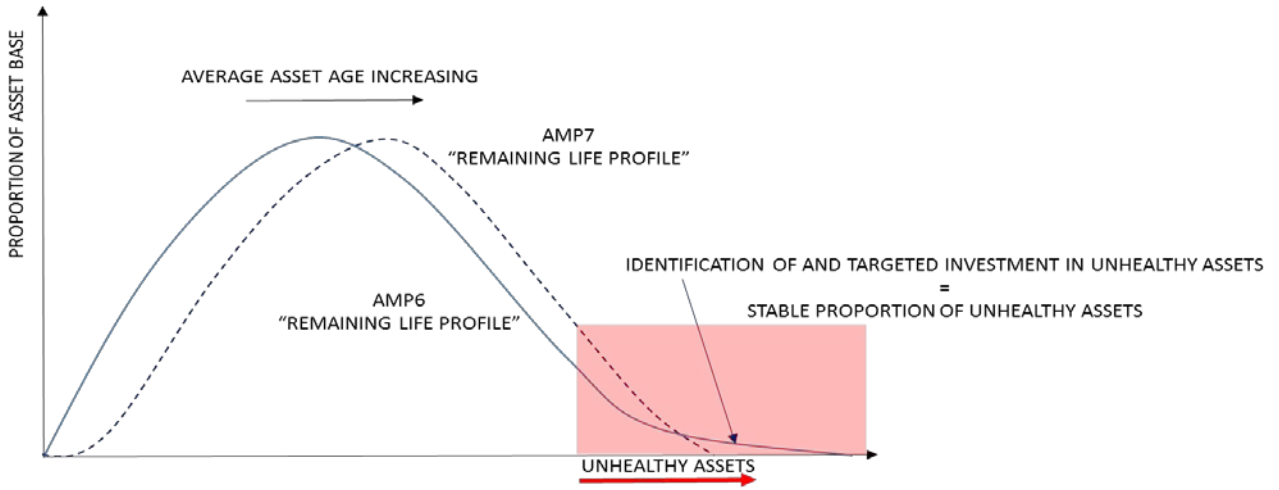
2 Asset health – customer insight

2.1 Approach to research

We have met Ofwat's challenge to engage customers in meaningful decisions around the health of our asset base, this is relatively complex as investment decisions about asset health do not generally result in an immediate impact upon service. For example, foregoing a proactive programme in sewer rehabilitation may help to keep bills low in the short term, but may lead to higher bills in the longer term.

We have used a number of methods to understand customer views on asset health, most recently we have engaged with our online customer community 'WaterTalk' specifically about asset health with quantitative and qualitative research, summarised in supplementary document T1081. The details of each of these surveys were:

- Quantitative – an online survey with 720 WaterTalk members (1st to 7th June 2018), selected to match United Utilities' customer base

- Qualitative – a three day pop-up community with 32 members who had completed the online survey (18th to 20th June 2018)

This research was designed to reveal:

- Whether our current asset health indicators are easy to understand
- Whether there was support for delaying the maintenance of assets, resulting in lower bills in the short term, higher risk and potentially higher bills in the future
- Which parts of our asset base customers thought were most important to keep healthy
- Whether there was support for incentives for beating or missing asset health performance commitments

These issues were evaluated across a range of customers to see how support for different approaches to asset health varies across the customer base.

We also carried out extensive customer research into supporting our Manchester and Pennines Resilience cost adjustment claim. The research focused on understanding customer views on the health of one of our largest strategic assets. The findings from this research were included within a cost adjustment claim.

3 Customer insight results

3.1 Understanding asset health measures

The results showed that customers generally understand the traditional measures of asset health, and how they might impact current and future service.

Network failures are quite intuitive as they are more likely to be visible and to have more immediate service impacts. A number of customers have experienced either

- a loss of supply, or reduced flow, and can relate that to a burst main or
- a blocked sewer or drain, and can relate that to flooding or pollution.

The measures around treatment works failures were less clear, with customer understanding lower than for the network measures.

The Base Asset Health indicator was one of the least well understood of the tested measures, however it still achieved a substantial positive understanding, demonstrating that for a clear majority of customers it was a meaningful way of expressing the health of our assets.

3.1.1 Investing in asset health

Customers were generally willing to see small increases in bills to fund improving asset health, they were also strongly supportive of maintaining at least the current level of asset health rather than supporting modest reductions in bills, if that would result in a less reliable asset base and more service failures.

Figure 3: Customer understanding of the importance of maintaining asset health

When explicitly asked, almost all consider it extremely important for United Utilities to maintain its assets
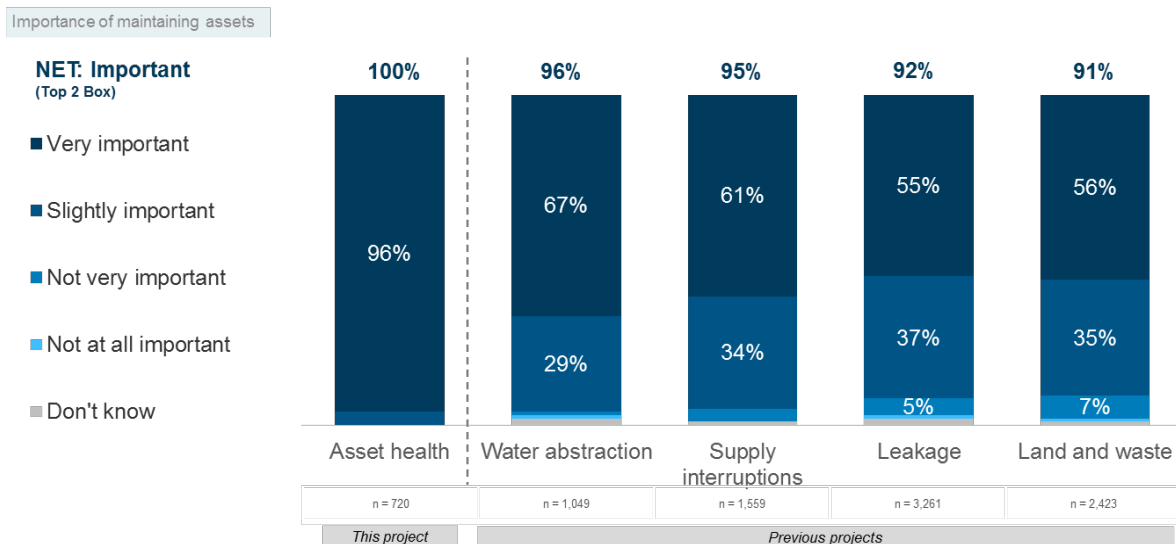
A typical customer quotation on sentiment towards asset health investment from our quantitative research:

> *"delaying investment is only putting off the inevitable. Breakdowns will be more likely and emergency repairs more costly"*

3.1.2 Priority areas for healthy assets

There was some difference in customer support for different parts of the asset base, although there was a slight preference for maintaining the health of environmentally impactful assets and network assets. This may be attributed to the more immediate service impacts associated with 'unhealthy' mains and sewers coupled with a strong desire to ensure that environmental damage is avoided.

When presented with a list of key asset health areas, the three areas seen as most important were:

1. Ensuring the compliance of waste water treatment works, seen as vital for a healthy environment
2. Preventing sewer blockages, important for public health
3. Reducing the risk of pipe bursts, which has a potential immediate and severe impact
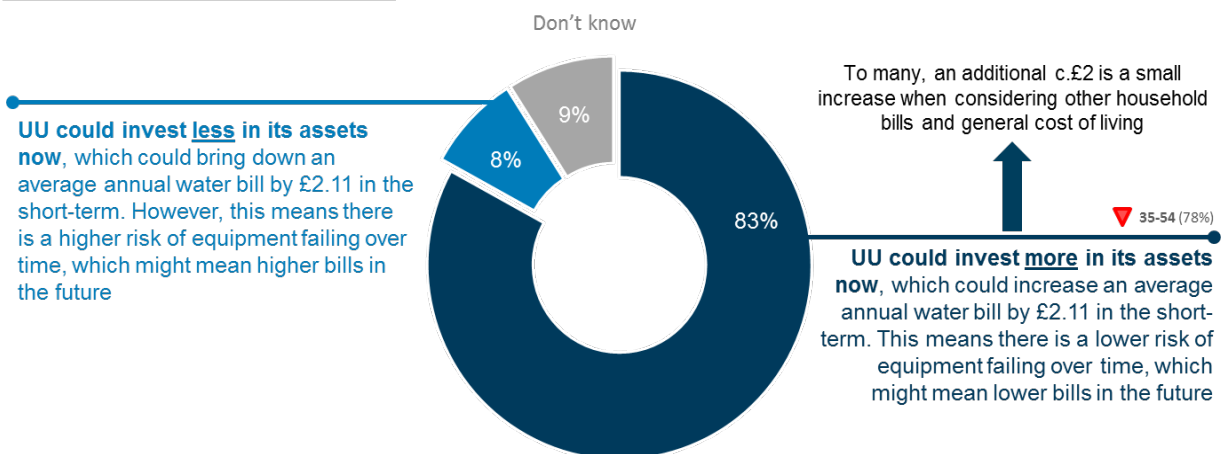
3.1.3 Support for incentives

There was some support for penalising poor performance and strong support for incentivising improved asset health performance during the AMP7 period as indicated below.

Figure 4: Customer support for investing more now to improve asset health

3.2 Customer insight conclusions

Our customer research has demonstrated that increased investment targeting changes to asset health was widely supported, particularly for measures with a clear environmental service benefit. We believe that this conclusion helps to support our plan to target both the least healthy assets and the potential service impacts associated with asset health issues. This approach to managing asset health will enable us to deliver to our performance commitments whilst ensuring that the proportion of our asset base that is unhealthy does not degrade during AMP7, despite a general aging of the asset base as indicated within section 5.

4 Asset health at United Utilities

4.1 Why measure asset health?

Understanding the health of our assets is a key part of managing our business. The health of our assets underpins their ability to deliver our services to customers and the environment and understanding this helps us to focus our maintenance appropriately. Many of our assets need more intensive operational maintenance as they get older and more worn, needing periodic replacement of components and more frequent inspections to help manage the risk of unexpected failures.

It is important to understand and monitor the health of our assets to allow us to provide a resilient service, both now and in the future. If we understand which of our assets will need a little more care we can manage our proactive maintenance programme more effectively, helping us to predict and minimise the risk of service impact due to deterioration in our asset base.

Understanding our asset health can help us to make better decisions in managing performance and underlying risks to service. In certain parts of our business during AMP7 we will be allowing 'average' Asset Health to deteriorate in a managed way, whilst we focus on more cost effective and innovative operational strategies to deliver the required service performance. We will track and understand the underlying risks, following good asset management practice to deliver our performance commitments.

4.2 How we measure asset health

There are many well-established measures of asset health widely used within the water industry, a selection of these will be retained through AMP7 and will be reported externally as performance measures across the industry. The principle asset health measures defined by Ofwat either as common measures for AMP7 or proposed health measure are listed in:

Table 2: Key asset health measures with AMP7 performance commitments

Measure Code	Measure Description
F01-WWN	Sewer collapses
F02-WWN	Sewer blockages
C02-WWN	Treatment works compliance
B02-WN	Mains repairs
B04-CF	Unplanned outages

The following four measures are less direct measures of health, as they are also heavily influenced by operational response and recovery capability and as such are not described further in this document.

Table 3: Secondary asset health measures heavily influenced by operational activity

Measure Code	Measure Description
G02-WWN	Internal flooding incidents
G03-WWN	External flooding Incidents
B03-WN	Reducing interruptions to water supply
C01-WWN	Pollution incidents

In addition to the above core measures we developed an industry leading standard measure of asset health we call the Base Asset Health indicator (BAH). This measure is an indication of an asset's remaining life expectancy and has been externally audited by Jacobs and been found to be a "best in class" metric, see supplementary T9035.

Each of the five measures are described below.

- Sewer collapses (including rising main bursts) – sewer collapse performance is a key lagging indicator for the end of service life of sewer infrastructure. For a sewer to structurally collapse the density of structural defects has typically increased to the point where there is no structural integrity remaining, resulting in the collapse.
- Sewer blockages – sewer blockage performance is a key lagging indicator of the presence of structural defects. Although, only a proportion of blockages are associated with defects, and many are associated with misuse of sewers or specific weather patterns, blockage rates are a good indication of the presence of structural defects, some of which are associated with assets approaching the end of their service lives.
- Treatment Works Compliance (with numeric discharge consents) – when our treatment works are unable to meet their consented discharge quality it is often due to underlying asset health issues associated with equipment reliability, although there are other causes not associated with asset health.
- Mains repairs – the rate of repair to water mains is a key lagging health indicator for the water industry. However, the data can be heavily distorted by the mix of visible and discovered faults repaired. Also for more critical large mains the actual repairs rates are typically low and not necessarily a good predictor of the health of these assets as catastrophic failures should be avoided where possible through proactive intervention prior to failure.
- Unplanned outages – when water treatment works are unable to deliver high quality compliant water this is often an indication of underlying asset health issues associated with equipment reliability.

4.3 Operational asset health monitoring

We have two substantial programmes of operational asset health monitoring, plus numerous bespoke smaller programmes. The two most substantial programmes are:

Condition monitoring (field service engineers) – many of our field service engineers now have thermographic imaging cameras as well as a dedicated team equipped with these and handheld vibration monitors. These equipment have been a core part of our operational monitoring programme for many years, but are becoming a more pervasive part of our maintenance capability as we migrate to more and more condition based monitoring.

Figure 5 shows the summary from our condition monitoring teams of work raised and types of defects reported.

Figure 5: Live Condition Based Monitoring (CBM) dashboard
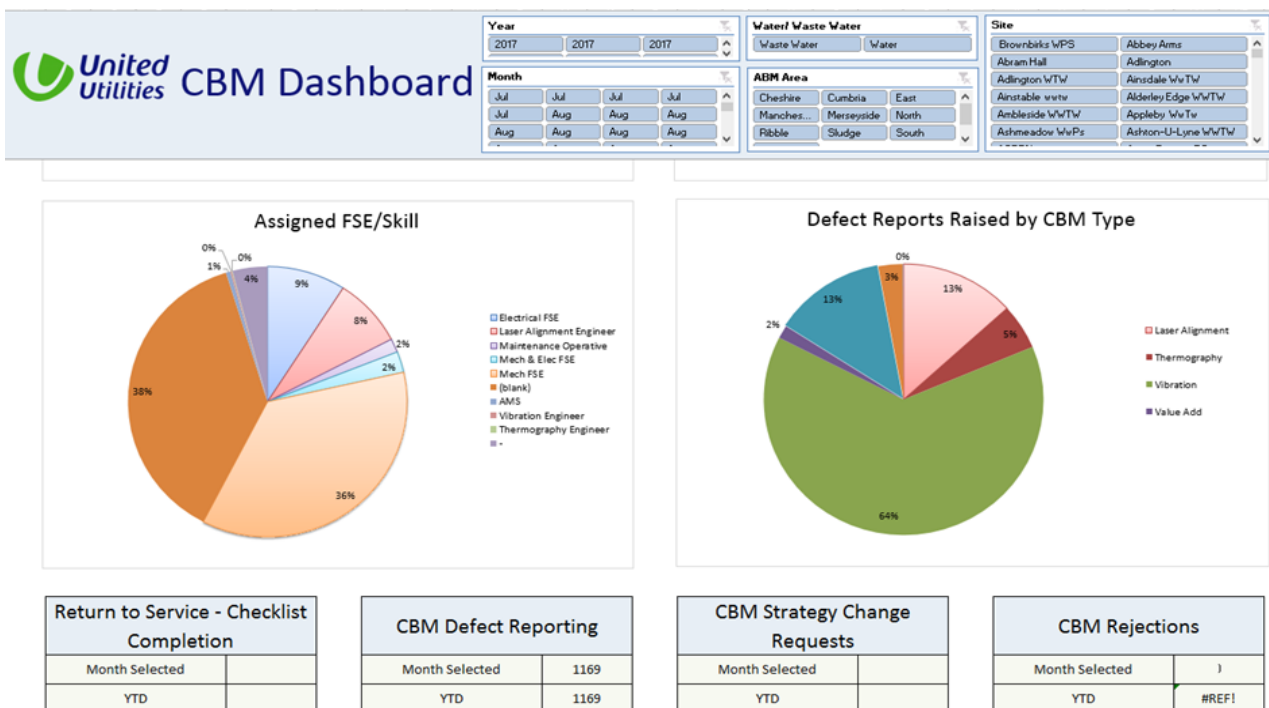
Condition monitoring (telemetry) – our most critical sites are equipped with widespread condition monitoring instruments connected to our company wide telemetry system. Our approach to systems thinking will help us to better leverage this technology during AMP7 and beyond as we make better use of this rich source of data, turning it into even more useful information. Figure 6 demonstrates our target architecture currently under active development.

Figure 6: Condition based monitoring configuration management
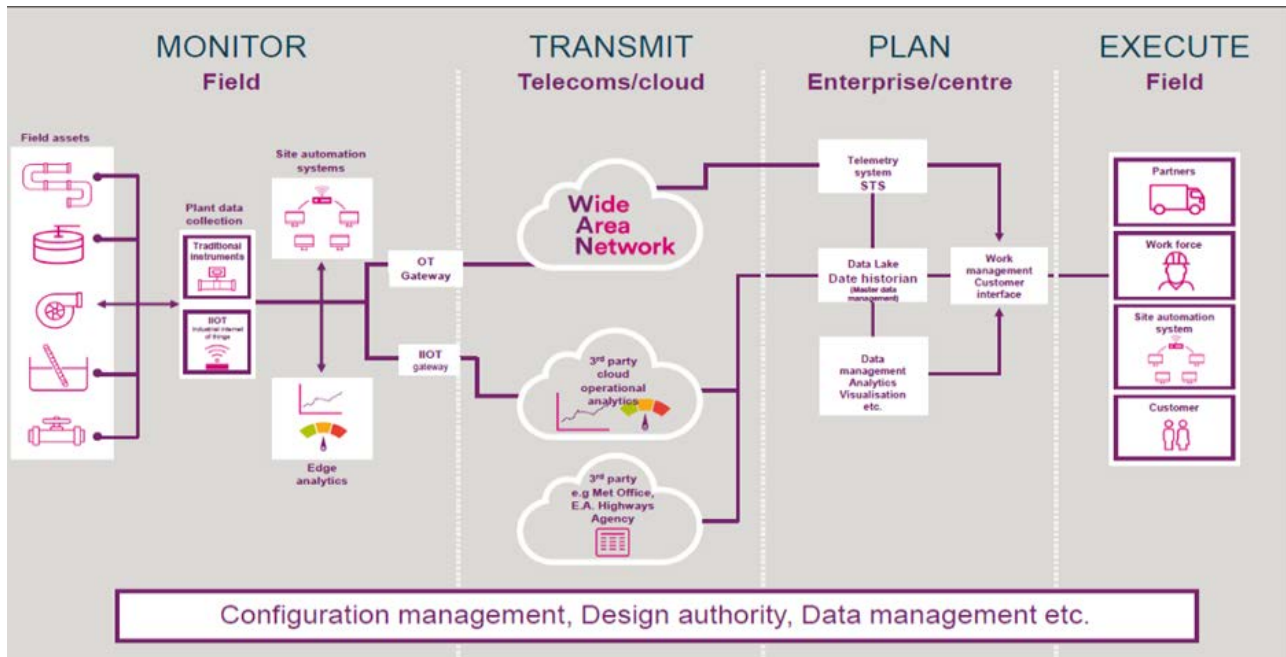
A few examples of other asset health monitoring programmes carried out as business as usual within specific parts of the business are described below:

Sewer CCTV surveys – As part of our response to routine incidents across our wastewater network we capture vast amounts of CCTV data. This data is used to help inform both operational decisions associated with incidents and to inform our longer term strategic understanding of the health of our sewer network.

Service Reservoir inspections – we undertake standardised and regular condition inspections of service reservoirs, prioritised on a risk basis. These deliver information which itself feeds into both the inspection and investment programmes.

Impounding reservoir inspections – part of our commitment to managing societal risk ensures ongoing monitoring of both the performance and condition of our extensive fleet of impounding reservoirs.

4.4 Operational asset health reporting

We have a dedicated Maintenance Performance team responsible for reporting asset health performance across our business. The following is a selection of our current, business as usual reports, all available through an integrated Tableau dashboard.

The traditional core metric is found in the 'Worst Performing Asset' report, see Figure 7. This is a trailing indicator for the identification of comparative, poor performance and is routinely used to refocus maintenance, initiate capital maintenance investment or other intervention strategy driven by our Operational Engineering department.

Figure 7: Example Worst Performing Asset Report for Wastewater and Bioresources treatment and pumping
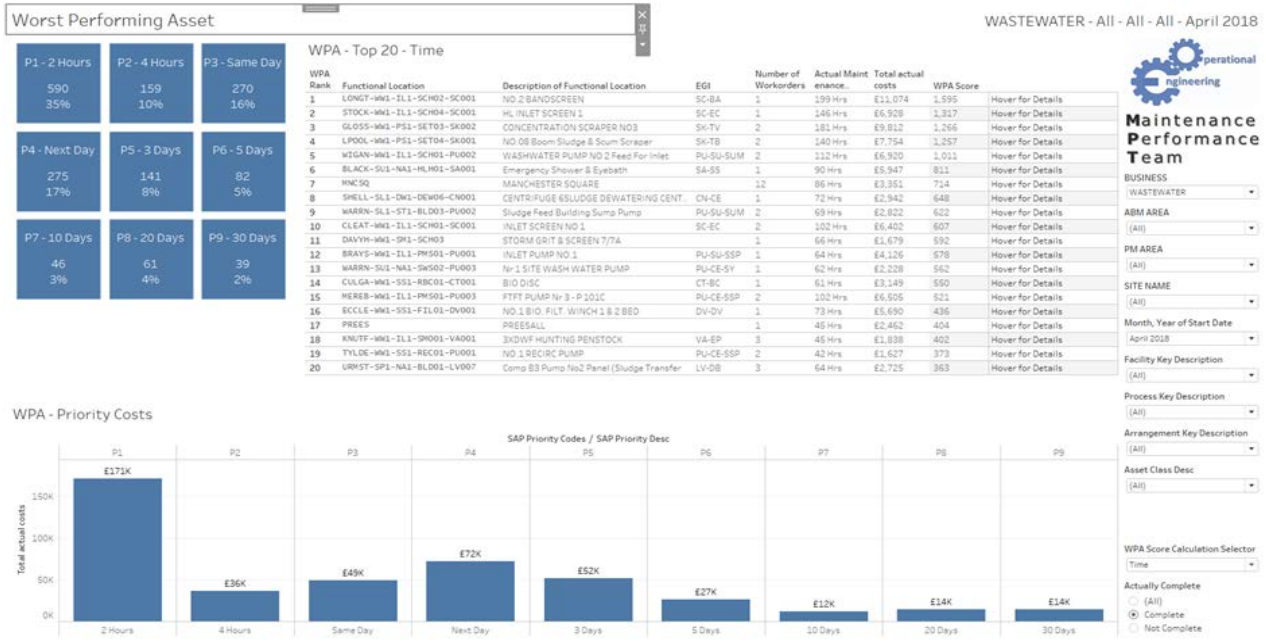
The 'Worst Performing Asset' report is highly flexible and can be used to compare across geographic areas, classes of assets and types of facilities.

One of the key objectives of our recent Mobile Asset Resource Scheduling (MARS) project has been to drive down the proportion of reactive maintenance in order to help to deliver our performance commitments for 'Treatment works compliance' and 'Unplanned Outages'. We track the split of maintenance by reactive, proactive and cyclic categories as we travel towards our targeted 20:20:60 split during AMP7, see

Figure 8: Example reactive, proactive, cyclic maintenance report for Wastewater and Bioresources treatment and pumping
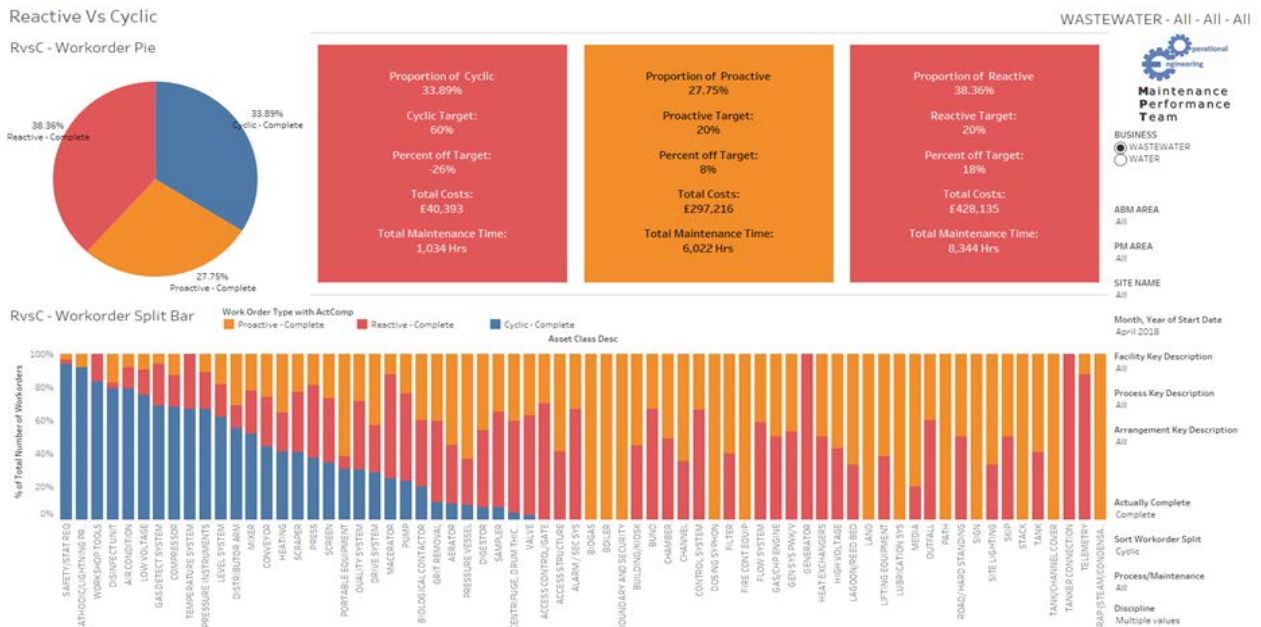
We also use leading indicators of asset health to help us prioritise our risk management activities, such as the Mean Time Between Failure (MTBF) across our above ground asset base, see Figure 9.

Figure 9: Example Mean Time Between Failure report for Wastewater and Bioresources treatment and pumping
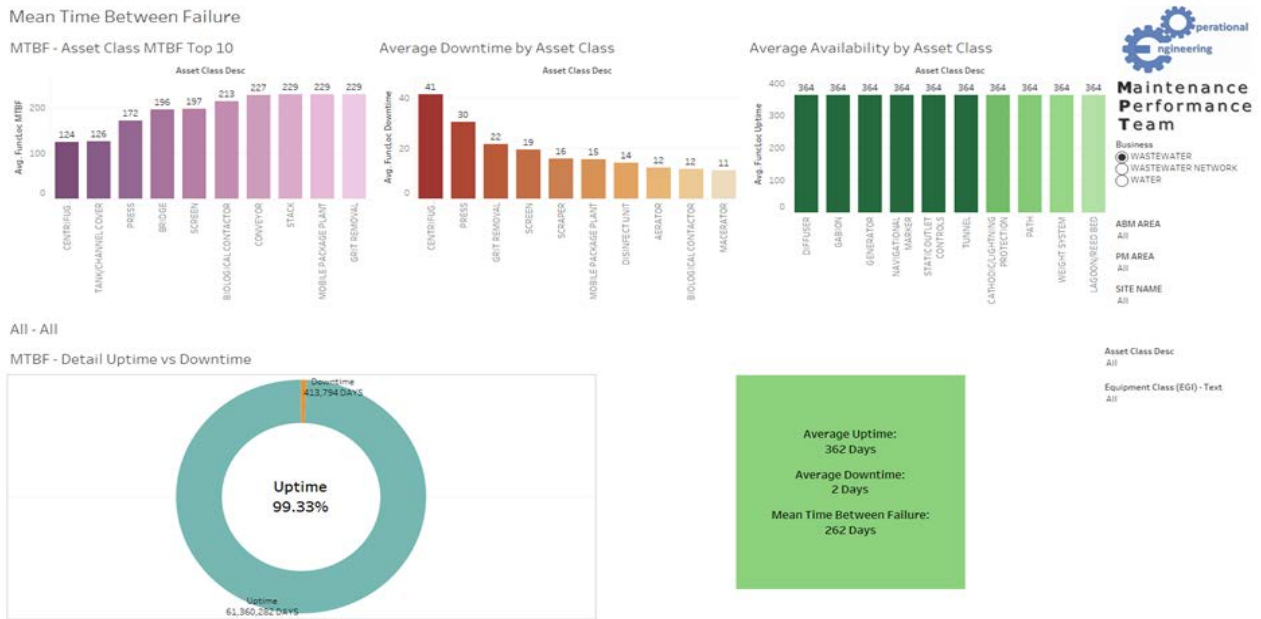
4.5 What is our Base Asset Health indicator?

We have developed a standard measure of asset health that has been applied across our whole asset base whilst taking account of the various existing asset health data streams well embedded across our business, see Figure 10 below.

Figure 10: How existing asset health data streams feed into the Base Asset Health indicator

Base Asset Health (BAH) indicator values are predictions of remaining economic life of assets as informed by the age, condition and performance of the assets coupled with our asset deterioration models. They can be aggregated together at any level of the Wholesale business. The flexibility of the measure means that we can represent the health of a wastewater treatment works, all pumps of a particular type, all water mains of a given size and material, or even the company as a whole. This gives us the ability to use the metric for both operational and strategic purposes (see case study 1 in section 4.11).

Importantly, we can join our BAH measure with criticality assessments to produce a view of operational risk. We are able to use this risk value for prioritising proactive maintenance as part of our wider Reliability Centred Maintenance (RCM) approach.

4.6 From serviceability to asset health

Since privatisation, serviceability measures such as pollution incidents and interruptions to supply have been extremely useful to deliver a change of industry focus from age and condition to service and performance when making investment decisions across the water industry in the UK leading to a step change in performance. However, it is extremely important to retain a link to the underlying state of the assets, responsible for reliable service delivery; this is what our BAH indicator gives us.

By constructing the BAH in a flexible manner that can accommodate additional data and information as it becomes available, we have built a future proof measure that is already being widely adopted into existing processes and systems across our business.

It is important to understand and monitor the health of our assets to allow us to provide a resilient service, for the near (0-10 years), medium (10-25 years) and long term (25-100 years). If we understand and monitor trends in asset health, we are able to make informed decisions for both operational and capital maintenance, balancing risk, performance and cost in customers' best interests.

4.7 The Base Asset Health indicator in United Utilities

Our Base Asset Health indicator is enabling us to deliver:

- A clear view of asset health at any level from organisation, price control, facility, process or individual asset
- Useful comparisons across different assets and groups of assets in a consistent and simple manner
- Better investment decisions through a clear indication of the relative asset health of specific assets
- Risk based proactive operational maintenance, in conjunction with criticality assessments
- Access to good quality, standard data about our asset base

The BAH is currently determined using the following data:

1. Asset identification - date installed, replacement cost of asset, location etc

2. Condition of asset (for civil assets and sewers)

3. Performance of asset (for mechanical assets, sewers and mains)

4. Failure analysis - Analysis of the most common reasons for failure, as well as failure trends

This data forms the asset deterioration curves, which are then used to determine a typical economic asset life for each type of asset, such as a screw pump or a certain size and material of sewer. Data (such as performance, condition or failure rate) specific to an individual asset is used to determine its effective asset age. These data are used to calculate the BAH indicator. The effect of differing operation and maintenance regimes upon asset health can be to improve or degrade the asset health. Great maintenance may mean that a relatively old asset may have an increased life expectancy, and hence a reduced BAH indicator value.

The following formula indicates how Base Asset Health indicators are calculated and aggregated.

Equation 1: Calculation of Base Asset Health indicator

$$BAH = \frac{\sum \left(\frac{Effective\ Age}{Economic\ Life} \times GMEAV \right)}{\sum GMEAV}$$

Where:

- Effective Age - the age of the asset – adjusted by condition, performance and refurbishment history
- Economic Life – The number of years that a typical asset of a given type is economically 'useful'
- GMEAV - Gross Modern Equivalent Asset Value, the cost in current terms to replace an asset of this type with its modern equivalent

4.8 Base Asset Health categorisation

BAH values are also allocated into broad 'health' categories, in line with a typical deterioration curve for ease of visualisation and mapping. These categories are defined as;

🔴	Unhealthy Asset	85% ≤ 100%
🟡	Minor Health Issues	65% ≤ 85%
🟢	Good Health	0% ≤ 65%

The categories are a useful way to identify and highlight where groups of assets are approaching the end of their economic life and can give a quick overview of asset health in an area or across a population of equipment or structures.

## 4.9 Example BAH calculations

Our Glass Reinforced Plastic (GRP) chemical storage tanks, with appropriate use and maintenance can be expected to economically last for about 28 years. For these assets, we have a condition based deterioration model, as well as an age based model. Condition grades are defined through complex weighted sets of observational data for these assets, but are assessed against grades from 1 to 5. In broad terms the grades can be summarised as in Table 4.

Table 4: Approximate condition grade descriptions

Grade	Description
1	As new
2	Good
3	Moderate
4	Poor
5	Unacceptable

We have a condition based deterioration model for this type of asset, as with many assets they tend to progress fairly rapidly through the higher grades, 3 to 5.

Figure 11: Example deterioration model for GRP tanks
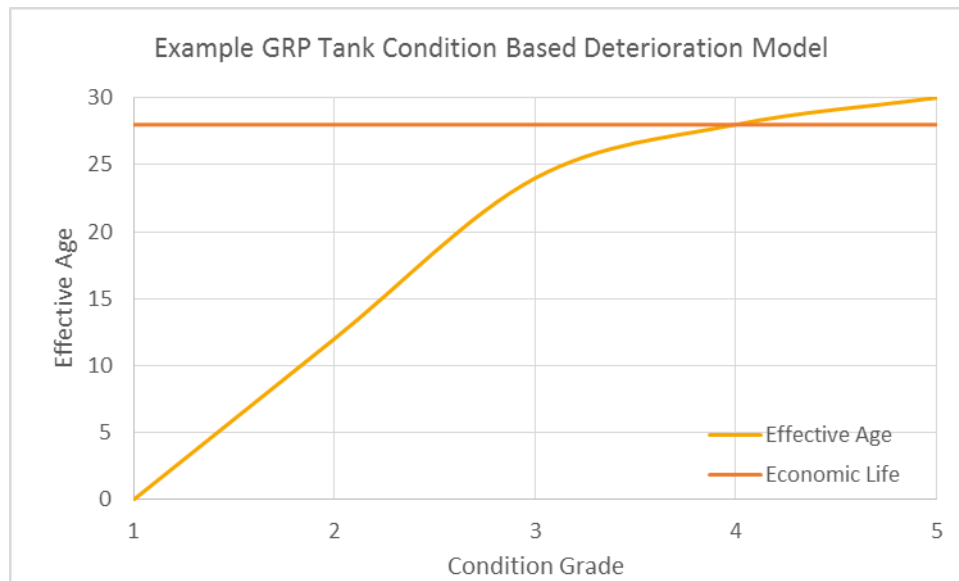
Comparing two tanks:

Tank A was installed in AMP3 and is 17 years old. It is installed in a heated process building on a manned site and included in the daily process tours. It has been recently assessed as condition grade 2, and therefore has an effective age of 12 years old according to our model. BAH_A = (12/28) = 43% = **Good Health**

Tank B was also installed in AMP3 and is 15 years old. It is installed in a fenced compound outside, but within a second wider site security fence. The site is visited regularly but is located on an exposed hillside; the tank is included in twice weekly process tours. It has been recently assessed as condition grade 4, and therefore has an effective age of 28 years old according to our model. BAH_B = (28/28) = 100% **Unhealthy Asset**
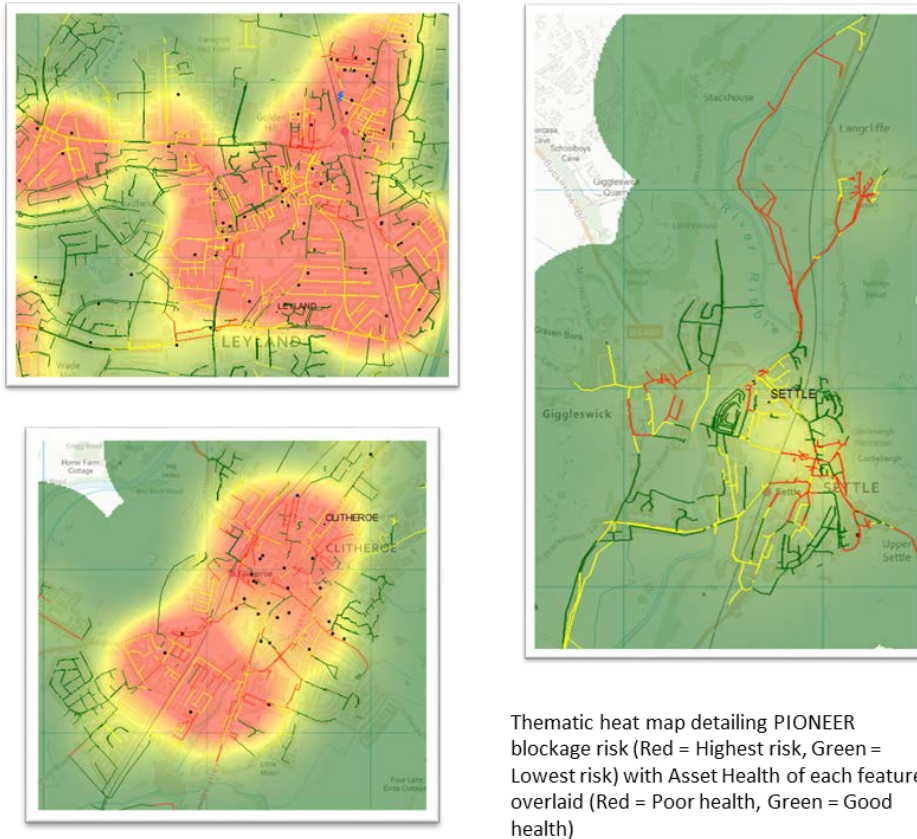
4.10 Visualisation

Data visualization can be an effective way to help to identify correlations, trends, outliers, patterns, and relative performance or condition. Data visualisation dashboards have become an important tool to help us to make quick and accurate decisions. The creation of BAH indicator dashboards has allowed the information to be adopted throughout the business for use in both strategic and everyday operational decisions.

For our below ground assets, we produce thematic maps. These are published and accessible to the operational and capital planning teams to use to inform their programmes of work. (See case study 1 in section 4.11). The following thematic map details the asset health of the sewer network in the north of our region, the green coloured pipes are predicted to be in good health, the red poor. We have overlaid the forecast risk of blockage from PIONEER[2] in the area, where the red thematic shading is the highest risk of blockage, the green is the lowest.

Here we can see that there are a high population of good / medium health pipes in a high risk of blockage area. Suggesting that the deterioration of the pipes is not causing the blockages, we can use health and risk to understand where we need to maintain our assets differently, or as in this case, use customer behaviour initiatives to improve service in an area.

---

[2] PIONEER helps us understand the long-term investment requirements of our existing asset base. PIONEER models all of our assets including over 5,000,000 sewers and lengths of water main and over 400,000 pumps, tanks, instruments and other equipment. The modelling helps us to understand when we should invest in these assets and what action we should take, i.e. refurbish or replace them.

Figure 12: Thematic heat map detailing PIONEER blockage risk

Thematic heat map detailing PIONEER blockage risk (Red = Highest risk, Green = Lowest risk) with Asset Health of each feature overlaid (Red = Poor health, Green = Good health)

For our above ground assets, we have developed a dashboard using Tableau, a commercial data visualisation product, which enables us to easily and quickly visualise the health of our assets across our region by price control.

The summary dashboard allows users to filter and view different aspects of the data. Users can drill down within the dashboard from price control all the way to a particular asset class.

The BAH indicator helps to improve evidence based decision making by allowing simple, but informed comparisons across our asset stock. By bringing together maintenance records, degradation models, service impacts, condition and age to determine economic lives and effective ages; we have assembled many different data streams into a simple metric.

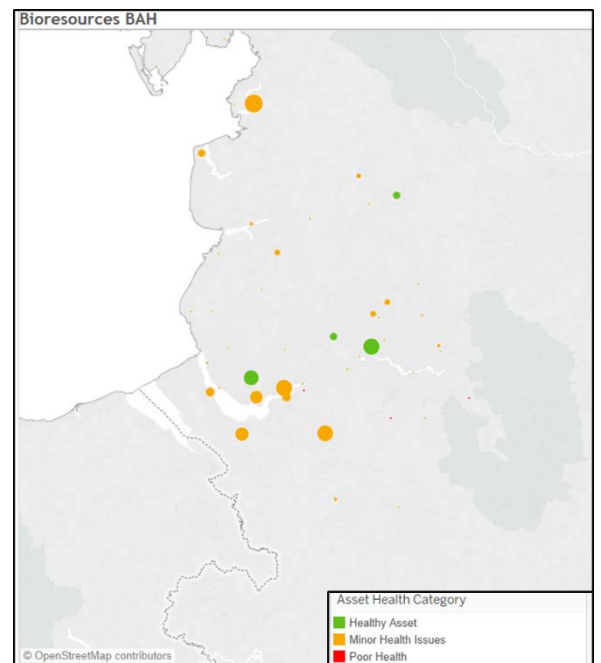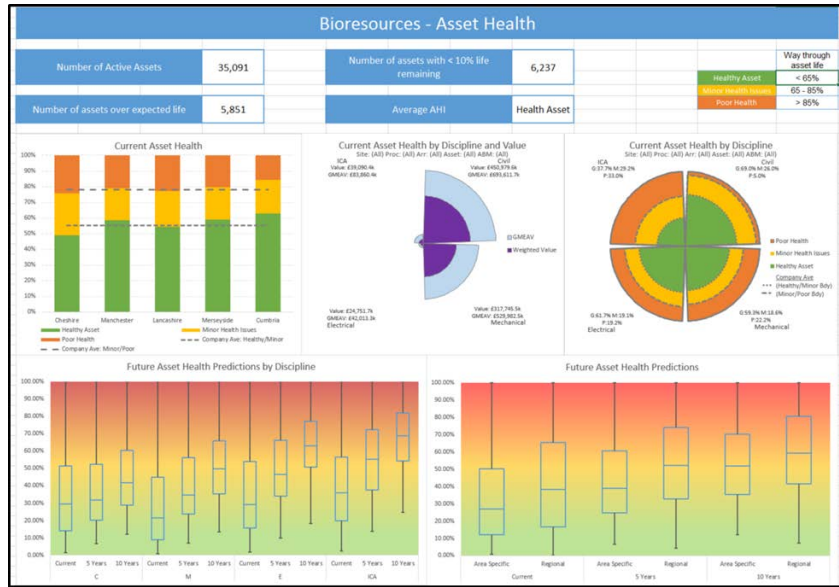*Figure 13: Visualisation of Bioresources asset health*

Figure 14: Bioresources - Base Asset Health Dashboard

The development of the BAH indicator has given better visibility of the overall health of our asset base, assisting with the optimisation of operational maintenance, capital replacement and risk mitigation across our business.

4.11 Case Study 1 – Base Asset Health for targeting proactive sewer inspections

We have used the BAH indicator to target proactive CCTV in the Freckleton area of Preston. We surveyed the top 10 highest risk/poor health assets to investigate the condition of the sewers. Of the ten surveyed sewers, seven had significant defects requiring intervention.

No structural collapses were found; however the surveys confirmed deterioration in line with the BAH indicator assessments.

Similar validation of our predictive models has allowed our operational teams to develop confidence in their outputs and now the BAH indicator has been used to inform a widespread sewer network inspection program during AMP6.

Figure 15: Build-up of silt, and circumferential cracking within a sewer

Figure 16: Root ingress

Figure 17: Partial blockage and protruding grout

5 Asset health – analysis and forecast

5.1 Introduction

As a business as usual process, we routinely analyse our underlying asset health, and since the introduction of our Base Asset Health indicator we have been reviewing and forecasting the expected change in this indicator under different investment scenarios during AMP7 and beyond.

5.2 Approach

We have analysed our asset health forecasts for our four operational wholesale asset bases using three different approaches described below and against two scenarios:

- where we take a 'maintenance holiday' and therefore don't invest in asset health during AMP7 and beyond
- where we target maintenance expenditure on asset health

Unhealthy Assets– the assessment of assets in poor health and how that population is expected to change through the planning horizon under differing investment scenarios. This is the most detailed assessment included in this report. Since it is the 'unhealthy' assets which contribute most to asset related service failures, managing this population is critical to achieving our wider performance commitments. As above, these results are based upon the two extreme scenarios described.

Average Asset Health – this provides a summary 'average' impact on asset health over the planning horizon, including the current health of the asset base into the assessment. This approach helps to indicate whether an asset base is healthy overall and expected to remain so through the planning horizon.

Bespoke asset health trends– an assessment of trends and forecasts in the traditional asset health indicators that will be widely used across the industry during AMP7. These data feed into the models supporting the BAH indicator, but the data themselves can be revealing about trends in asset health and changes in operational practices.

A selection of traditional asset health measures are being retained within our AMP7 measures of success, as listed in section 4.2. Whilst these are clearly useful measures, and have been shown to be leading indicators of potential service failures, some of these measures may mask good asset management practice. The analyses outlined below demonstrates how our targeted investment strategies during AMP6 and into AMP7 have affected asset health and how we expect asset health to change. These analyses complement our Base Asset Health measure, which allows aggregation and company-wide comparisons, by demonstrating how asset health metrics can provide deeper insight into specific parts of our asset base.

We have then separately analysed the retail and other wholesale assets.

5.3 Water Resources

5.3.1 Water Resources - unhealthy assets

This assessment of the forecast proportion of 'unhealthy' assets has been made using the Base Asset Health (BAH) indicator and focuses upon the 15% most 'unhealthy' assets as these relate to the majority of asset health related service failures. The two forecast scenarios presented for each set of assets looks at the relative extremes of targeting no maintenance investment on asset health and targeting all investment upon asset health.

5.3.1.1 Intakes, boreholes, raw water tanks

Figure 18: Forecast proportion of assets in 'poor health'– Water Resources - intakes and boreholes
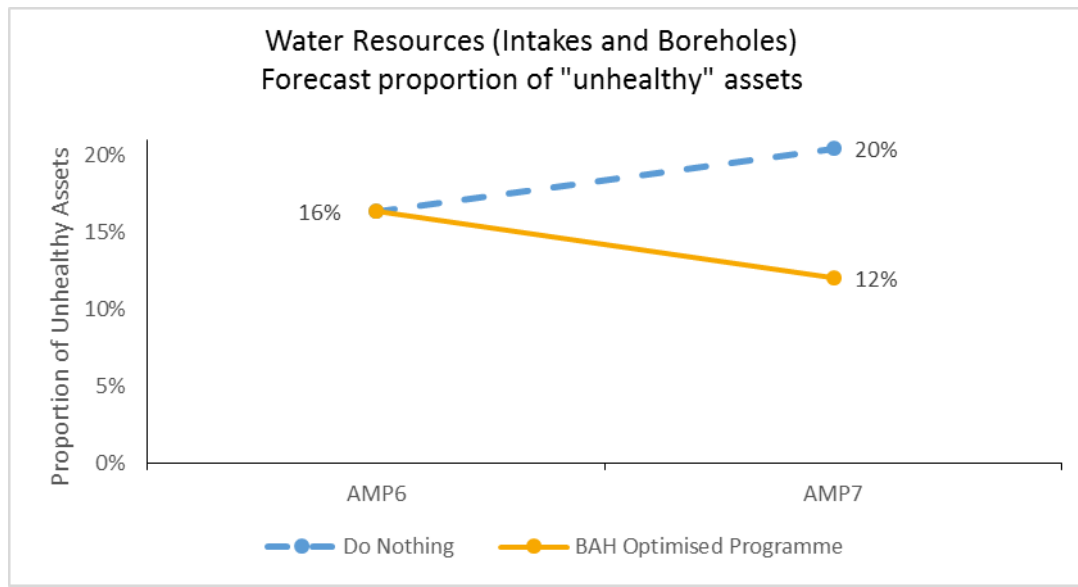
The above ground assets within the Water Resources price control has the largest proportion of assets approaching the end of their economic lives across our business. However, careful targeting should enable us to continue to stabilise the proportion of unhealthy assets through AMP7.

5.3.2 Water resources - average asset health

The largest part of our water resource asset base by value is our fleet of impounding reservoirs. We have a well developed asset health, criticality and risk assessment process used to underpin our operational work and investment programmes for these assets, and these assets have consequently not been modelled with the BAH indicator. The approach for these assets is described in section 5.3.3.1.

The rest of our water resource asset base consists of raw water mains and aqueducts, intakes, boreholes, pumping stations and the associated storage and stilling structures. Most of these assets have been included within our BAH indicator assessments.

5.3.2.1 Raw water mains and aqueducts

Our raw water mains and aqueducts our generally long life assets, many of which originate from the early part of the 20th century. Whilst deterioration is usually slow in these assets, the extreme age of some of these assets requires targeted investment to enable them to continue to provide a reliable service.

#### 5.3.2.2 Intakes, boreholes, raw water tanks

Our water resource pumping stations, from river, reservoir or borehole are an integral part of our supply network. Maintaining their health is critical to managing a long-term sufficient supply of water across the North West of England. Of particular focus is the reliability of key, strategic pumped sources and the continued accuracy of abstraction meters.

Figure 19: Forecast Base Asset Health expected life profile – Water Resources - intakes and boreholes
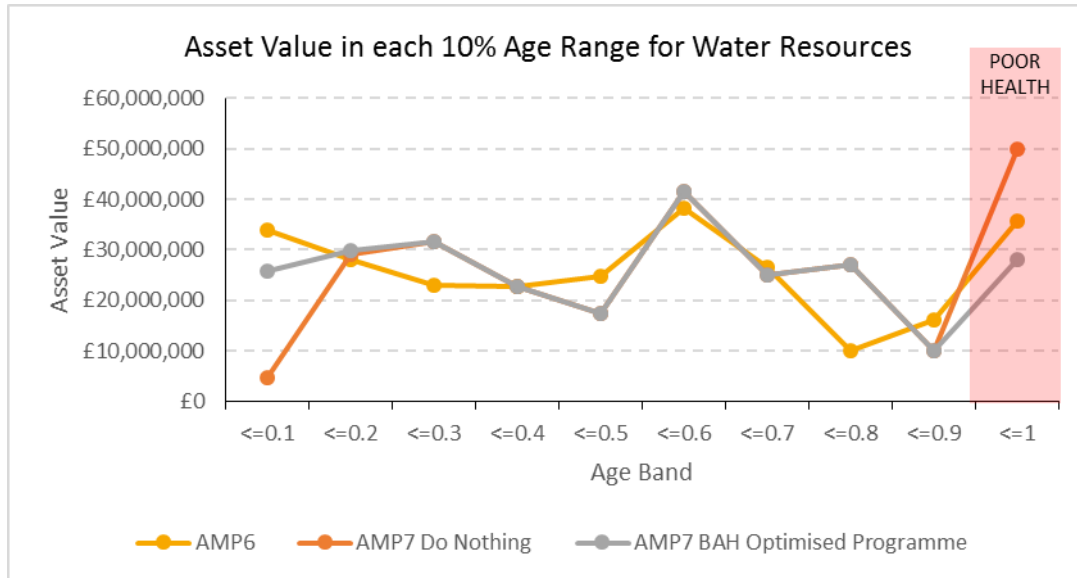
As can be seen by the 'uptick' in the final data point for each of these plots, there are a substantial number of older or less healthy assets within this price control, outside of the dam and impounding reservoir fleet, not included here.

Figure 20: Forecast average Base Asset Health – Water Resources - intakes and boreholes
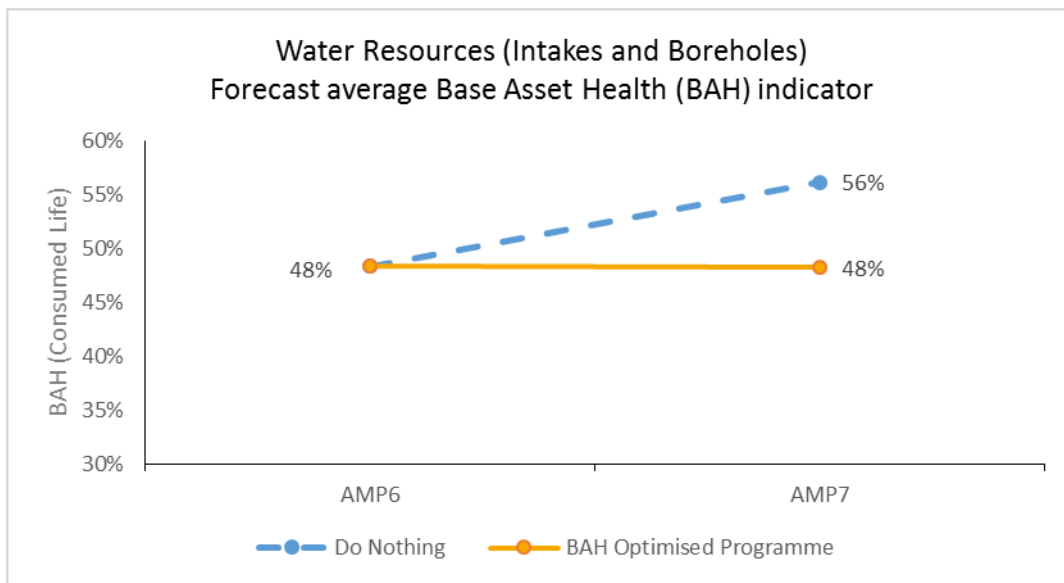
The analysis of the average BAH for these assets shows that our planned investment programme is expected to lead to a minor degradation in average asset health for these assets during AMP7, the investment on these assets during AMP7 will be targeted on those which carry the largest risk.

For the water resource intakes and boreholes we have also modelled the potential impact on asset health of our planned AMP7 investment levels continued through to AMP9 to demonstrate our capability for this analysis. This shows a wider range of uncertainty as both the scale of the programme and the effect of investment during future investment periods are less well understood.

Figure 21: Forecast average Base Asset Health under two extreme scenarios - Water Resources - AMP6-AMP9
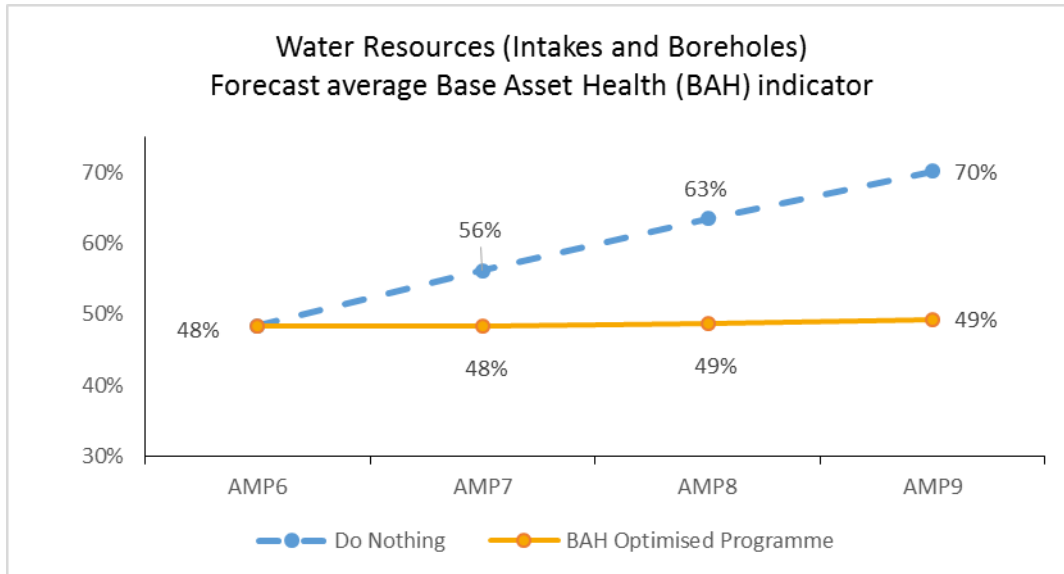
5.3.3   Water Resources – bespoke asset health trends

5.3.3.1   Dams and impounding reservoirs

We have continued to improve the health of impounding reservoirs, in terms of both failure probability and service risk through AMP6 and as forecast into AMP7.

Figure 22: We are improving the asset health of our 165 impounding reservoirs

During AMP6 we have consistently targeted a reduction in dam failure risk through our proactive Portfolio Risk Assessment (PRA) processes. We have largely targeted flood-risk failure modes during AMP6 and plan to be targeting erosion dam failure modes during AMP7.

Figure 23 below shows how the change in focus to reducing societal risks in AMP7 is expected to have a dramatic effect upon the level of risk that our fleet of reservoirs represents. The majority of this risk is assessed to be associated with erosion failure modes.

Figure 23: Forecast societal risk reduction – Water resources – impounding reservoirs
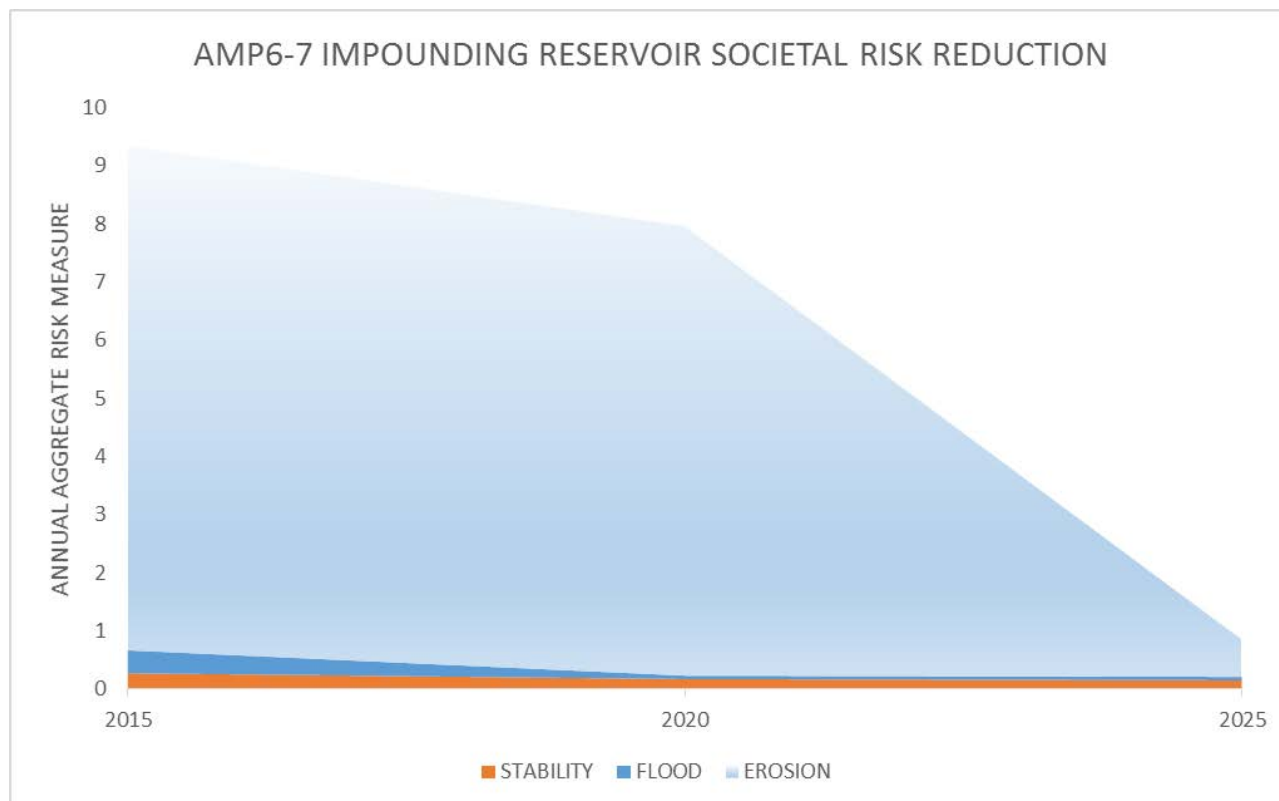

5.4 Water Network Plus

The overall water network associated with water treatment and potable distribution is one of the most flexible and resilient within the industry. However, the health of some of the key strategic assets, which form the backbone of this integrated network is relatively poor. We are planning to make substantial progress towards addressing the largest of these service risks during the coming investment period, but nonetheless key elements of our infrastructure date back to the early twentieth century or the late Victorian period.

5.4.1   Water Network Plus unhealthy assets

Once again, the forecast proportion of 'unhealthy' assets has been made using the Base Asset Health (BAH) indicator and focuses upon the 15% most 'unhealthy' assets as these relate to the majority of asset health related service failures.

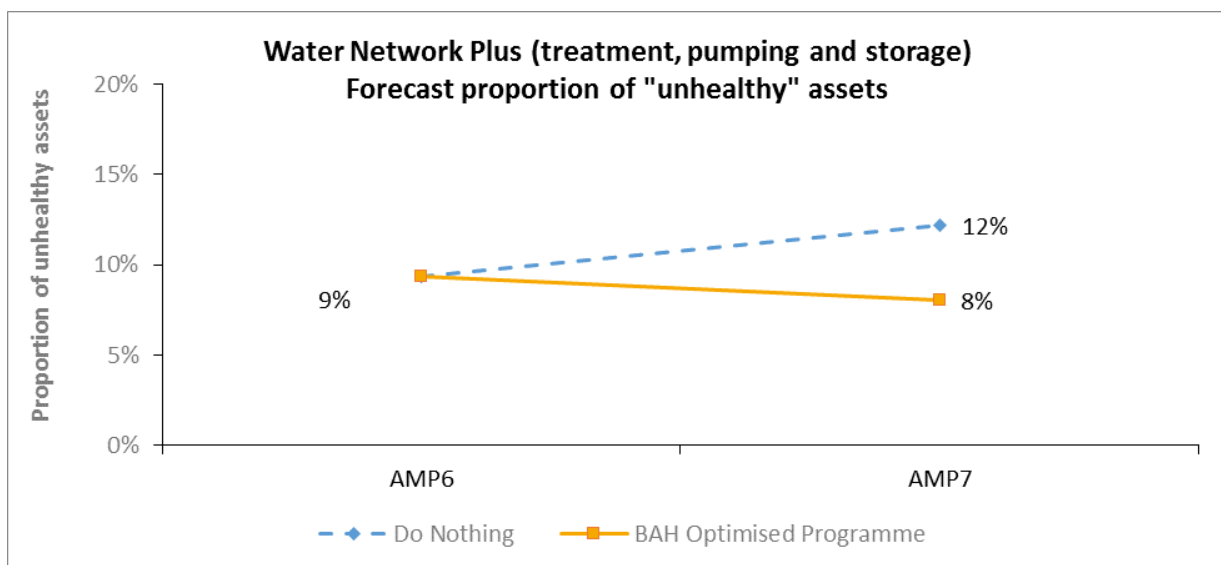### 5.4.1.1   Trunk mains and distribution mains

Figure 24: Forecast proportion of assets in 'poor health'– Water Network Plus - trunk and distribution mains
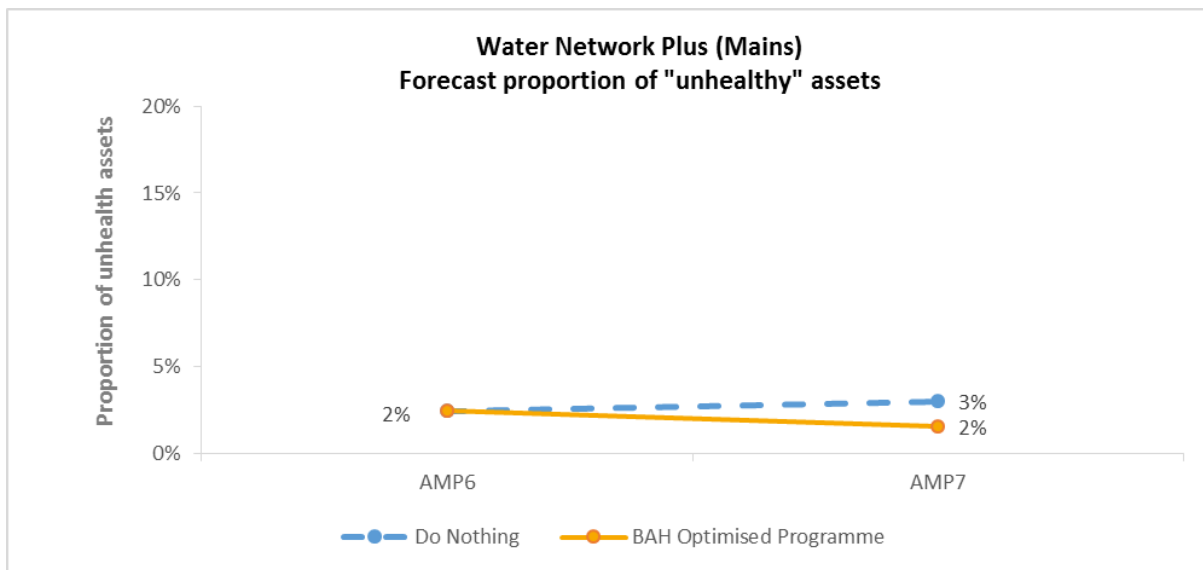
There is expected to be very little change in the proportion of unhealthy water mains during AMP7, as indicated by Figure 24 above.

5.4.1.2   Water treatment works, service reservoirs, pumping stations

Figure 25: Forecast proportion of assets in 'poor health'– Water Network Plus - treatment, pumping and storage

There is expected to be very little change in the proportion of unhealthy above ground Water Network Plus assets during AMP7, as indicated by Figure 25 above.

## 5.4.2   Water Network Plus average asset health

5.4.2.1   Trunk mains and distribution mains

We have one of the youngest water distribution networks in the country having replaced or rehabilitated approximately 40% of the network by length due to our large-scale replacement of mains under the NW90 quality programme since privatisation. Since the NW90 programme largely finished in 2010 our water network investment has been targeted around different strategies that have led to major service improvements, but have not involved

wholesale replacement or rehabilitation of mains. This has led to a gradually aging asset base, but also a predicted extension to the average service life of many of our assets.

This increased service life is related to the more controlled environment that our network now experiences, particularly through improved pressure management leading to lower and more stable pressures for many of our pipes. The increased prevalence of pressure management has led to new asset health challenges as the larger population of active control and monitoring equipment from Pressure Management Valves (PMVs) to various loggers requires active maintenance to maintain overall network health.

Figure 26: Forecast average Base Asset Health – Water Network Plus - trunk and distribution mains
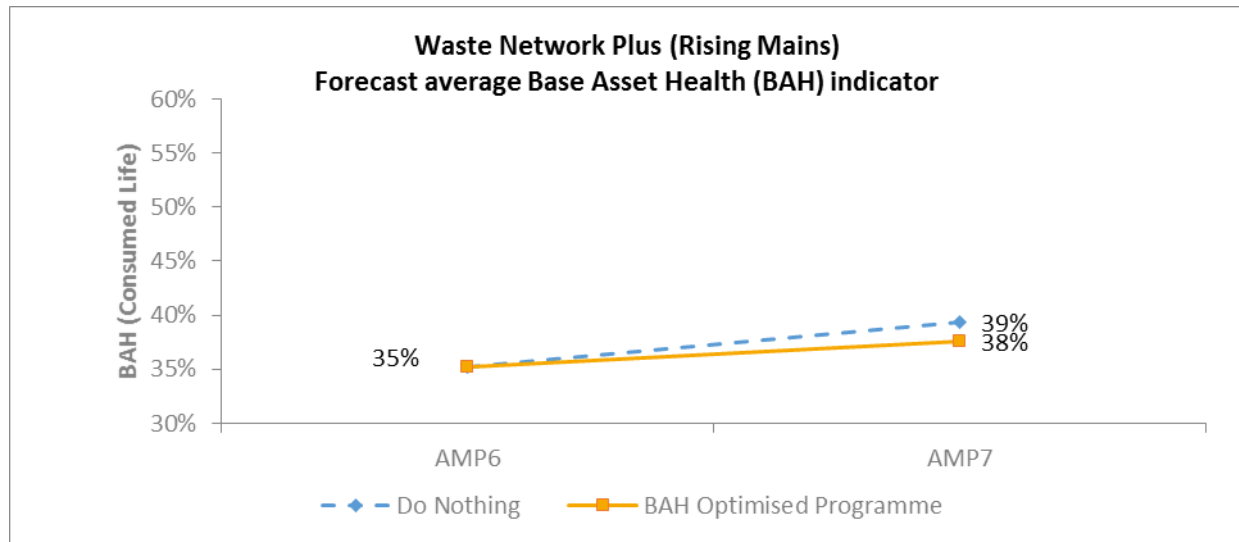
The analysis of the average BAH for these assets shows that our planned investment programme is expected to lead to a minor degradation in average asset health for these assets during AMP7 with the continuation of investment targeted at service failures rather than replacement and rehabilitation of the asset base. The investment on these assets during AMP7 will be targeted on those that carry the largest risks to interruptions, discolouration, taste and smell.

5.4.2.2   Water treatment works, service reservoirs, pumping stations

The treatment works, service reservoirs and pumping stations that form the majority of the active elements of the water service have a broad profile of age, condition and performance. Our active risk identification processes including the Hazrev (Hazard Review) within the Wholesale Risk and Asset Planning process lead to targeted risk reduction activities designed to increase service lives and reduce performance risk.

Figure 27: Forecast Base Asset Health expected life profile – Water Network Plus – treatment, pumping and storage
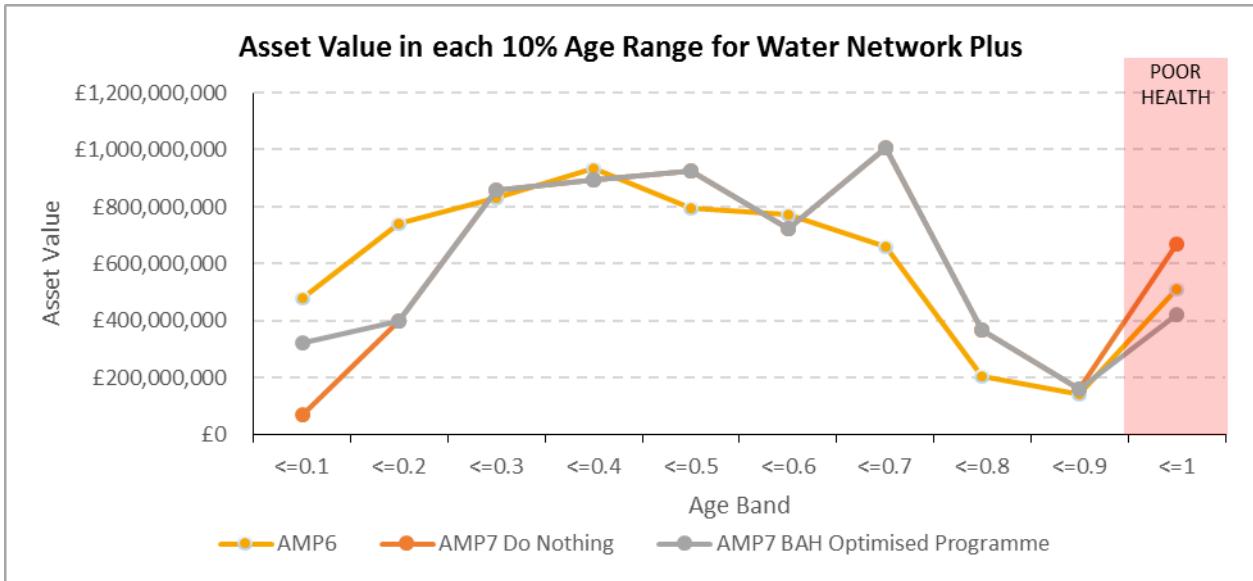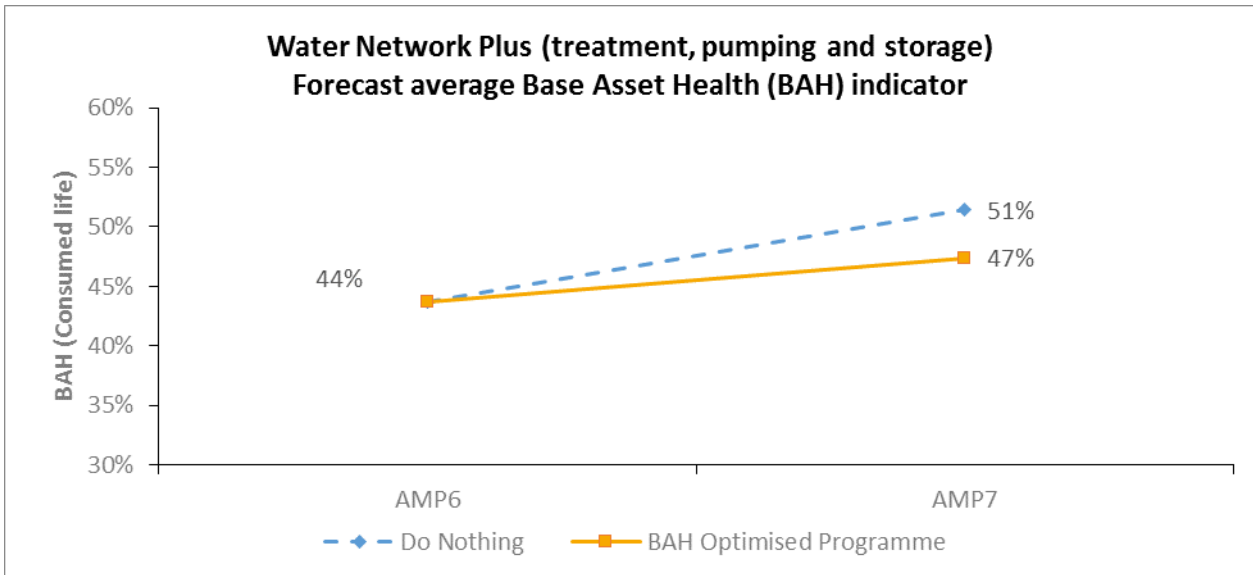

Figure 28: Forecast average Base Asset Health – Water Network Plus – treatment, pumping and storage


The average BAH for these assets shows a substantial proportion approaching the end of their operational lives during AMP6 and into AMP7. We are expecting to see a reduction in the expected average remaining life of this asset base during AMP7.

5.4.3   Water Network Plus bespoke asset health measure

5.4.3.1   Mains bursts – detected and reported

For the last two investment periods (2010-2018) we have focused our water network proactive maintenance activities in reducing the level of leakage and the number and duration of interruptions, rather than in wholesale rehabilitation of our asset stock. Our strategy has led to a small overall decrease in the number of bursts over this period, although recognising that we have had a number of large and impactful trunk main failures in this period.

Figure 29: Mains bursts – detected (hidden) and reported (visible)
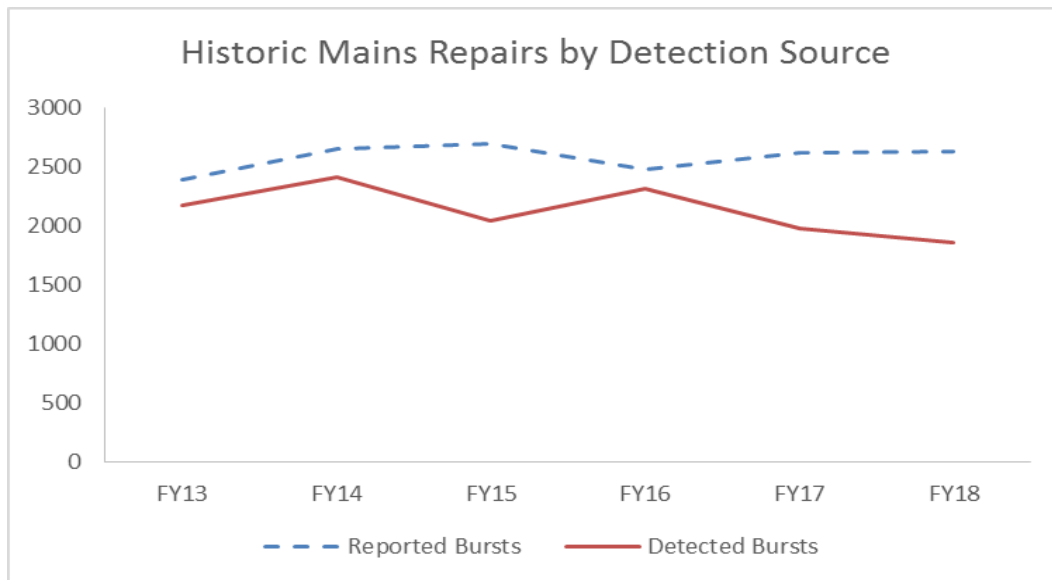
We have segregated our burst records into those detected and those reported, to help to indicate the impact of both the proactive and reactive components of this key asset health measure. The number of reported bursts is fairly stable indicating little change in the underlying health of the asset stock during the period. The number of detected bursts has been decreasing over the same period as 'hidden' bursts become harder to detect due to the overall decrease in the operating pressures in our distribution network.

We are expecting that this decrease in detected bursts will stabilise and potentially reverse during AMP7 as we increase our leakage reduction activities. However, we would expect to see an overall reduction in the 'visible' (or reported) bursts as our detection efforts help us to identify leaks before they surface as visible bursts.

5.5 Wastewater Network Plus

Our wastewater network service covers our services for the collection and treatment of foul and surface water. Much of our sewage collection infrastructure is aged and there has been little wholesale replacement of sewers and rising mains in the last 30 years since privatisation, as investment has been targeted upon:

- removal of defects that result in service failures;
- provision of capacity to limit the effects of both growth and extreme weather on our service performance; and
- enhanced overflow, storage and pumping capacity to mitigate the effects of storms upon flood risk and environmental pollution.

Our sewage treatment facilities have undergone a systematic improvement in performance coupled to a process of ever tightening environmental discharge consents. Much of this improved performance has been driven by new tertiary treatment processes, as well as improved operation and maintenance of the asset base since privatisation. The effect of new processes added through environmental enhancement programmes has been to deliver a consistent asset age profile, however this partially masks many aging primary and secondary processes.

5.5.1 Wastewater Network Plus unhealthy assets

As previously, the forecast proportion of 'unhealthy' assets has been made using the Base Asset Health (BAH) indicator and focuses upon the 15% most 'unhealthy' assets.
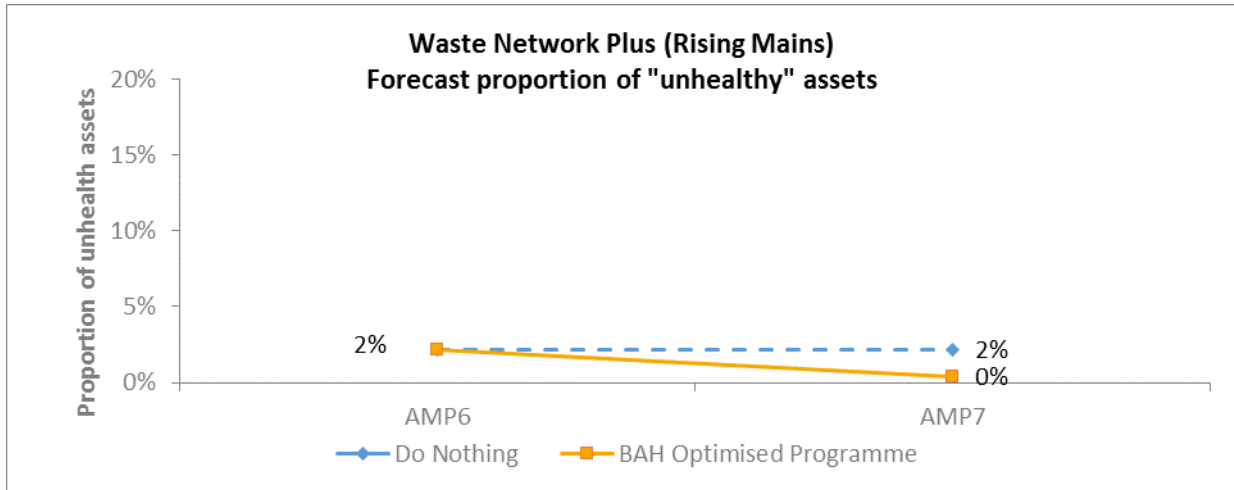
5.5.1.1 Sewers and rising mains

Figure 30: Forecast proportion of assets in 'poor health' – Wastewater Network Plus – sewers
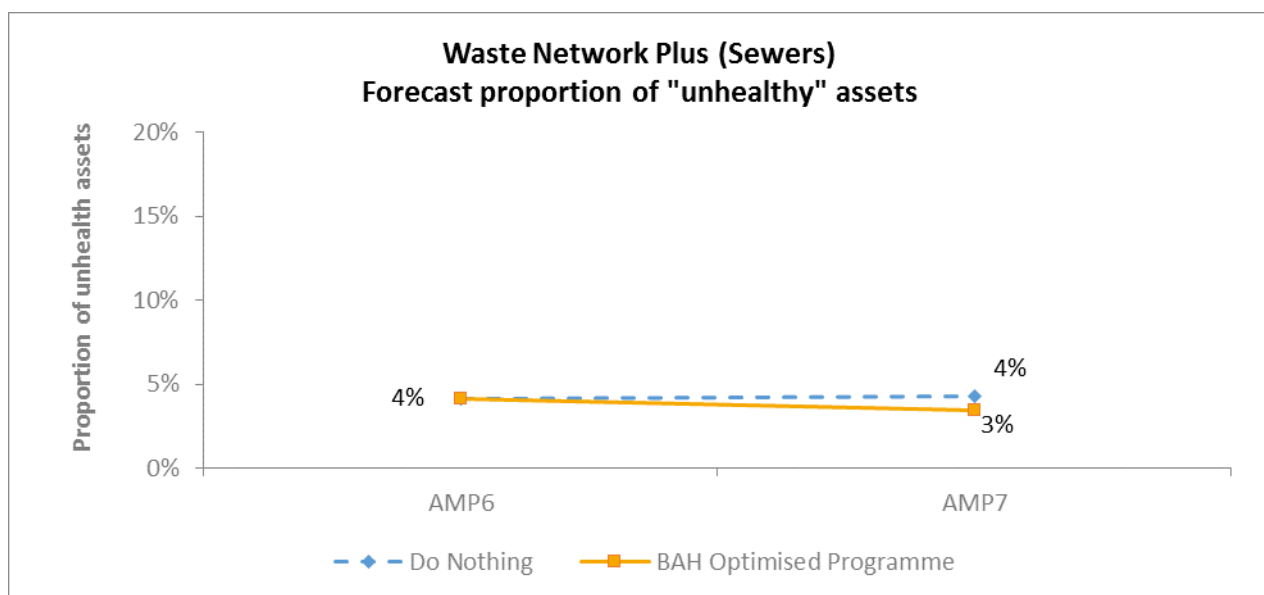
There is expected to be very little change in the proportion of unhealthy sewers during AMP7, as indicated by Figure 30. This is expected for these relatively long life infrastructure assets.
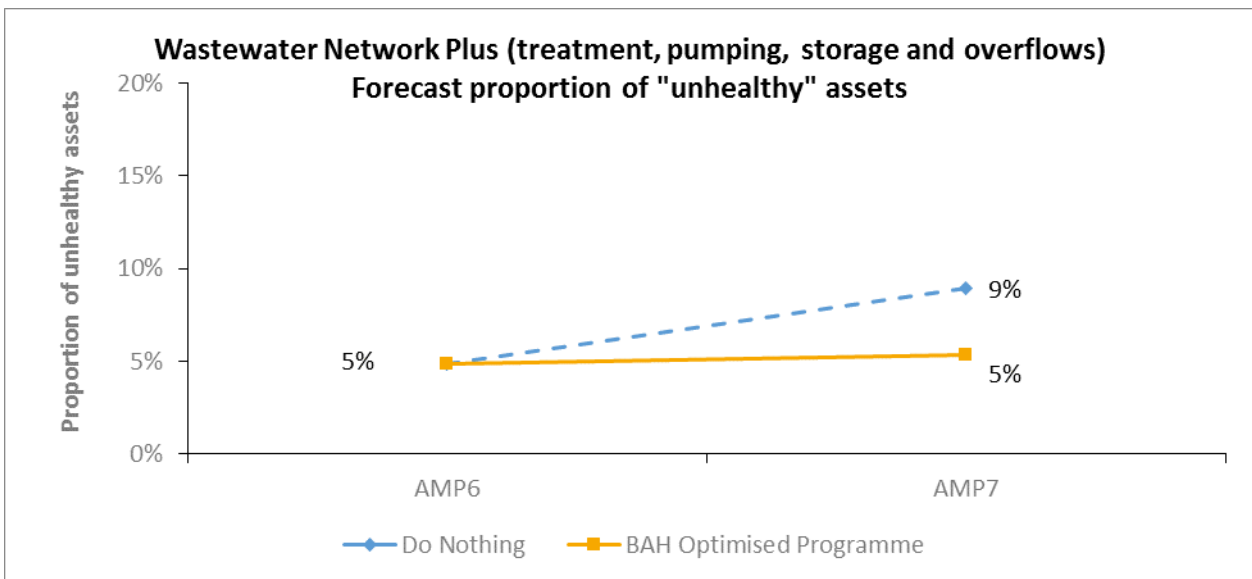
Figure 31: Forecast proportion of assets in 'poor health' – Wastewater Network Plus – rising mains

There is expected to be very little change in the proportion of unhealthy rising mains during AMP7, as indicated by Figure 31 above. However, it should be noted that non-linear deterioration of particular cohorts of rising mains grouped by material could influence this prediction; this is a particular risk for longer PVC rising mains approaching the end of their service lives.

5.5.1.2   Wastewater treatment works, pumping stations, detention tanks, CSOs

Figure 32: Forecast proportion of assets in 'poor health' – Wastewater Network Plus – treatment, pumping, storage and overflows


There is expected to be very little change in the proportion of unhealthy above ground Wastewater Network Plus assets during AMP7, as indicated by Figure 32 above.

5.5.2   Wastewater Network Plus average asset health

5.5.2.1   Sewers and rising mains

Our sewers and rising mains are inherently long life assets, although certain obsolete materials such as PVC used during the '70s for rising mains and pitch fibre used during the '70s for sewers are becoming brittle and prone to failure.

Figure 33: Forecast average Base Asset Health – Wastewater Network Plus – rising mains
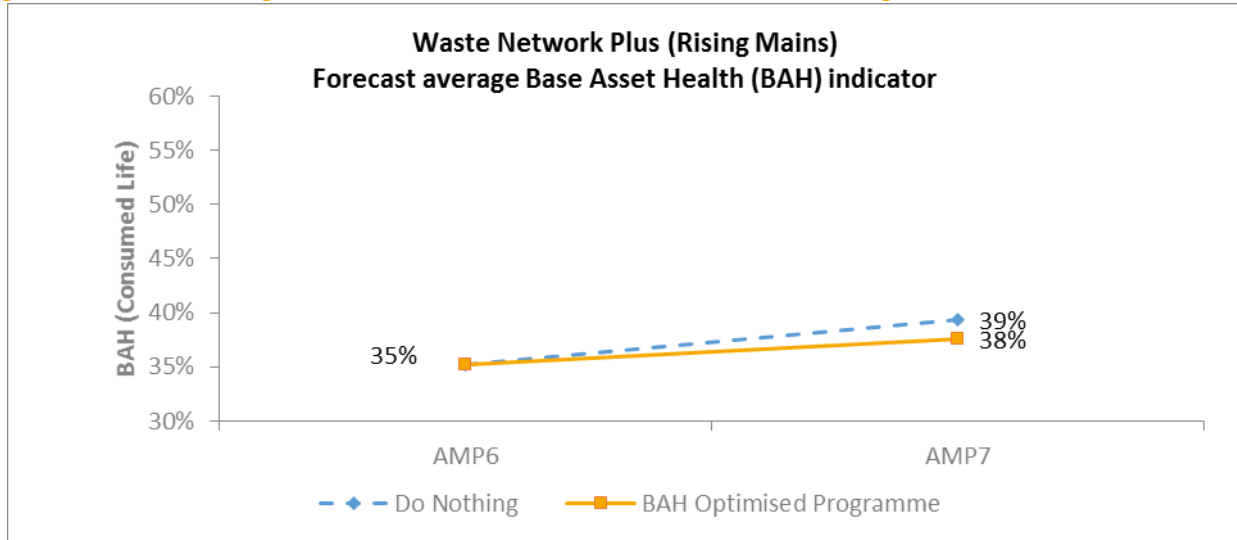
The average health of our rising mains is expected to deteriorate marginally during AMP7, although many of these assets have a substantial remaining life expectancy, largely depending upon their operating pressure and material.

Figure 34: Forecast average Base Asset Health – Wastewater Network Plus – sewers
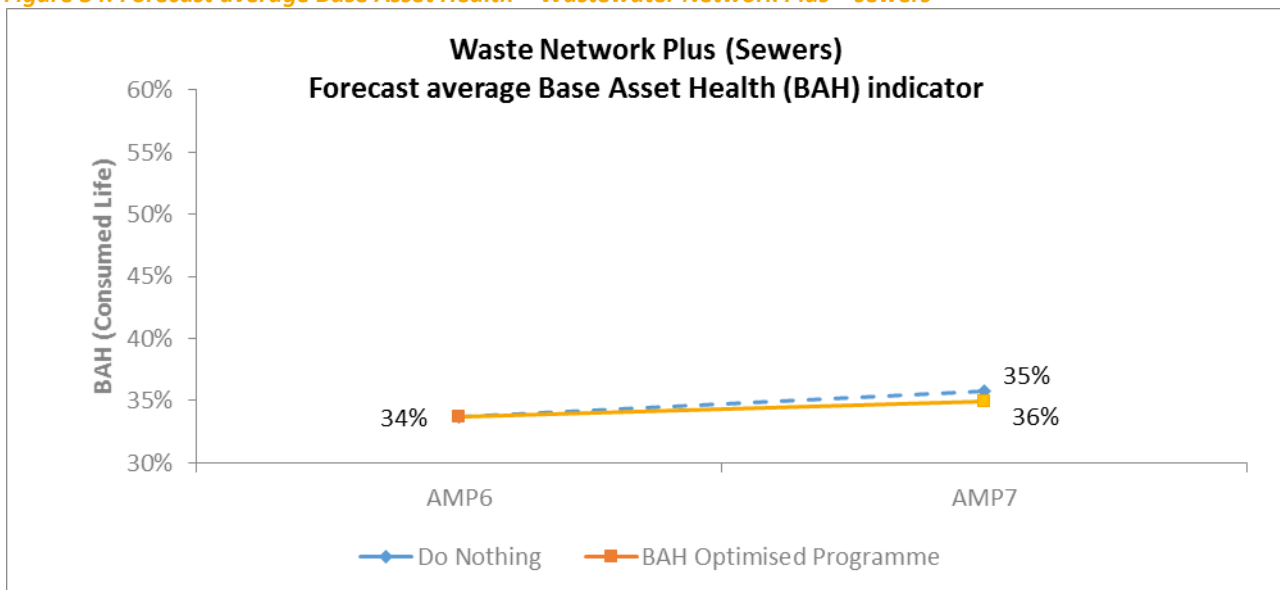

The average BAH for these assets shows a substantial proportion are midway through their expected lives. Wholesale renewal of this asset base due to poor condition is not anticipated within the immediate investment horizon. Pressure on these assets is primarily anticipated from growth and changing weather patterns. The effects of these factors will be to gradually reduce the proportion of the asset base that is capable of delivering adequate service due to inadequate capacity; this issue is highlighted with the '21st Century Drainage' project[3].

---

[3] 21st Century Drainage Programme - Assessing the Available Capacity in UK Sewerage Systems
https://www.water.org.uk/policy/improving-resilience/21st-century-drainage

We currently target defect removal for incidents where service defects are identified as being partially responsible for the incident. Analysis demonstrating the effect of this strategy is included in section 5.5.3.1.

5.5.2.2   Wastewater Treatment Works, Pumping Stations, Detention tanks, CSOs

Figure 35: Forecast Base Asset Health expected life profile – Wastewater Network Plus – treatment, pumping, storage and overflows
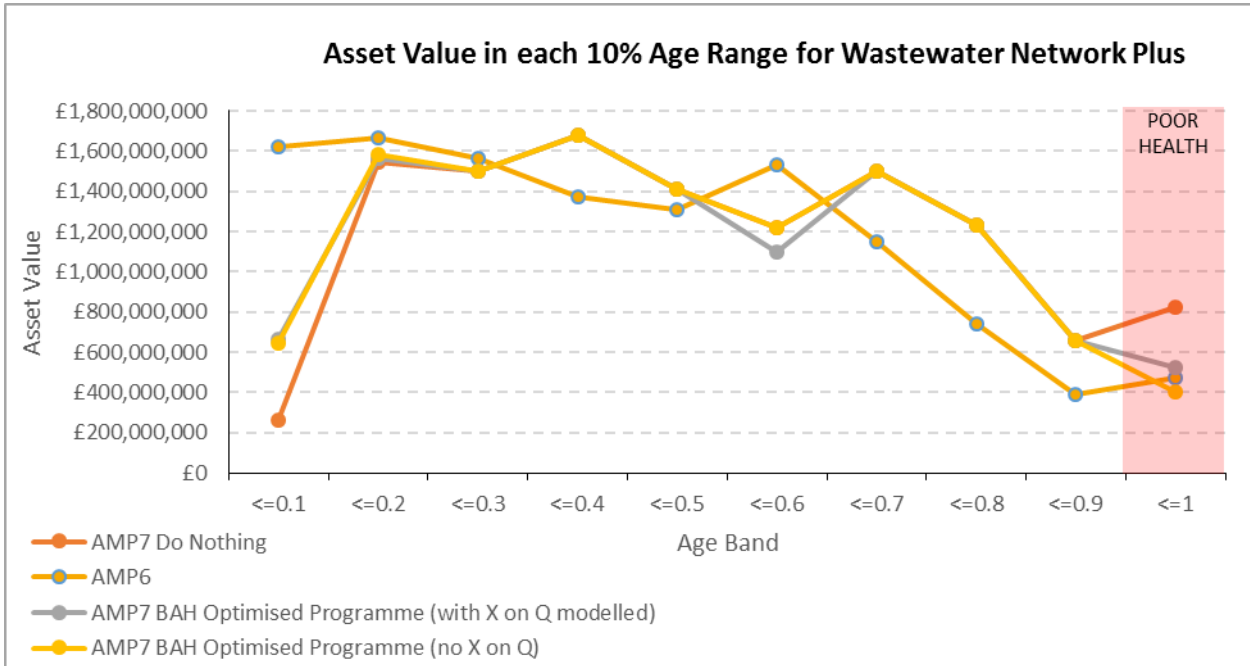
The above profile shows the effect of the substantial quality enhancement and maintenance programmes since privatisation. The forecast dip in the 'youngest assets' for AMP7 is due to the exclusion of the new asset stock associated with the environmental quality programme from this analysis. Inclusion of this investment would be expected to produce a similar profile for AMP7 to AMP6, apart from the 'bulge' in assets greater than 70% of the way through their expected lives.

Figure 36: Forecast average Base Asset Health – Wastewater Network Plus – treatment, pumping, storage and overflows
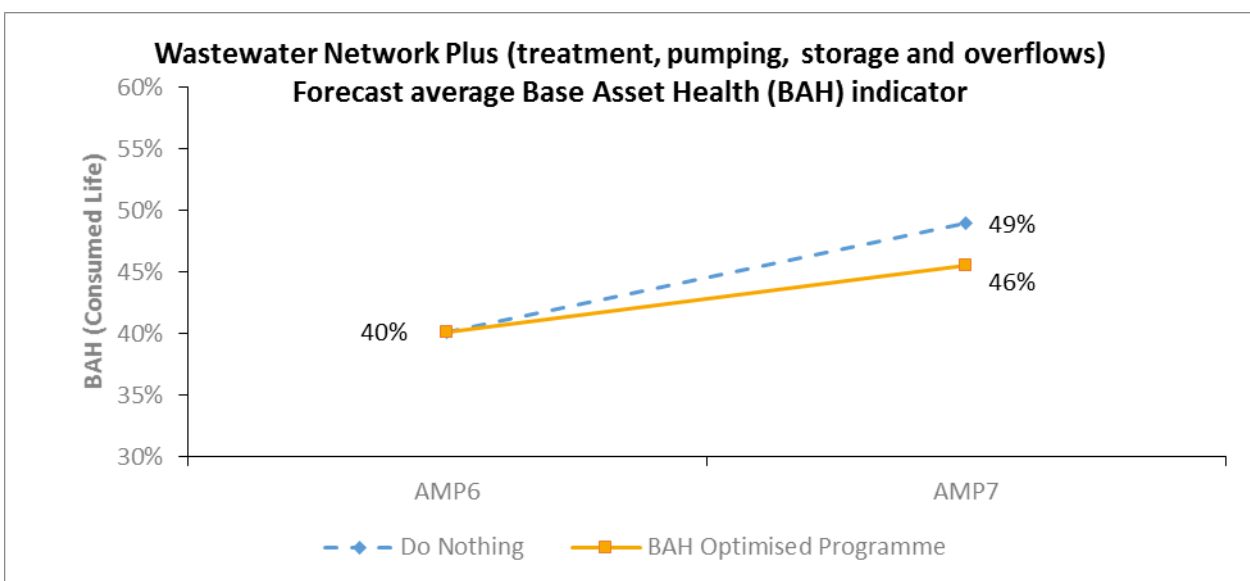
The forecast increase in average Base Asset Health indicator during AMP7 indicates the continued impact of focussing on supporting the enhancement programmes, with performance able to be maintained and improved to meet our

performance commitments via the planned improvement in the management, control and operation of the asset base.

5.5.3   Wastewater Network Plus bespoke asset health measures

5.5.3.1   Sewer rehabilitation

During 2013-14 we instigated a new strategy for maintaining our sewer infrastructure. We changed how we responded to incidents and introduced a 'first time resolution' approach. This was initially a more expensive approach to incident response than the more typical response to blockages, limited to quickly removing the blockage, rather than fixing less severe defects identified.

The following analyses demonstrates the effects of this enhanced strategy over the last 6 years.

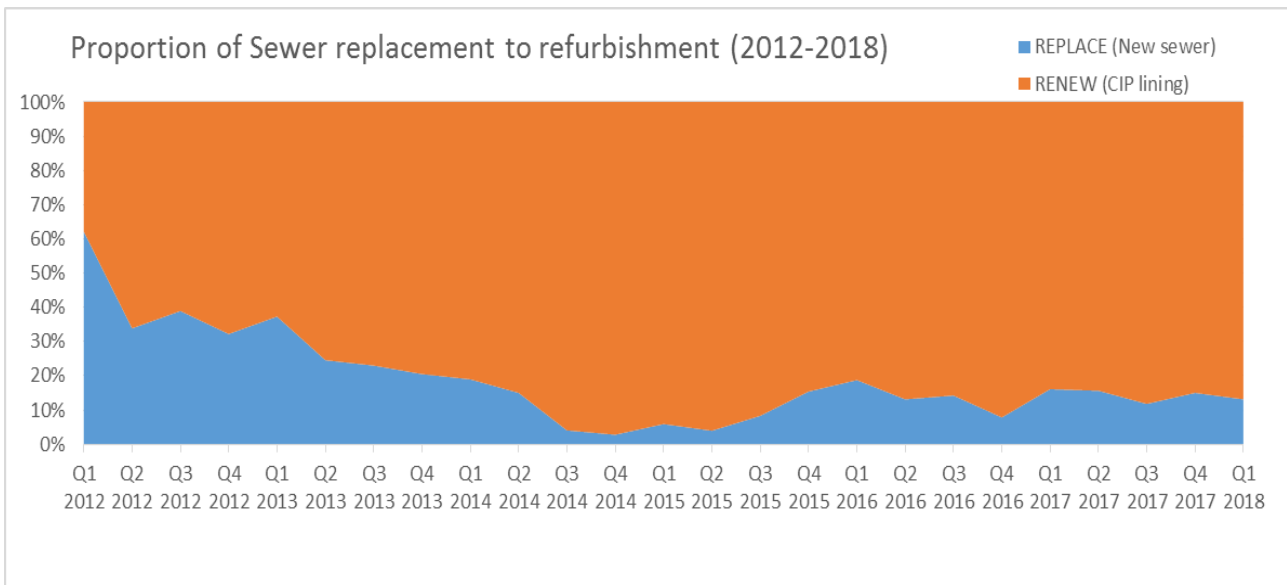*Figure 37: Innovation in sewer rehabilitation*

Figure 37 indicates the uptake of 'Cured In Place' (CIP) lining sewer rehabilitation as a widespread and viable technique, initially forming approximately 40-60% of sewer rehabilitation in 2012 and now routinely 80-90% or even higher. CIP lining provides a structural liner to a deteriorated sewer without requiring disruptive and expensive disruption of roads, paths and gardens.

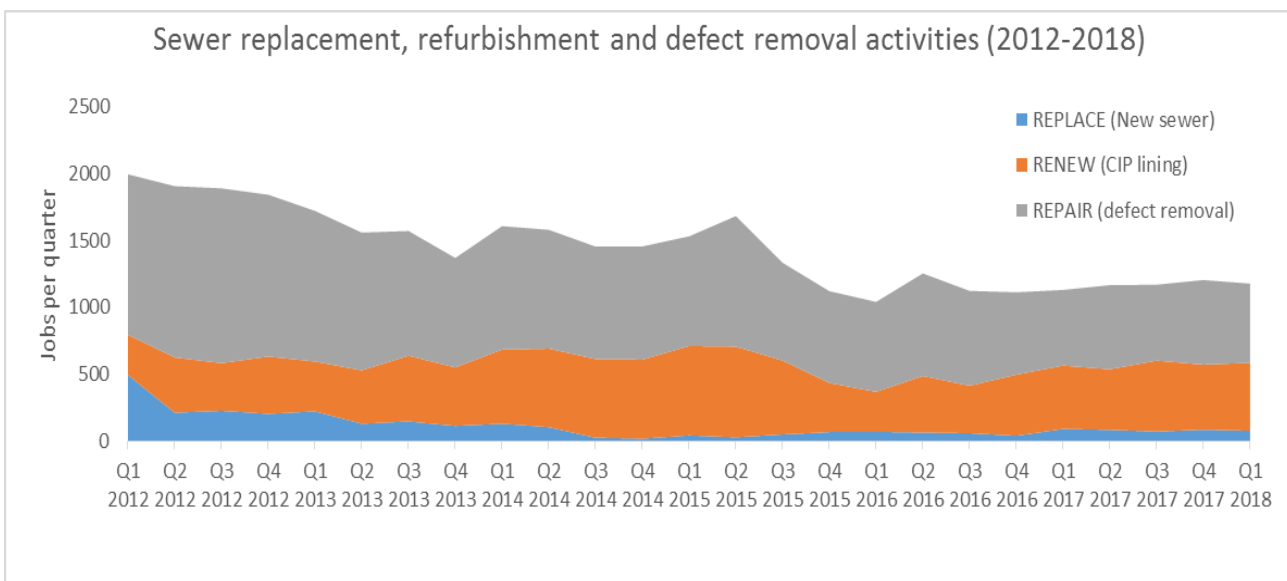*Figure 38: Gradual removal of sewer defects*

Figure 38 shows the reduction in the number of sewers requiring structural intervention over the last 6 years as we address the backlog of pre-existing sewer defects, and improve the health of our least healthy sewers.

Figure 39: Stable maintenance of manholes

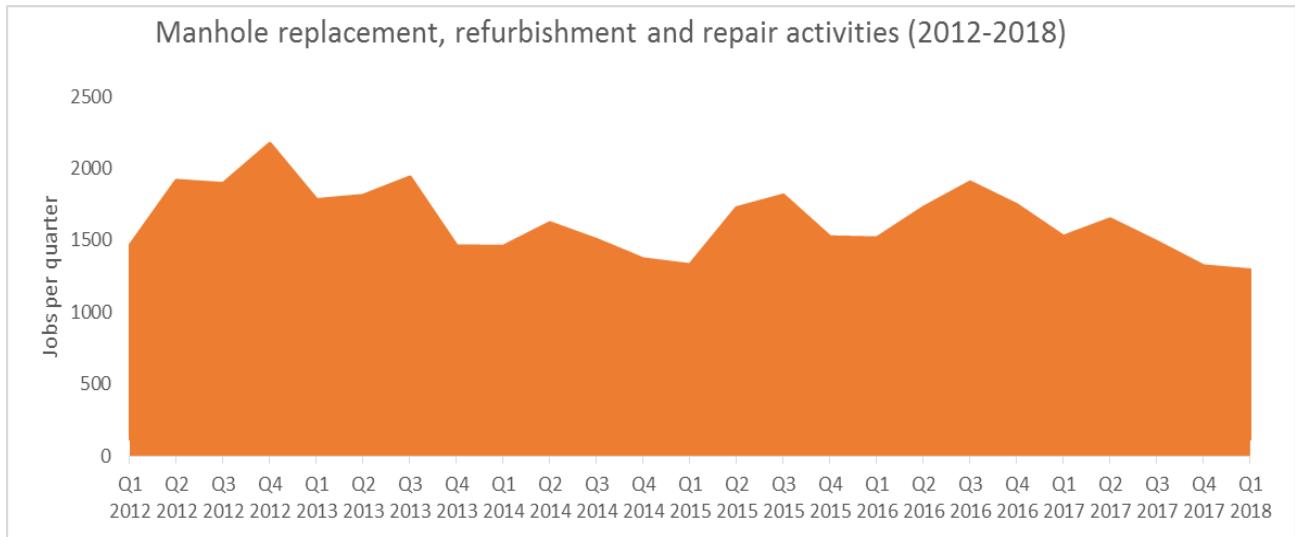Manhole replacement, refurbishment and repair activities (2012-2018)

Figure 39 indicates that level of required maintenance of manholes and manhole covers is constant. As these assets are largely affected by road loading and other third party use, it is to be expected that there would be a fairly stable requirement for maintenance, largely unaffected by our changes in incident response strategy.

Figure 40: Reduction in the prevalence of silt and roots

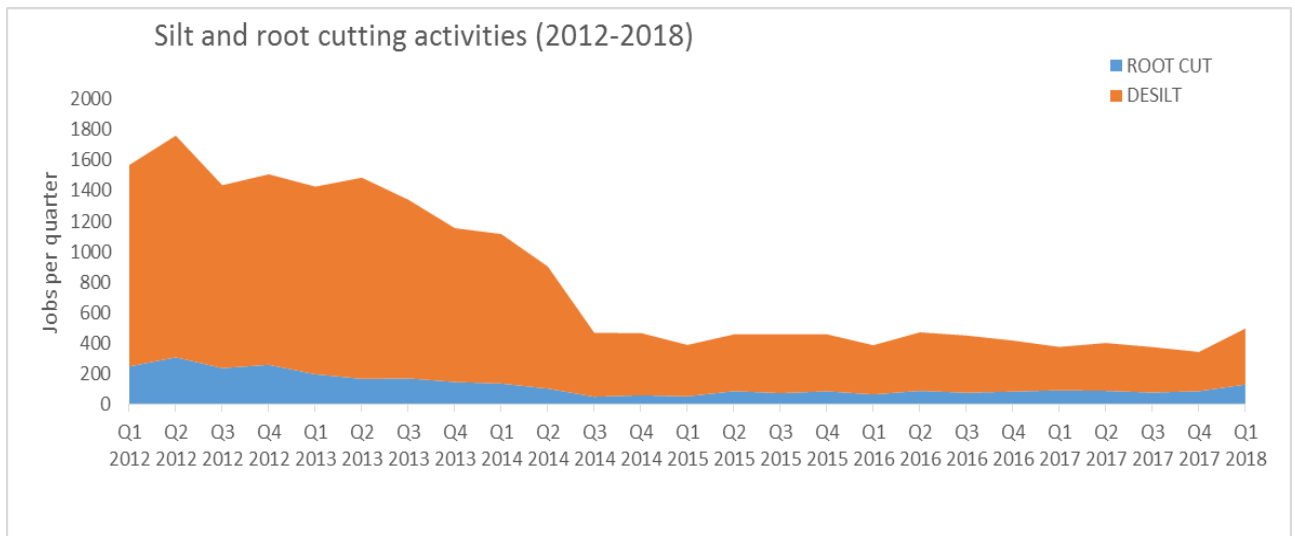Silt and root cutting activities (2012-2018)

Figure 40 shows the impact of our revised strategies around desiltation and root cutting. We have a mature desiltation programme with a good understanding of the rate of silt build up and the related impact upon sewer incidents. This knowledge has enabled a more efficient and targeted risk based desiltation programme. The routine removal of roots where they can lead to incidents has led to a reduced requirement for root cutting as we have addressed the historic backlog of roots in sewers.

Figure 41: Implied asset lives based on replacement, renewal and repair rates
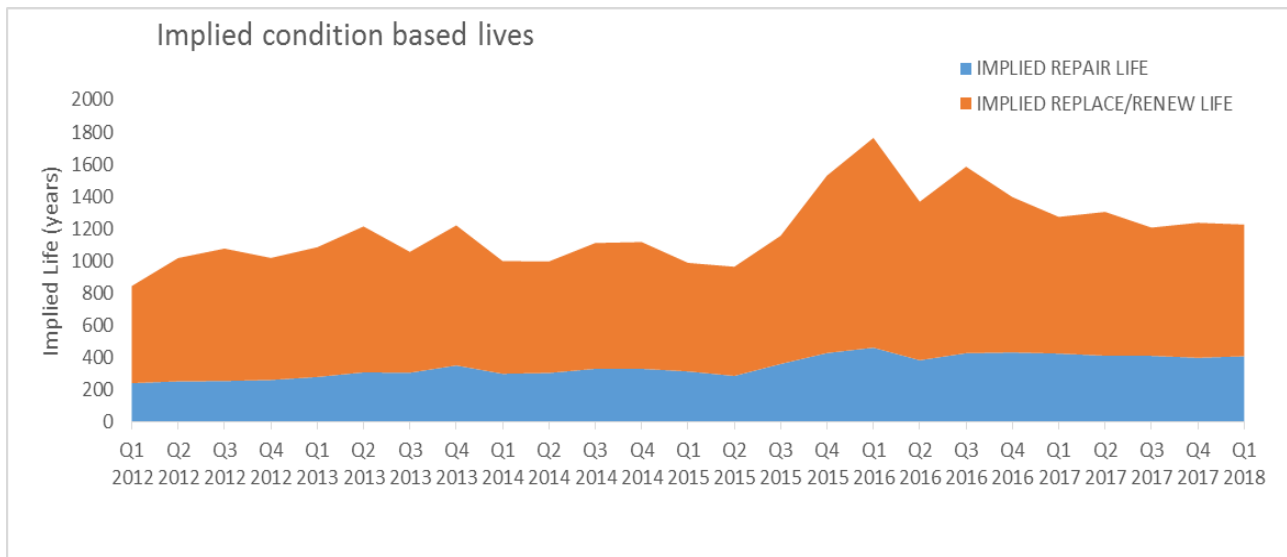

Figure 41 demonstrates the implied sewer life for two of the modes of asset health deterioration:

- The rate at which defects arise which can act as initiation points for incidents (blockages, ingress etc.) and
- The rate at which structural deterioration progresses to the point where a sewer requires replacement or renewal (CIP lining).

This demonstrates that after a period of historic defect removal up until 2015 we appear to be at a fairly stable rate of defect removal and sewer replacement or renewal, with a typical vitreous clay (VC) sewer accruing a service defect after 400 years and requiring replacement after about 800 years. It should be noted that since these assets are typically less than 100 years old, it is likely that the current rate of defect arisal will increase with time, and the implied lives will decrease substantially. This is an excellent example of the use of asset health monitoring as a leading indicator.
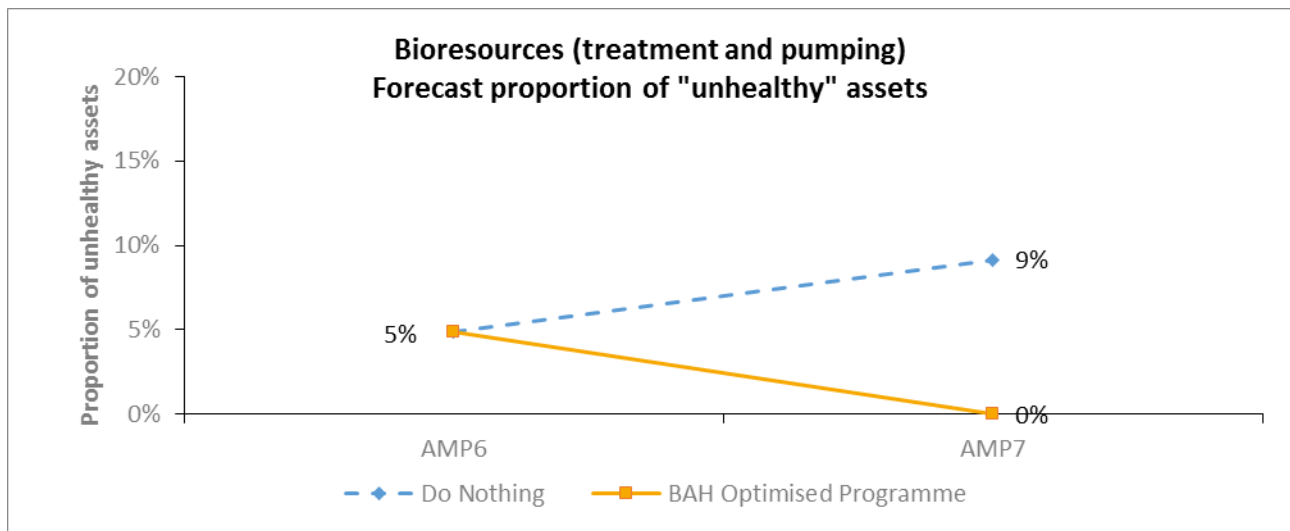
5.6   Bioresources

The Bioresource service asset base is mainly above ground assets coupled with a major strategic sludge pipeline running the length of the Mersey Valley. Investment in this key strategic asset is relatively uneven with little investment during AMP6 but a significant project currently planned for AMP7.

5.6.1   Bioresources unhealthy assets

Once again, the forecast proportion of 'unhealthy' assets has been made using the Base Asset Health (BAH) indicator and focuses upon the 15% most 'unhealthy' assets.

5.6.1.1   Bioresources treatment facilities, pumping stations

*Figure 42: Forecast proportion of assets in 'poor health' – Bioresources – treatment and pumping*

There is expected to be very little change in the proportion of unhealthy above ground Bioresources assets during AMP7, as indicated by Figure 42 above. The asset base currently has a small proportion of life expired assets, and this proportion is expected to be managed at a stable level during AMP7.

5.6.2   Bioresources average asset health

#### 5.6.2.1   Bioresources treatment facilities, pumping stations

Figure 43: Forecast Base Asset Health expected life profile– Bioresources – treatment and pumping
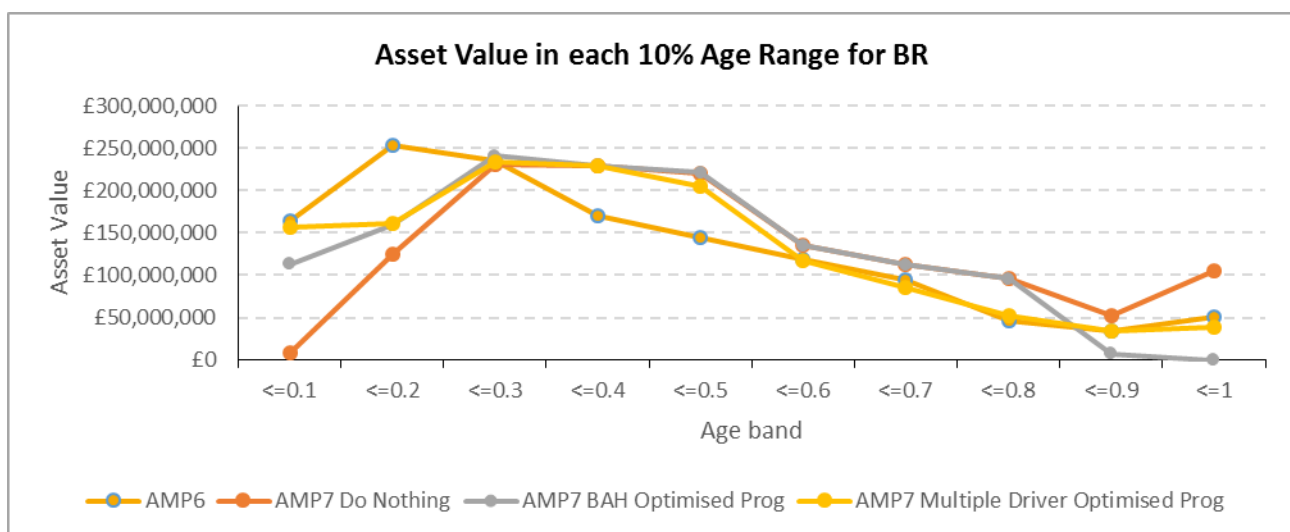
The above profile shows that the Bioresource asset base has a fairly even distribution of asset health, with a relatively large value of newer, healthy assets reflecting the recent strategic investment in these assets over the last 10 years.

Figure 44: Forecast average Base Asset Health – Bioresources – treatment and pumping
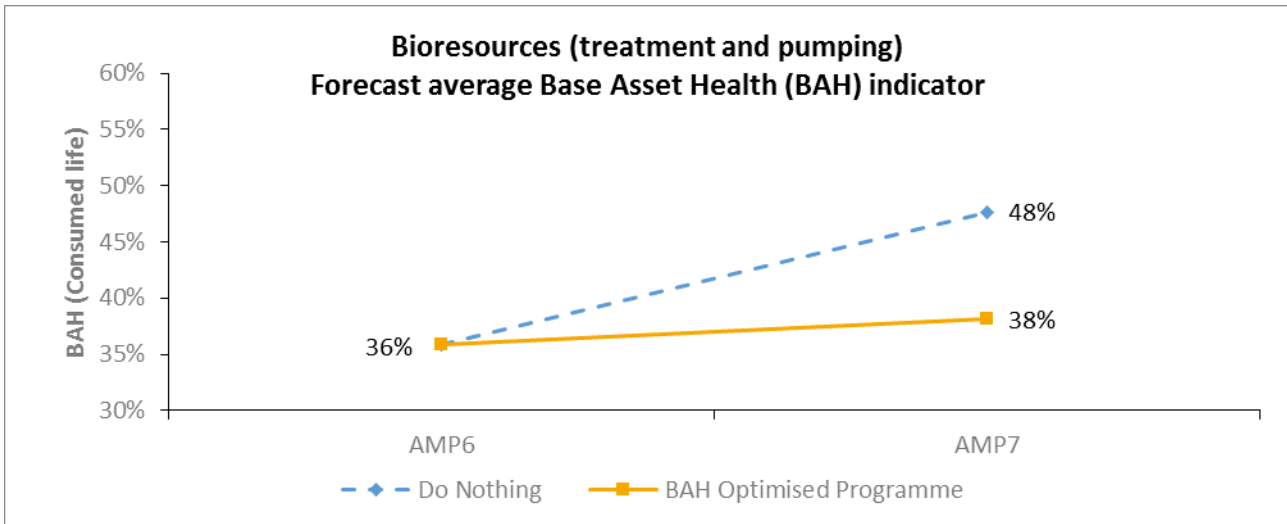

As for the other price controls there is a forecast increase in average Base Asset Health indicator during AMP7.

5.6.3   Bioresources – bespoke asset health measures

5.6.3.1   Bioresources AMP7 detailed programme

As an example of the capability of our BAH forecasting for the Bioresources price control we have modelled a detailed candidate programme of works for AMP7, balancing numerous regulatory, statutory, financial and other strategic drivers alongside a programme simply optimised for asset health. The impact of the multiple driver, optimised programme on the predicted base asset health by the end of AMP7, has been assessed and is summarised in Figure 45 below, with the current BAH profile.

Figure 45: Forecast Base Asset Health expected life profile– Bioresources – treatment and pumping – including facility specific programme
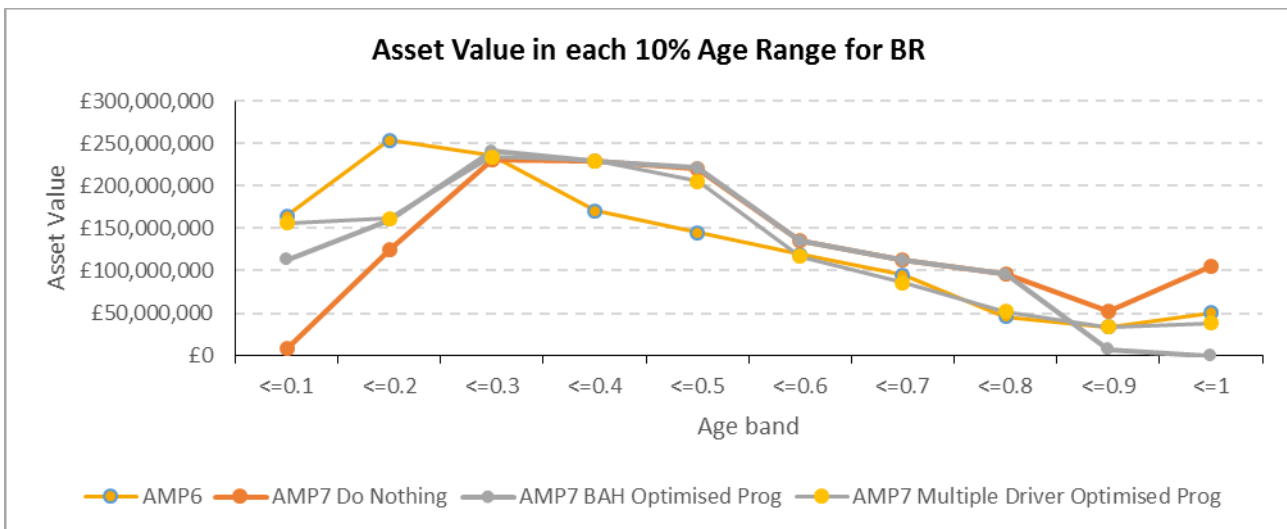
In Figure 45 above the 'AMP7 Multiple Driver Optimised Prog' data series has a profile that is very similar to the current effective age profile, as indicated by the series 'AMP6'. The main difference between the profiles is the slight reduction in new assets as the major strategic investments in AMP5 and AMP6 age.

5.7 Retail and other wholesale asset health

Whilst most of our assets are covered by assessments using our Base Asset Health indicator there are other classes of assets associated with the retail price controls or within the wholesale business but historically grouped under the title of 'Management and General'. This short section reviews our approach to the maintenance and monitoring of asset health across these assets with a brief discussion on the following categories of asset:

- IT – these assets span all price controls including residential retail and their health is critical to the ongoing efficient delivery of services
- Fleet – fleet assets also span all price controls and are a key enabler to service delivery
- Laboratory services – our quality and scientific service assets enable our wholesale business to proactively understand the product we deliver to customers and the environment
- Property – non-operational property is largely associated with our water resource price control, primarily consisting of farms and other agricultural or commercial properties. Managing the health of these assets helps to protect our natural capital and the quality and availability of our raw water
- Customer meters – maintaining customer meters is necessary to understand our water supply demand balance and for accurate billing.

5.7.1 IT asset health

Our IT department maintains the hardware and software systems and infrastructure required for our business to function. The health of much of this infrastructure is driven by time-bound factors such as obsolescence, rather than necessarily by condition and performance. This means that often asset health planning for IT assets is more predictable than for other physical assets.

The department maintains long term plans for all of the corporate systems, including key dates when products and systems are expected to go out of support, as well as options for updating support models to improve efficiency and reduce the whole life cost associated with these systems.

The following are the key drivers that influence IT asset health:

- The ability to meet current and future security threats
- The ability to comply with current and future legislation or regulation, such as general data protection regulations
- The alignment of system functionality with current and anticipated business requirements, including increasing operational resilience or new business processes
- The reliability and resilience of the systems to deliver greater availability whilst supporting robust disaster recovery
- Vendor support plans and the associated timetables
- Incompatibilities with underlying infrastructure, such as operating systems or hardware
- The drive for operational efficiencies through activities such as license management or system consolidation on to commodity solutions
- The physical condition of hardware
- The forecast level of demand upon the system, including both hardware and software
- The availability of innovative new capabilities in the market

These elements are considered within our long term IT plans which targets maintaining stable asset health within the context of a rapidly changing internal and external environment, leading to increased customer and user demand, shorter system lifecycles, increased regulatory requirements and greater security threats. Fortunately, this is an area where constant innovation is brought to market and it is typically possible to meet the increasing demand through new and innovative products, techniques and tools. We plan to continue to manage asset health through investment in commodity infrastructure, robotics, template driven IT, cloud services, agile delivery and other innovative approaches that will enable us to continue to deliver more for less.

5.7.2 Fleet asset health

Our fleet supports all parts of our business and is managed using an industry leading system for vehicle asset management Tranman from Civica. Our fleet assets have a relatively short life and reliability and safety are critical to

this asset base. A continual process of review is built into our business processes whereby we scan for new capability in the market; this ensures that we are well placed to identify innovative new platforms to improve our service and performance.

We have been early adopters of renewable technologies within our fleet including all electric vehicles, hybrid cars and larger vehicles running exclusively on biofuels.

Since this is a safety-critical element of asset base, with asset health risks for both our staff and for customers, our plans for our fleet are to maintain the asset health across our planning horizon whilst investing in a diverse and innovative vehicle mix.

5.7.3   Laboratory services asset health

Our water quality laboratory provides underlying services across our wholesale business to ensure that we are delivering a high quality product to the environment and customers. The assets associated with the delivery of these services are subject to a comprehensive audit and assurance process to maintain accreditation. Our plan is to maintain the health of these assets in line with the regulatory and statutory requirements in order to retain the required accreditation to operate the service.

5.7.4   Non-operational property asset health

Our non-operational property covers a variety of assets associated with an extensive 40,000 hectare land holding. This includes numerous farms, woodland and commercial and recreational assets. Maintaining the health of these assets is necessary to meet our statutory obligations for our tenants as well as maintaining and enhancing the substantial natural capital embedded in these assets.

5.7.5   Customer meter asset health

Our substantial population of customer meters is replaced on a regular basis to ensure an appropriate understanding of the changing level of customer demand and the wider implications to our overall supply demand balance for water supplies. This is an area of the asset base where careful consideration is made in the decisions around exchanging older meters with new, innovative meters. This is a particular focus area since these assets have relatively long lives, but the technology and innovation associated with meters is moving relatively quickly. Our plans involve maintaining the health of this asset base, whilst improving the capability of the asset base through the planned replacement programme.

6 Asset Health in risk management

We have embedded our Base Asset Health indicator into our Wholesale Risk and Asset Planning (WRAP) framework, described in our Corporate Resilience supplementary referenced as S4003, the name for our current asset planning processes and systems. BAH indicators are used as part of the initial risk quantification process as risks are initially identified and escalated within our 'tier' process, through to risk management, either via investment or operational interventions, see Figure 46.

Figure 46: Use of Base Asset health indicators in risk assessment

The remaining life expectancy of an asset is not the only consideration in deciding how and when to invest in an asset; however, it is often an important factor. We join this data together with our assessment of the criticality of the asset, the available mitigation, anticipated changes in the asset context as well as uncertainty assessments.

7 Asset health – independent audit

During 2018, Jacobs were commissioned to carry out an independent audit of our approach to asset health. This audit supplements Ofwat's 2017 horizontal audit of Asset Health[4], by providing a more in depth look at our company's capabilities across all areas of asset health. The same team responsible for the Ofwat audit also carried out our company specific audit.

The full report from the Jacobs audit is available for review. The audit presents summary findings against seven key areas, and found that we were performing in three areas, leading in three areas and best in class in one area; in no areas were we assessed as lagging or worst in class. We are adjusting our existing plans to ensure that they align with the findings from the audit to help us address the recommendations to enhance our capabilities during AMP7 and beyond.

Table 5: Summary asset health assessments from independent audit

Assessment Category	Assessment
Understanding of asset health	Best in class
Measurement of asset health (physical)	Performing
The link between asset health, performance, service and outcomes	Performing
Influence of asset health on investment planning and decision making	Leading
Communication and the views of the customer	Leading
Asset health assurance	Leading
Innovation and collaboration	Performing

Some of the key findings from the audit report are repeated below:

> *"UU's base asset health indicator (BAH) is considered industry-leading. It acknowledges the importance of asset health and it supports the use of asset health in decision making."*

> *"UU's enthusiasm to learn from approaches to asset health and asset management from other industries has been influential in implementing new ways of working."*

> *"UU recognises the importance of asset health to service delivery and is committed to engaging customers directly on this topic to understand their views on asset health."*

We will continue to monitor improvements in available tools, techniques and technologies within and beyond the water industry to ensure that we stay abreast of advances in the monitoring and use of asset health measures to deliver best customer value.

---

[4] Targeted Review of Asset Health and Resilience in the Water Industry' 14th September 2017
https://www.ofwat.gov.uk/publication-targeted-review-asset-health/

8   Asset health - future development

Monitoring and understanding changes in the health of our asset base is a key part of our business. Understanding when assets start to degrade and approach the end of their useful lives enables us to target where and when we need to intervene before customers experience service failures.

Our Base Asset Health indicator will enable us to introduce new and innovative ways of assessing changes in asset health without costly disruption to our downstream tools, processes and systems that use this information. This is because we are moving to including this simple mechanism of expressing asset health in a consistent way throughout our downstream processes across our wholesale business.

Some of the areas of particular innovation with respect of asset health are:

- Improving health models for buried assets; distribution mains, trunk mains, rising mains and sewers
- Improving condition based monitoring to support both our operational maintenance activities and wider planning processes with better feeds into corporate systems
- Testing and incorporating new technologies for asset health monitoring into BAU and our Base Asset Health indicator.
- Further embedment of the Base Asset Health indicator into our Wholesale Risk Asset Planning processes and throughout the entire asset lifecycle.

These initiatives will help us to keep asset health central to our business and our planning processes now and for the future.