## INTRODUCTION

This document includes five annexes that support our **Long-term strategy** (NES_LTDS).

- **Annex 1: You said, we did** – summarises the engagement we have had with and the feedback from our customers and stakeholders through the process of developing our Long-term strategy.
- **Annex 2: Plausible futures scenario analysis** – provides a detailed description and assessment of the impact of our core pathway and five plausible futures scenarios.
- **Annex 3: Common reference scenario analysis** – provides a detailed description and assessment of the impact of Ofwat's Common reference scenarios.
- **Annex 4: Delivering our goals** – our performance commitments – provides a summary of the link between our 2025-30 performance commitments and our Long-term strategy.
- **Annex 5: Review of Net Zero technologies** – presents our review of the Net Zero technologies assessed in Jacobs' '**Net zero Technology Review**', August 2022.

## 1. ANNEX 1: YOU SAID, WE DID

### Draft Long-term strategy development

We carried out customer engagement to develop the **draft Long-term strategy** (NES_LTDS3) as set out in Table 1. We engaged with the Water Forum (customer challenge group) to develop our customer engagement approach including for the Long-term strategy. You can see how we have sought challenge and assurance on our customer engagement approach in **A7-05 Independent report from Customer Engagement Panel** (NES46) and **A7-06 Water Forum report** (NES47).

Due to the complex nature of the Long-term strategy, we engaged with customers through our People Panel as this discursive form of research with a set of informed customers is well suited to tackling more challenging areas.

**TABLE 1: CUSTOMER ENGAGEMENT TO INFORM DEVELOPMENT OF DRAFT LONG-TERM STRATEGY**

| Engagement | Coverage |
|---|---|

| | |
|---|---|
| People Panels #2: Personas and scenarios (April 2022) (NES_LTDS4) | Development of future customer personas and long term scenarios |
| People Panels #3: Aims and measures (May 2022) (NES_LTDS5) | Introduce panellists to aims and measures and rank relative importance |
| People Panels #4a: Long term strategy metrics and ambition – part 1 (May 2022) (NES_LTDS6) | Detailed discussion of long-term metrics and ambition |
| People Panels #4b: Long term strategy metrics and ambition – part 2 (June 2022) (NES_LTDS7) | Detailed discussion of long-term metrics and ambition |

Further information on the engagement we undertook with academics, futurologists and innovators can be found in Long-term strategy Section 3.2: Horizon Scanning (NES_LTDS).

## Feedback from Ofwat

In January 2023 we met with Ofwat to present our progress on the development of our Long-term strategy. In April 2023 they provided feedback following this meeting and meetings with other water companies.

Ofwat were invited to provide feedback on our published draft Long-term strategy but declined to do so.

TABLE 2: OFWAT FEEDBACK ON OUR LONG-TERM STRATEGY DEVELOPMENT PRESENTATION

| Ofwat said | We did |
|---|---|
| Ambition:<br>Your presentation demonstrated a good understanding of how to set your ambition in line with our guidance. In line with that, in your PR24 submission we expect you to use the factors listed in our guidance to inform your ambition. | Long-term strategy Section 2: Ambition (NES_LTDS) sets out how we have developed our ambition in line with Ofwat guidance. |

| Ofwat said | We did |
| --- | --- |
| Core and alternative pathways:<br>Your presentation demonstrated a good understanding of how to develop the core pathway in line with our definition.<br><br>In your PR24 submission, we expect you to clearly explain how you have identified and prioritised low-regret investment. You should show that the selected investment, and the timing of that investment, is optimal given a wide range of plausible scenarios and their likely occurrence. This includes investment required to keep future options open or investment required to minimise the cost of future options. Where possible, low-regret investments should be flexible and modular.<br><br>Your presentation demonstrated a good understanding of how you are formulating alternative pathways in line with our guidance. In your long-term delivery strategy, you should clearly describe your decision and trigger points and explain how you have decided on the optimal timing of these points. We noted from your presentation that you intend to request enhancement expenditure at PR24 to support one or more of these pathways. In your PR24 submission, you should present compelling quantitative evidence that undertaking the preparatory work at risk now is better value than waiting until the next price control period or when there is more certainty of need. We expect all requests to align with our key principles for enhancement funding for preparatory work. | In our PR24 submission we explain how each of our enhancement expenditure business cases is linked to the Long-term strategy. We explain for each why we consider the investment is low/no regret and/or is required to meet short term requirements or to keep future options open or minimise the cost of future options.<br><br>**Long-term strategy** Sections 3.6: Core pathway, 3.7: Core pathway by investment area (NES_LTDS) and **Annex 2: Plausible futures scenario analysis** of this Long-term strategy describe our core pathway.<br><br>**Long-term strategy** Section 3.9: Decision and trigger points, **Long-term strategy** Section 3.10: Alternative pathways (NES_LTDS), **Annex 2: Plausible futures scenario analysis** and **Annex 3: Common reference scenario analysis** describe our alternative pathways and the decision and trigger points for each. |

| Ofwat said | We did |
|---|---|
| Scenario testing:<br>In your presentation, you set out how you are planning to use the full range of common reference scenarios to inform your strategy, alongside wider scenario testing. Scenario testing is important to evidence that you have identified low-regret investment and that you are able to efficiently meet long-term outcomes in a range of plausible futures. We expect you to use scenario testing to inform the development of your strategy, including the selection and timing of activities in your core pathways and the development of alternative pathways. In your PR24 submission, you should also demonstrate the sensitivity of your proposed enhancement investments to future needs and uncertainty.<br><br>However, you should note it is essential that only plausible scenarios are used to develop the core and alternative pathways. We noted from your presentation that you are planning to test a number of wider scenarios as part of your strategy. Wider scenarios should be measurable factors with clear and observable metrics that can be used to define decision and trigger points. We will expect you to clearly demonstrate in your Business Plan that your proposed investments are required across a wide range of plausible scenarios. Where a wider scenario is driving an alternative pathway, based on potential changes in local or company-specific factors, you should clearly set out the associated decision and trigger points, and explain how you will monitor, review and report the relevant metrics over time.<br><br>We saw only limited evidence that you are testing the common reference scenarios for technology in line with our guidance. We expect you to use the technology scenarios to test the sensitivity of options to different futures and justify the optimal timing and sequencing of activities in your strategy. The scenarios describe futures where the adoption of the listed technologies becomes cost-effective at different dates, as a result of technology developing faster or slower than expected. The adoption of the listed technologies should be assumed to reduce the costs of meeting long-term outcomes.<br><br>In your PR24 submission you should clearly set out all assumptions you are making about the impact of the scenario. If there are specific technologies where you consider it implausible that their adoption could be cost-effective in your region by the dates in the scenarios, you should clearly explain the reasons why. You should also consider a wider range of technological developments, beyond those set out in the reference scenarios. | We have included analysis against each of Ofwat's common reference scenarios including for the adverse and benign technology scenarios in line with Ofwat guidance in **Annex 3: Common reference scenarios.**<br><br>In addition, we have explored an additional 'plausible future' scenario called 'technological advance' in which we explore the impact of indicative step changes in technology. This is described in **Annex 2: Plausible futures scenario analysis.**<br><br>We set out the assumptions we have made in the detailed descriptions of each scenario and in our **Long-term strategy model** (NES_LTDS9).<br><br>In our PR24 submission we explain how each of our enhancement expenditure business cases is linked to the Long-term strategy. We explain for each why we consider the investment is low/no regret and/or is required to meet short term requirements or to keep future options open or minimise the cost of future options. |

| Ofwat said | We did |
|---|---|
| Base expenditure:<br>We saw only limited evidence that you are considering long-term performance improvements from base expenditure. It is important that you develop your own forecasts of improvements expected from base expenditure, and clearly set these out for each of the outcomes and metrics that make up your ambition. Enhancement investments should build on these activities to meet your long-term ambition. We expect you to challenge yourself to deliver stretching levels of performance from your base expenditure allowance, and to reflect this in your long-term delivery strategy. | We have estimated for each of our performance commitments the improvements expected from base expenditure and the improvements that will require enhancement expenditure to meet our long-term targets (in **Annex 4: Delivering our goals – our performance commitments**). |
| Engagement:<br>We are encouraged to see that customer engagement is informing your ambition and the selection and sequencing of key investments. In your PR24 submission, you should clearly explain how your strategy has been informed by customer preferences, including bill impacts and the selection and sequencing of key investments. You should also provide sufficient and convincing evidence that your customer engagement activities meet our standards for research, challenge and assurance. As part of our ambition assessment we will consider how far you have engaged meaningfully with your customers on their preferences and affordability concerns to inform your PR24 submission. | In **Long-term strategy** Section 2.4 Aiming high (NES_LTDS) we explain how customer engagement has been used to inform our ambition.<br><br>In **Long-term strategy** Section 3.6 Core pathway (NES_LTDS) we explain how our strategy has been informed by customer preferences. |
| We are pleased to see that you are engaging your Board and senior management in the development of your strategy. In your PR24 submission, we expect your Board to provide an assurance statement that explains how it has challenged and satisfied itself that the strategy is the best it can be. | **Long-term strategy** Section 6: Board assurance statement (NES_LTDS) explains how our Board has challenged and satisfied itself that this strategy is the best it can be. |

## Consultation on our draft Long-term strategy

We engaged with stakeholders and customers on '**Shaping our future: developing our long-term strategy 2025-2050**' (NES_LTDS3) over June and July 2023. We invited written responses to the published strategy, which we shared with around 250 stakeholders. We invited key stakeholders to round table discussions to enable more discursive engagement, and the online session was also observed by the chair of the Water Forum.

### TABLE 3: CUSTOMER AND STAKEHOLDER ENGAGEMENT ON OUR DRAFT LONG-TERM STRATEGY

| Engagement | Stakeholders | |
|---|---|---|
| Roundtable (In person) | Durham Wildlife Trust | |
| | Esh (Construction partner) | |
| | Thirteen Group (Housing association) | |
| Roundtable (Online) | Suffolk Wildlife Trust | |
| | Galliford Try (Construction partner) | |
| | Newcastle City Council | |
| | Essex County Council | |
| | Voluntary Organisations Network North East | |
| | National Farmers Union | |
| Deliberative customer research | Innovation Festival customer group – bill impacts, intergenerational fairness, long-term targets | Long-Term Delivery Strategy – Young People Panel and Innovation Festival (August 2023) (NES_LTDS8) |
| | Young People Panel | |
| Written responses to consultation document | Shared with around 250 stakeholders. One response received from Newcastle Gateshead Initiative | |
| Meeting | Environment Agency (EA)<br>Drinking Water Inspectorate | |

The tables below summarise the findings from our customer and stakeholder engagement, and how we have addressed them in this updated Long-term strategy.

### TABLE 4: CUSTOMER FEEDBACK ON OUR DRAFT LONG-TERM STRATEGY

| Customers said | We did |
|---|---|
| Customers described the potential bill increases in the Long-term strategy as "scary", "exasperating" and "overwhelming". However, some customers and the Environment Agency noted the need for a cultural shift in how society values water as it is currently potentially too cheap. | We have considered further how we can address affordability over the longer term. This includes "changing the conversation" about the value of water as a potential tool to address affordability.<br>We have also worked to improve our understanding of the investment need and have aimed to reduce the investment requirement where possible. For example, we have made a more conservative assumption in the core pathway about the sustainable long-term level of capital maintenance expenditure. We have however also needed to increase forecast expenditure where better information has become available, for example in relation to lead replacement. |

| | |
|---|---|
| A significant majority of customers thought the best balance of intergenerational fairness would be achieved through steady bill increases over time rather than significantly pushing back or bringing forward investment. | This aligns with our 2025-30 Business Plan, and this Long-term strategy, which will see bills increasing over the next five price reviews in a roughly continuous way across most scenarios. |
| We tested long-term targets not previously tested with customers for pollution incidents, sewer flooding, net zero, biodiversity and renewable generation, interruptions to supply (ITS), lead replacement. Customers generally support a balanced long-term plan that is neither the budget or gold standard.<br>Customers considered net zero (and renewables) to be the most important target, followed by sewer flooding, ITS and lead replacement. Biodiversity and pollution incidents were considered important to include as a target, but questioned whether we should go beyond statutory minimum. These targets were however supported by other stakeholders.<br>Bathing water target supported by stakeholders (Newcastle Gateshead initiative) but only limited support from customers – young people panel did not consider we needed a target. | We have introduced targets for interruptions to supply (ITS), bathing waters and lead replacement.<br>We have reduced the scale of the biodiversity target so that it still covers all construction activity but will not require us to go 5% beyond the statutory or local requirements in line with customer feedback.<br>We have included a target for bathing waters as although our Young People panel did not consider this was a priority area, stakeholders (NGI) did. We do not consider this will be a major driver of additional costs as improvements will be delivered through, for example, storm overflow discharge reductions. |

**TABLE 5: STAKEHOLDER FEEDBACK ON OUR DRAFT LONG-TERM STRATEGY**

| Stakeholders said | We did |
|---|---|
| Stakeholders (Esh, Durham Wildlife Trust, Thirteen Group) considered some long-term targets unnecessary – zero High Potential Incidents by 2050 and zero CRI. | We included a long-term target in our draft Long-term strategy on eliminating high potential incidents by 2050 as an indicative measure of health and safety. Following stakeholder feedback, we agree that this is not an appropriate long-term target, because we should be and are already highly focussed on improving the safety of our operations in the short term. We have therefore removed this long-term target and instead reaffirm our commitment to continual improvement to health and safety.<br>We have retained the CRI target. While we agree that CRI does not have the same focus as other targets on making significant improvements, we consider that it is such a fundamental part of what our customers expect from us that we need to include a long-term target. |
| Stakeholders (Esh, Galliford Try, Thirteen Group, Durham Wildlife Trust) identified attracting enough of the right people into the sector as one of the biggest challenges for the next 25 years. | We agree that attracting people to the sector is one of the biggest long-term challenges we will face. We have carried out deliverability analysis to support the increase in expenditure needed in 2025-30 in our PR24 Business Plan and explain further in Long-term strategy Section 3.8: Key enablers for our investment (NES_LTDS) what we are doing to support the future attractiveness of the water sector as a great place to work. |
| The Environment Agency noted that investment in resilience and asset health is important. | We maintain the case for increasing investment in resilience over the long-term. |

| Stakeholders said | We did |
|---|---|
| Some stakeholders considered the affordability scenario should be removed (Environment Agency, Martin Hurst). | We have removed the affordability focus scenario from our **Long-term strategy** (NES_LTDS). The purpose of this scenario was to examine the possibility of delaying expenditure from 2025-30 to later period, a position on which has been proposed in our 2025-30 plan. We continue to focus on how we will maintain affordability of bills for customers over the long-term. |
| A high technology change scenario should be included (Durham Wildlife Trust, Esh, Thirteen Group, Martin Hurst) that captures potential for macro-technology development like the impact of AI. Innovation like this and the resulting efficiency provides one of the strongest areas to reduce costs and improve affordability. | We have introduced a technological advance scenario, based on the scenario excluded from Arup's original proposals. This scenario explores the potential for a step change in technology to reduce the costs of delivering in the long term. |
| Martin Hurst considered the Long-term strategy should be restructured to reflect Ofwat's requirements. | We have restructured the **Long-term strategy** (NES_LTDS) in line with Ofwat requirements. The resulting Long-term strategy is therefore more Ofwat focused. We have therefore included a summary of our strategy for our regions in our 2025-30 Business Plan summaries (**NES78**, **NES79**) to inform customers and stakeholders. |
| Long-term targets should be included for bathing waters (NGI). | Although customers do not see this as a priority area currently, we have introduced a long-term target for bathing waters. We consider it more appropriate to include a target, but for the target to reflect the relative priority of bathing waters to customers. |
| Stakeholders discussed with us whether we could go beyond statutory targets for environmental targets. (Durham Wildlife Trust, Suffolk Wildlife Trust, Martin Hurst) | We do not consider there is scope to commit to going beyond 2050 statutory minimum requirements for environmental targets yet as the statutory targets have been set at ambitious levels which already require significant technological development and/or behaviour change to deliver – for example on PCC and net zero. Technology may allow us to go further in future, and we expect to review and revise these long-term targets in updated versions of our **Long-term strategy** (NES_LTDS).<br>The exception to this is our biodiversity target. Environmental stakeholders considered we should go even further to secure net gain in biodiversity than we proposed in our draft **Long-term strategy** (NES_LTDS), but customers were not supportive of going beyond the statutory requirements. We have updated our target to remove the ambition to go 5% beyond the statutory or local requirement in line with customer preferences. However, we retain the commitment to apply the minimum 10% biodiversity net gain to all our construction activities as we consider it would be inconsistent and morally questionable to report biodiversity net gain on developments requiring planning permission while allowing biodiversity net loss on permitted developments. This is discussed in more detail in our **Environment Strategy** (NES75). |

| Stakeholders said | We did |
|---|---|
| The Environment Agency asked whether we should include a climate change resilience target. | While understanding climate change is imperative to managing climate related risks and resulting required investment, such as for power and flooding resilience identified in our Business Plan for 2025-30, it would be difficult to separate out impacts related to climate change from other events. We therefore consider that our existing resilience targets capture the impact of climate change resilience needs.<br>However, we consider that asset health, which is important for climate change resilience and resilience more generally could be better measured using alternative approaches, which we are currently working to develop with the wider industry. In the long-term therefore we consider that good performance under **Ofwat's Asset Management Maturity Assessment (AMMA)** (NES67) is a more valuable target than the previous target on sewer blockages. |
| One stakeholder (Thirteen Group) noted that supporting volunteering can help those struggling with affordability as demand for volunteer services such as food banks increases as affordability worsens. | We have a long-term target to support volunteering. This point is noted in the **Long-term strategy** Section 4.4: Maintaining affordability for customers (NES_LTDS). |

## 2. ANNEX 2: PLAUSIBLE FUTURES SCENARIO ANALYSIS

We face an uncertain future. The plans we put in place, and the investment decisions we make, need to set a solid foundation for delivering the service and the performance our customers expect from us. At the same time, we need to maintain the right level of adaptivity and flexibility so that we can adjust our course in future.

This means making the necessary investment now, in the upcoming investment period from 2025-2030, that will be 'no-regrets' – in that the investment is required across many plausible futures – which is what we term our 'core pathway'. It also means taking a view, which will inevitably evolve over time, as to what might trigger the need for a different approach and investment profile – these are our 'alternative pathways'.

We have set out alternative pathways for five different plausible futures that we see could play out and have examined when key decisions will need to be made that will determine which pathway we follow.

This adaptive planning approach aims to optimise interventions over time, ensuring that options are kept open until there is sufficient certainty around the best course of action, while ensuring investment decisions are taken when needed.

By looking across future investments we can also identify crunch points and manage these by moving investment forward or backward within our investment portfolio.

It is important to note that in PR24, our regulator, Ofwat, will set the allowances only for 2025-2030. Even though we are looking at potential investment pathways beyond that, to make sure we efficiently invest as needed in the coming years, the levels of investment through customer bills from 2030 does not get set at this time.

We will continue to reassess future investment needs and innovations and efficiencies will emerge that can help manage our costs. Here we set out a summary of the different pathways and what they mean in terms of customer bills.

### Core pathway

**Our core pathway includes all the activities and investment we know are 'no-regrets or low-regrets' because they are required under a wide range of plausible futures. It includes investment to meet short-term requirements, and to keep the necessary options open for potential longer-term investments.**

It is built on a foundation of pushing and challenging ourselves to make sure we achieve as much as we can from our day-to-day expenditure before looking for further investment, of continuing to be leaders in innovation

and being efficient in how we work, and of making sure we continue to be financially resilient to attract the necessary capital for investment. It aligns with our core pathways under our WRMPs and DWMP.

Our core pathway maintains a strong focus on reducing leakage and supporting and enabling customers to reduce their demand. It reflects the 'least cost' approach to achieving our statutory environmental requirements, including to meet the requirements and timetable as currently set out under the **Government's Storm Overflows Discharge Reduction Plan**.

It puts forward the minimum necessary investment to shift us to a sustainable level of asset maintenance expenditure, with investment in asset health and climate change adaptation required to meet our legal obligations.

It focuses, for 2025-30, on decarbonising in those areas where we have the most information and direct control over emissions; and it aims to continue to deliver straight line reductions in emissions beyond that towards 2050. Our indicative estimate of the enhancement cost of the core pathway between 2025-2050 is around £14.8bn. Under the core pathway, we phase and smooth investment over the long-term to create a sustainable and deliverable pipeline of no-regrets investments. It includes the significant enhancement investment we will need to put into 2025-2030 across our investment areas.

While this remains one of the least impactful scenarios for customer's bills, under the core pathway, bills progressively go up towards 2050 with a similar % bill increase between price periods. Between 2025 and 2050 we expect to see bills increase up to an annual amount of £663 which is nearly double bills in 2025 for water and wastewater customers in the North East. We expect bills to increase up to an annual amount of £313 which is around 23% more than bills in 2025 for customers in Essex and Suffolk. This is largely driven by the increasing statutory expectations and the subsequent investment that is higher than previously allowed for in price reviews.

### Key assumptions

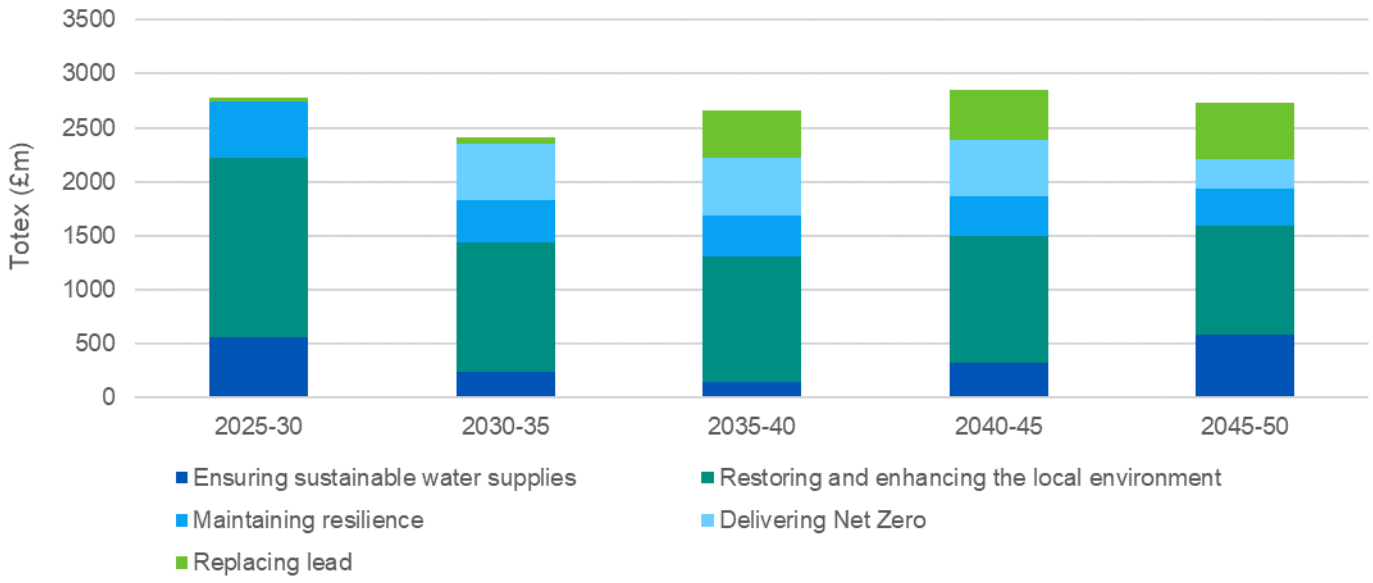
- The core pathway includes only no/low regret investments and enabling investment, for example, investments made to reduce PCC, business demand and leakage.
- We make additional water resource investments in:
    - Lanford Ultra-violet treatment.
    - Langham nitrate scheme.
    - Lanford nitrate scheme.
    - Abberton raw water pumping station and Langford clarifier.
    - Linford new water treatment works.

  - Barsham water treatment works and Saxmundham Tower upgrades.
  - Transfer from Holton water treatment works to Eye Airfield.
  - Bungay to Barsham water treatment works pipeline.
  - Barsham nitrate scheme.
  - Lowestoft water reuse for Ellingham Mill and transfer to Holton.
- The core pathway only includes preparatory investment in water resources where we know investment will be needed but do not yet know which investment to carry out; for example, it includes feasibility studies into the North Suffolk reservoir.
- We deliver WINEP requirements.
- We deliver Storm Overflow Discharge Reduction Plan requirements.
- We increase investment to deliver a 60% reduction in internal and external sewer flooding by 2050.
- We increase asset health monitoring and capital maintenance expenditure from 2030 by 40% relative to 2020-25.
- We achieve net-zero company emissions by 2050.
- We deliver our lead replacement plan by 2050.
- Technological progress: 0.8% productivity improvement per year.

### Long-term outcomes

- We expect we would deliver all our outcomes until 2030 under this scenario. We will reach several decision points in 2027 when we will need to decide which water resource options are required to ensure sustainable water supplies. Therefore, under the core scenario we would not expect to deliver resilience to 1 in 500-year drought for all customers without further investment. We would expect to deliver all other long-term targets.
- We risk not being able to foresee every required future intervention at present as some events are unforeseeable, for example, Covid-19. We do not consider it would be prudent to include investments for very unlikely events in our core pathway as there is a strong chance that the investment would be ‘regrettable’.

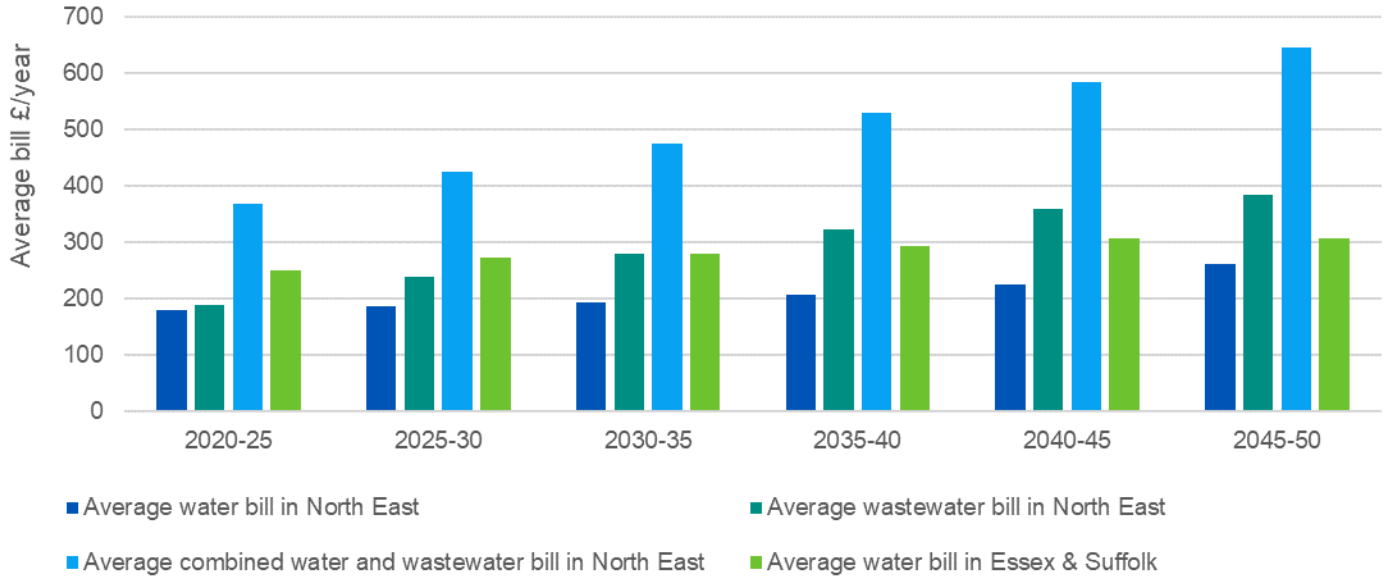
FIGURE 1: CORE PATHWAY TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)




## Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 72% by 2050. This could be 1.3% to 2.7% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 23% by 2050. This would be 0.4% to 1.1% of average incomes in the South East.
- This scenario would result in lower variation in changes in water bills in Essex and Suffolk. This is in line with current customer preferences. However, customers in the North East would still see significant variation in bill increases.

FIGURE 2: CORE PATHWAY AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)




## Alternative pathways

The remainder of this annex covers our alternative pathways. We consider the key assumptions that differ to the core scenario, the differences that arise because of these assumptions, the adaptation required and alternative pathways followed as a result and the impact on long-term outcomes and customers.

These scenarios include investments which would be low/no regret in future if the assumptions set out for the scenario come to pass, not just for 2025-30. These scenarios therefore include more investment than the core pathway.

## Water resource investments

One of the main variations between the core pathway and the alternatives is the water resources investment choices that are made. The water resource investments for each scenario are discussed in our WRMPs. The investments for each of the common reference scenarios are set out in Table 6. To manage our financing requirements, we will aim to deliver large water resource schemes through DPC wherever possible, as explored in supporting document **A6-01 'Assessment of projects for DPC eligibility at PR24'** (NES38).

TABLE 6: WATER RESOURCE INVESTMENTS UNDER PLAUSIBLE FUTURES SCENARIOS

| Plausible futures scenarios / alternative pathways | Sustainable future | Climate failure | Regional growth | Environmental challenges | Technological advance |
|---|---|---|---|---|---|
| Equivalent WRMP pathway | North Suffolk reservoir | High PCC | Habitats Regulations SR | Best environment | Central plan (least cost and BVP) |
| Langford UV | Active | Active | Active | Active | Active |
| Langham nitrate | Active | Active | Active | Active | Active |
| Langford nitrate | Active | Active | Active | Active | Active |
| Langford clarifier and Abberton raw water pumping station | Active | Active | Active | Active | Active |
| Linford new Water treatment works | Active | Active | Active | Active | Active |
| Southend reuse phase A and transfer | | Active | | | |
| Southend Water reuse and transfer | | | | Active | |
| Canvey Island desalination and transfer | | | | Active | |
| Barsham water treatment works and Saxmundham Tower upgrades | Active | Active | Active | Active | Active |
| Transfer from Holton water treatment works to Eye Airfield | Active | Active | Active | Active | Active |
| Bungay to Barsham water treatment works pipeline | Active | Active | Active | Active | Active |
| Barsham nitrate scheme | Active | Active | Active | Active | Active |
| Corton desalination infiltration gallery and transfer | | | | | |
| Corton desalination beach well and transfer | | Active | | Active | |
| Lowestoft water reuse for Ellingham Mill and transfer Holton | | Active | Active | Active | Active |
| California Caister Desalination IG and transfer Caister tower | | | | | |
| North Suffolk winter storage 3500 and transfer | Active | | Active | | |
| Caister water resuse and Ormesby transfer | Active | Active | Active | Active | |
| North Suffolk winter storage 7500 and transfer | | | | | Active |

We make the following assumptions for WRMP Essex & Suffolk (ESW). For Northumbrian Water (NW) varying scenario assumptions does not change the actions we take.

TABLE 7: OTHER WATER DEMAND / SUPPLY ASUMPTIONS UNDER PLAUSIBLE FUTURES SCENARIOS

| Plausible futures scenarios / alternative pathways | Sustainable future | Climate failure | Regional growth | Environmental challenges | Technological advance |
|---|---|---|---|---|---|
| **Equivalent WRMP pathway** | **North Suffolk reservoir** | **High PCC** | **Habitats Regulations SR** | **Best environment** | **Central plan (least cost and BVP)** |
| Leakage reduction | NE: 55% ESW: 40% | NE: 55% ESW: 40% | NE: 55% ESW: 40% | NE: 55% ESW: 50%* | NE: 55% ESW: 40% |
| Metering | ESW WRMP option 5: high – compulsory | | | | |
| Water efficiency – household | Medium enhanced | Low | Medium enhanced | Medium enhanced | Medium enhanced |
| Water efficiency – non-household reduction | 9% | 2% | 9% | 9% | 9% |
| Growth data source | Local authority data | | | | |
| Government led interventions included | Yes | | | | |
| Supply forecast | Scenario forecasts | | | | |
| Environmental destination scenario | BAU+ | BAU+ | BAU+ | Enhanced | BAU+ |
| Sustainability reductions start | As expected | | Reg 19/64 derogation to 2031/32 | As expected | |
| New non-household demand profile | New non-household delayed to 2031/32 in Hartismere | | | | |

* In these scenarios we assume a leakage reduction of 50% in Essex and Suffolk; however, we do not consider that this deliverable / cost effective.

For definitions, please see our ESW WRMP.

## Sustainable future scenario

**In this future, strong action positively affects climate change including through rapid improvements in green technology and innovation.**

Sustainability becomes more important to our customers and the wider public. Climate change is also under control – extreme weather is minimised, and we expect global temperature rises to stay well below 2 degrees.

In this future, the trend of urbanization continues across the UK. However, its impact on the water sector is mitigated by changing attitudes towards water usage and government legislation on sustainability-focused decision making. From a regulatory perspective, water companies have a stronger mandate for action, driven by public preferences.

Changing attitudes towards water usage results in behavioural and demand side consumption reductions which allows us to be more efficient relative to other scenarios where there is a need to build more water supplies.

Customer expectations on environmental protection are increasing meaning the UK government brings forward the requirement to deliver our storm overflows programme to finish in 2040.

As such, customers experience environmental benefits such as improved river water quality sooner relative to future scenarios where the storm overflows programme is not accelerated.

Considerable climate finance investment is put into technology innovation which is rapidly taken up across the UK and across the water sector. This enables us to find cost efficient solutions to address environmental issues such as micro-plastics. Customers experience greater environmental benefits such as improved river water quality. They also experience those benefits sooner relative to future scenarios where there is less innovation and technological growth.

Early in the period there is a rapid improvement in economic conditions due to the influx of investment and the creation of new jobs, but this levels off later in the period as the UK has reached a stable point in the green transition which leads to steady growth.

Improvements in technology and innovation mean we are more likely to find cost-efficient solutions which partially offset expected bill increases and reduce expenditure. Improvements in economic conditions mean customers may be in a better financial position to afford bill increases relative to other scenarios.

### Key assumptions - differences from core pathway

- It is possible to deliver the North Suffolk reservoir in advance of the Lowestoft water reuse scheme, which delivers more environmental benefits in the near term – we follow the ESW WRMP ‘North Suffolk reservoir’ pathway. We avoid the need for investment in Canvey Island desalination plant and the Southend reuse scheme. This scenario aligns with the WRMP North Suffolk reservoir scenario.
- We provide a 140Ml/d transfer to Yorkshire Water.
- Other WRMP assumptions for ESW as specified in Table 7.
- There is widespread social and political support for increasing spending to alleviate environmental issues.
- There is global commitment and action to achieve Net zero.
- Technological progress faster than core pathway: 1.1% productivity improvement per year.

### Adaptation under the scenario: decision and trigger points

TABLE 8: SUSTAINABLE FUTURE DECISION AND TRIGGER POINTS

| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| 1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir | 1C: North Suffolk winter storage (3500) reservoir built. | 2027 | 2036 |
| 2. The need for Southend water re-use plant | 2A: Southend water reuse not built. | 2027 | |
| 3. The need for Canvey Island de-salination plant | 3A: Canvey Island de-salination plant not built. | 2027 | |
| 4. The need for other water supply, transfer and demand-side options | See Annex 2: Plausible futures scenario analysis - Table 6: Water resource investments under plausible futures scenarios | 2024-46 | 2027-46 |
| 5. The impact of new demand on Teesside | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |
| 6. A potential trade of raw water from Kielder reservoir | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| 7. Speed of delivering storm overflow programme and scale of surface water separation | 7Bii: DWMP alternative pathway 1 – accelerated storm overflows pathway – addressed by 2040. Lower costs to deliver sewer flooding reductions through surface water separation due to lower outturn climate change impacts (RCP2.6) – (DWMP adaptive pathway 4). | 2024, 2028 | 2026, 2030 |
| 8. Future environmental challenges | 8B: WINEP spend from 2030/31 falls to 40% of 2025-30 average with an additional investment from 2031 to address anti-microbial resistance and persistent organic pollutants. | 2027 | 2031 |
| 9. Potential for a technology step change | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| 10. Reduction in storm overflow discharge reduction costs from monitoring data | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | |
| 11. The need for investment in sludge incineration | 11C: Invest in bioresources cake storage barn in 2025-30 and high quality dewatering with additional 50% cake storage capacity in 2030-35, incinerator constructed by 2040 (with 10 year lead time) and alternative solutions implemented from 2045. | 2026 | 2030 |
| 12. Level of sustainable long-term capital maintenance expenditure | 12B: Increase of 80% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| 13. Timing of Net zero investment | 13B: Accelerated decarbonisation delivering Net zero before 2050. | 2028 | 2030 |
| 14. Timing of lead replacement | 14A: All lead replaced by 2050. | 2033 | 2035 |

## Sensitivity of the core pathway to the scenario

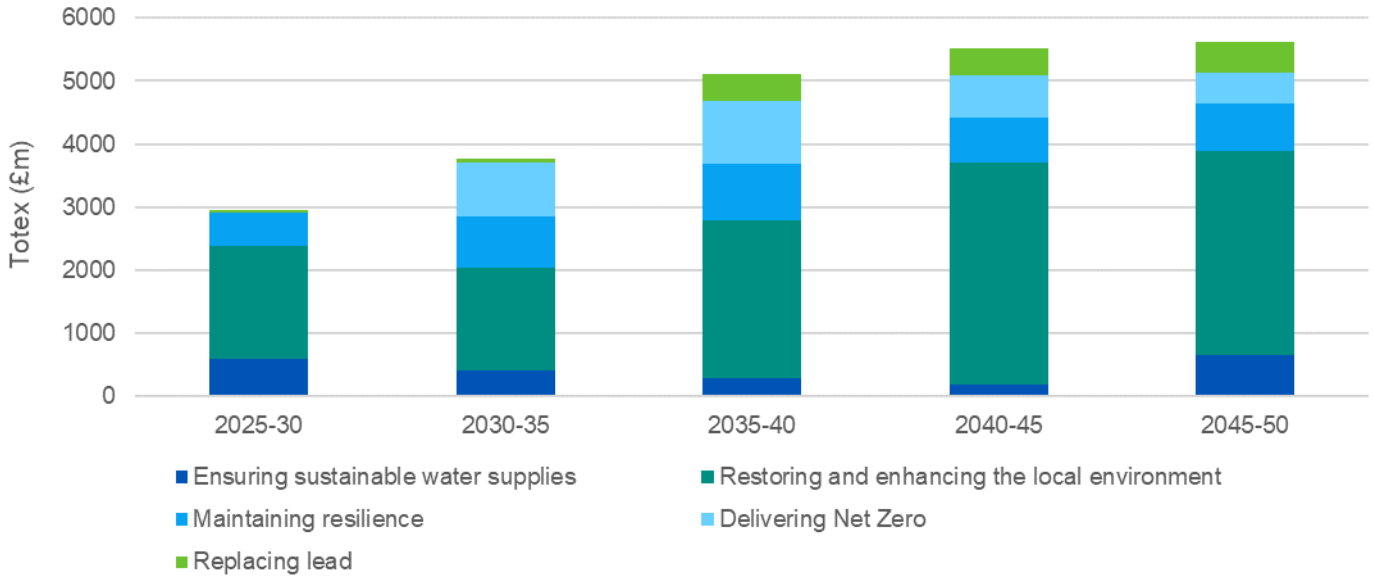
- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies.
- Customers experience greater environmental benefits. In particular, river quality improves more rapidly.
- It is possible to deliver the North Suffolk reservoir in advance of the Lowestoft water reuse scheme, which delivers more environmental benefits in the near term.
- The need to build additional water supplies is minimised due to demand-side reductions.
- Bill increases are partially offset by improvements in innovation and technology.
- Improvements in economic conditions mean customers are in a better position to afford bills increases.
- Bills and expenditure are higher due to greater investment in interventions.

- Increased investment drives even greater ramp up in supply chain partners.
- Political and social support for environmental investment may provide greater opportunities for us to increase partnership funding and generate additional revenue by providing ecosystem services.

### Long-term outcomes

- We expect we would deliver all our long-term targets under this scenario.
- As global action is taken to protect the environment, delivery of net zero targets and other targets affected by climate change, such as water supply resilience, are at lower risk.

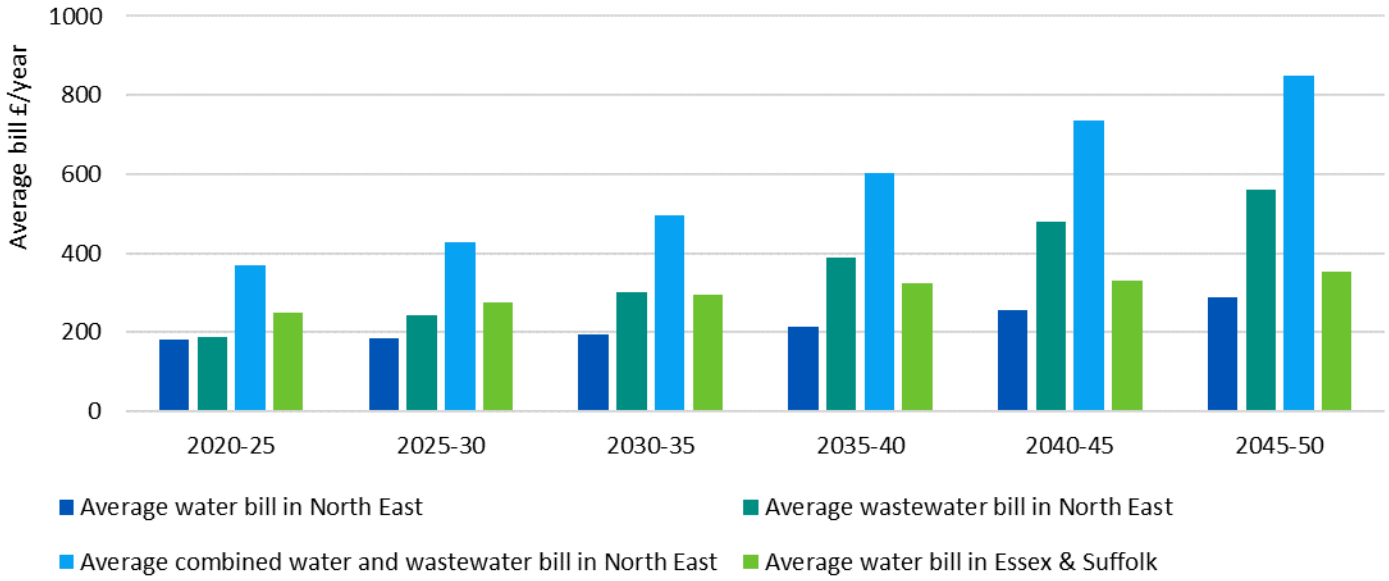
**FIGURE 3: SUSTAINABLE FUTURE TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)**




### Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 131% by 2050. This could be 1.7% to 3.6% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 42% by 2050. This would be 0.5% to 1.3% of average incomes in the South East.
- This scenario would result in lower variation in changes in combined bills in the North East and water bills in Essex and Suffolk. This is in line with current customer preferences. However, single service customers in the North East would still see significant variation in bill increases.

FIGURE 4: SUSTAINABLE FUTURE AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)




## Climate failure scenario

**This future sees high climate change impacts in part driven by a lack of effective global climate action.**

The UK is behind on carbon targets, there is continued reliance on existing technology, and sustainability is given less priority in society. This means we need additional water supplies and expenditure on climate change adaptation, and little progress is made on cost efficiency through technology innovation.

A lack of meaningful action has resulted in a trajectory towards four degrees of global warming by the end of the century. The North East and Essex and Suffolk regions see significant changes in weather with increased rainfall intensity and longer periods of drought, the latter more prevalent in Essex and Suffolk.

Although the period starts with a time of high growth, due to this being prioritised over environmental outcomes, economic conditions quickly decline putting significant pressures on the disposable incomes of customers. This pressure leads to further disregard of the environment and sustainability and as such, customer demand for water increases as consumption reduction is not a priority.

The priority for growth over environmental outcomes within legislation was accompanied by greater regulatory intervention that limited the response of water companies to the impacts of climate change.

This means there was a lower uptake of green and blue infrastructure and less focus on asset health. Solutions remain conventional or outdated with limited innovation, leading to more expensive solutions. The

lack of technological progress means no solutions are developed to eliminate micropollutants. The cost of investment has also increased, largely due to the regulatory burden.

To compensate for customers not decreasing their consumption, investment is required to ensure sustainable abstraction from our water resources. This investment is made more expensive by slow technological growth and low innovation.

However, the appetite to invest in interventions that improve the environment is low, which means not investing in eliminating micro-pollutants which reduces the totex spend compared to other scenarios.

### Key assumptions - differences from core pathway

- We build the Lowestoft water-reuse scheme in advance of the North Suffolk reservoir (but we avoid investment in Canvey Island desalination plant). We build phase A of the Southend water reuse scheme.
- We provide a 140Ml/d transfer to Yorkshire Water.
- Household and business customers are less focussed on environmental issues and so we do not see sufficient behaviour change to reduce demand – this scenario aligns with the WRMP high PCC scenario.
- Economy performs less well than in other scenarios, resulting in greater affordability issues for customers and so a reduced appetite from policy makers to invest in addressing environmental issues and increase resilience.
- Less focus on the environment in wider society makes reducing consumption less of a priority for customers.
- Technological progress slower than core pathway: 0.3% productivity improvement per year.

### Adaptation under the scenario: decision and trigger points

**TABLE 9: CLIMATE FAILURE DECISION AND TRIGGER POINTS**

| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| **1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir** | 1B: Lowestoft water reuse built. | 2027 | 2028 |
| **2. The need for Southend water re-use plant** | 2B: Southend water reuse phase A built. | 2027 | 2031 |
| **3. The need for Canvey Island de-salination plant** | 3A: Canvey Island de-salination plant not built. | 2027 | |
| **4. The need for other water supply, transfer and demand-side options** | See Annex 2: Plausible futures scenario analysis - Table 6: Water resource investments under plausible futures scenarios | 2024-46 | 2027-46 |
| **5. The impact of new demand on Teesside** | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |
| **6. A potential trade of raw water from Kielder reservoir** | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |

| | | | |
|---|---|---|---|
| **7. Speed of delivering storm overflow programme and scale of surface water separation** | 7A: DWMP preferred pathway – storm overflows addressed by 2050, bathing water sites prioritised. | 2024 | 2026 |
| **8. Future environmental challenges** | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2032 |
| **9. Potential for a technology step change** | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| **10. Reduction in storm overflow discharge reduction costs from monitoring data** | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | |
| **11. The need for investment in sludge incineration** | 11B: Invest in bioresources cake storage barn in 2025-30 and high quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| **12. Level of sustainable long-term capital maintenance expenditure** | 12A: Increase of 40% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| **13. Timing of Net zero investment** | 13C: Delayed decarbonisation delivering Net zero after 2050. | 2028 | 2030 |
| **14. Timing of lead replacement** | 14B: All lead replaced by 2075. | 2033 | 2035 |

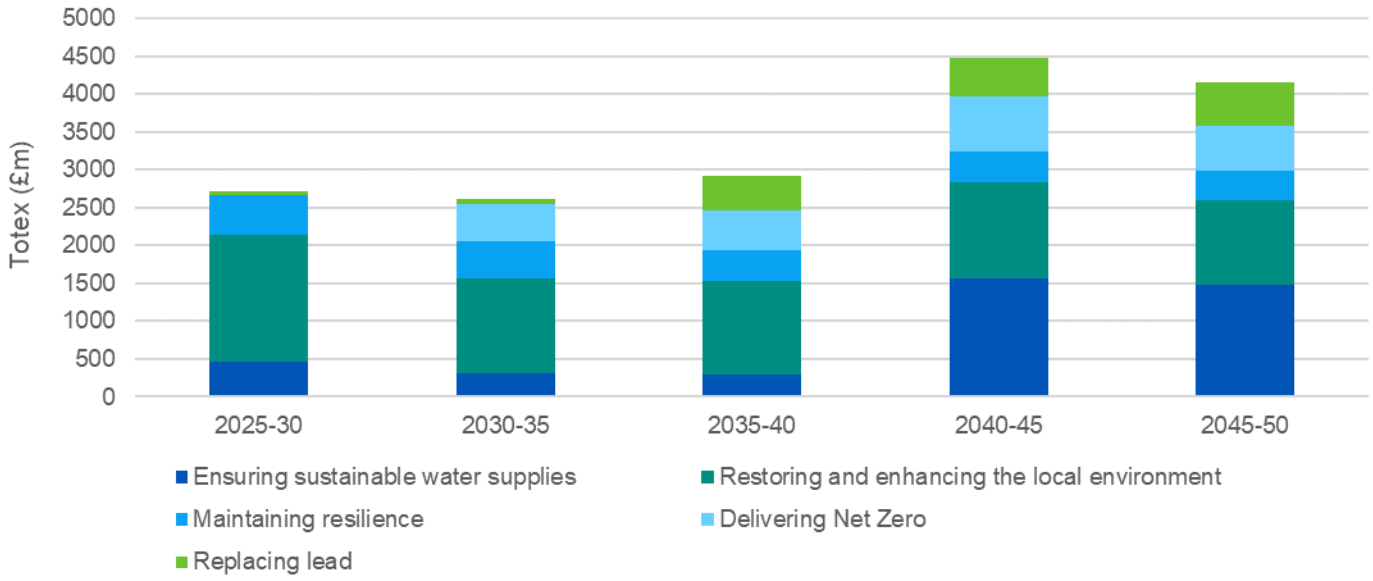
## Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies.
- Policy focuses on minimising bill increases over addressing environmental expenditure, but significant investment still required by law.
- Customers experience lower environmental benefits.
- Deterioration in economic conditions mean more customers suffer from affordability issues.
- Investment requirements are lower than some other scenarios, and other opportunities for investment are more limited in weaker economy, so securing capital for investment is easier.

## Long-term outcomes

- The failure of the climate will lead to deteriorating conditions for customers and the environment, further exaggerating problems and requirements for investment in the future.
- The risk to water supply is increased as climate conditions deteriorate. This is exacerbated by a relatively low level of investment in capital maintenance. Most of our long-term outcomes will be at greater risk of not meeting our long-term targets.
- We do not meet our long-term targets for PCC or non-household demand.
- We do not deliver our Net zero targets in this scenario.
- We delay investment in lead replacement and so we do not deliver our ambition to eliminate the risk to human health from lead until 2075.

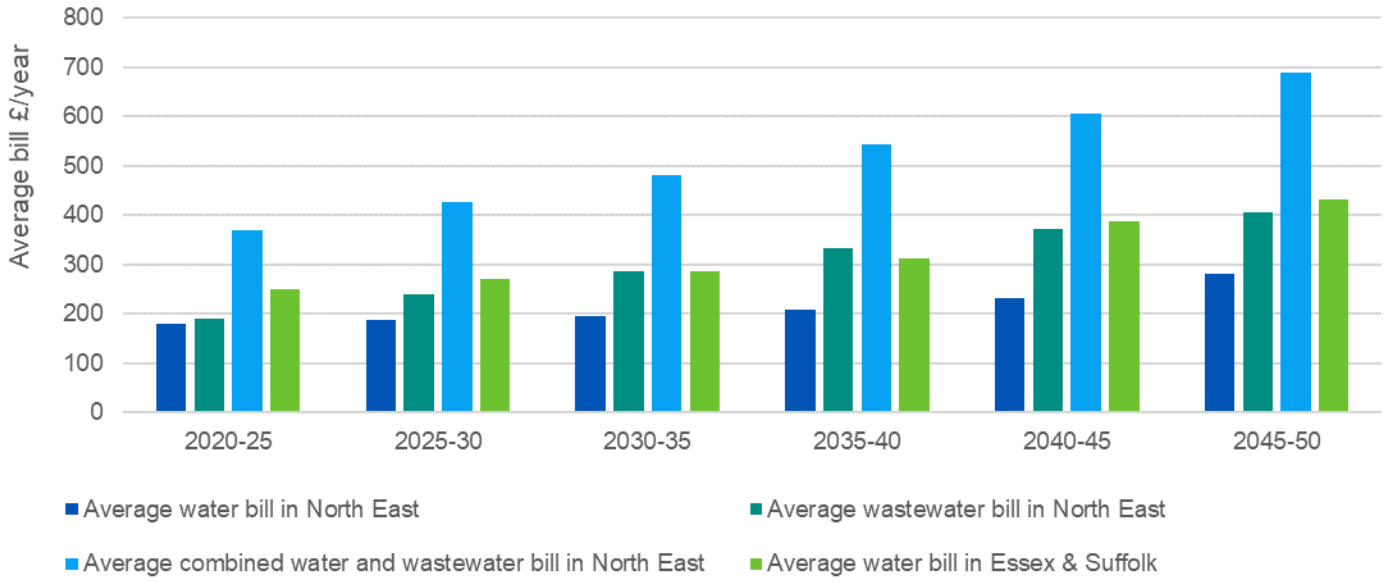
FIGURE 5: CLIMATE FAILURE TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)




## Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 85% by 2050. This could be 1.4% to 2.9% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 78% by 2050. This would be 0.6% to 1.6% of average incomes in the South East.
- This scenario would result in low variation in changes in combined bills in the North East. This is in line with current customer preferences. However, single service customers in the North East and water customers in Essex and Suffolk would see significant variation in bill increases.
- In the Essex and Suffolk, this scenario is the most expensive, due to required investments in water resources including the Canvey Island desalination plant, and results in the highest bill increases, putting the most pressure on lower income customers.
- Deteriorating economic conditions leave more customers at risk of being in water poverty.

FIGURE 6: CLIMATE FAILURE AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)




## Regional growth scenario

**In this future, prioritising economic growth over sustainability leads to higher demand, as well as relaxed restrictions on abstraction and bioresources.**

In a future where there is regional growth, the North East and Essex and Suffolk regions see an extended period of economic growth due to more focus on regional government spending and investment. There is greater demand from industrial customers.

Industrial demand growth in the North East reduces the surplus we have available for export, and a reduction in the need for additional supplies in Yorkshire means that WReN conclude we should provide a lower transfer of 100Ml/d to United Utilities.

This growth also leads to an increase in demand in these areas, particularly from industrial customers. This puts increasing pressure on water resources.

However, the political focus on economic growth means that most environmental ambitions have slipped, there are less stringent abstraction and bioresource restrictions. Climate change is on a moderate pathway leading to an increase in weather variability.

Relative to other scenarios, customers experience fewer environmental benefits and may be more exposed to the impacts of climate change due to lower focus on environmental ambitions.

Strong economic growth and prosperity means that customers may be in a better financial position to afford bill increases. If business demand increases its share of water consumption, this may also help to keep household bills lower than they might otherwise be, although we have not modelled this potential impact.

### Key assumptions - differences from core pathway

- We build the Lowestoft water-reuse scheme in advance of the North Suffolk reservoir (but we avoid investment in Canvey Island desalination plant and the Southend reuse scheme). This scenario aligns with the WRMP habitat regulations scenario.
- We provide a 100Ml/d transfer to United Utilities as increased demand in our regions reduces the amount of water available to export, meaning Yorkshire Water finds alternatives.
- Economic conditions are positive in our regions, increasing demand from business especially on Teesside for hydrogen production and other industries.
- Income growth in our regions reduces the impact of bill increases on affordability.
- Increased industrial demand on Teesside.
- Technological progress at same rate as core pathway: 0.8% productivity improvement per year.

### Adaptation under the scenario: decision and trigger points

**TABLE 10: REGIONAL GROWTH DECISION AND TRIGGER POINTS**

| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| **1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir** | 1D: Lowestoft water reuse and North Suffolk winter storage (3500) built. | 2027 | 2028, 2036 |
| **2. The need for Southend water re-use plant** | 2A: Southend water reuse not built. | 2027 | |
| **3. The need for Canvey Island de-salination plant** | 3A: Canvey Island de-salination plant not built. | 2027 | |
| **4. The need for other water supply, transfer and demand-side options** | See Annex 2: Plausible futures scenario analysis - Table 6: Water resource investments under plausible futures scenarios | 2024-46 | 2027-46 |
| **5. The impact of new demand on Teesside** | 5B: Demand on Teesside grows faster than other regional non-household demand. | Annually | Annually |
| **6. A potential trade of raw water from Kielder reservoir** | 6C: 100 Ml/d Kielder reservoir to UU transfer from 2055. | 2044 | 2055 |
| **7. Speed of delivering storm overflow programme and scale of surface water separation** | 7C: DWMP alternative pathway 2 – delayed storm overflows pathway – addressed by 2050, but bathing water improvements delivered later. | 2024 | 2026 |
| **8. Future environmental challenges** | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2031 |
| **9. Potential for a technology step change** | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| **10. Reduction in storm overflow discharge reduction costs from monitoring data** | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | 2030 |

| | | | |
|---|---|---|---|
| **11. The need for investment in sludge incineration** | 11B: Invest in bioresources cake storage barn in 2025-30 and high quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| **12. Level of sustainable long-term capital maintenance expenditure** | 12B: Increase of 80% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| **13. Timing of Net zero investment** | 13A: Central case decarbonisation delivering Net zero by 2050. | 2028 | 2030 |
| **14. Timing of lead replacement** | 14A: All lead replaced by 2050. | 2033 | 2035 |

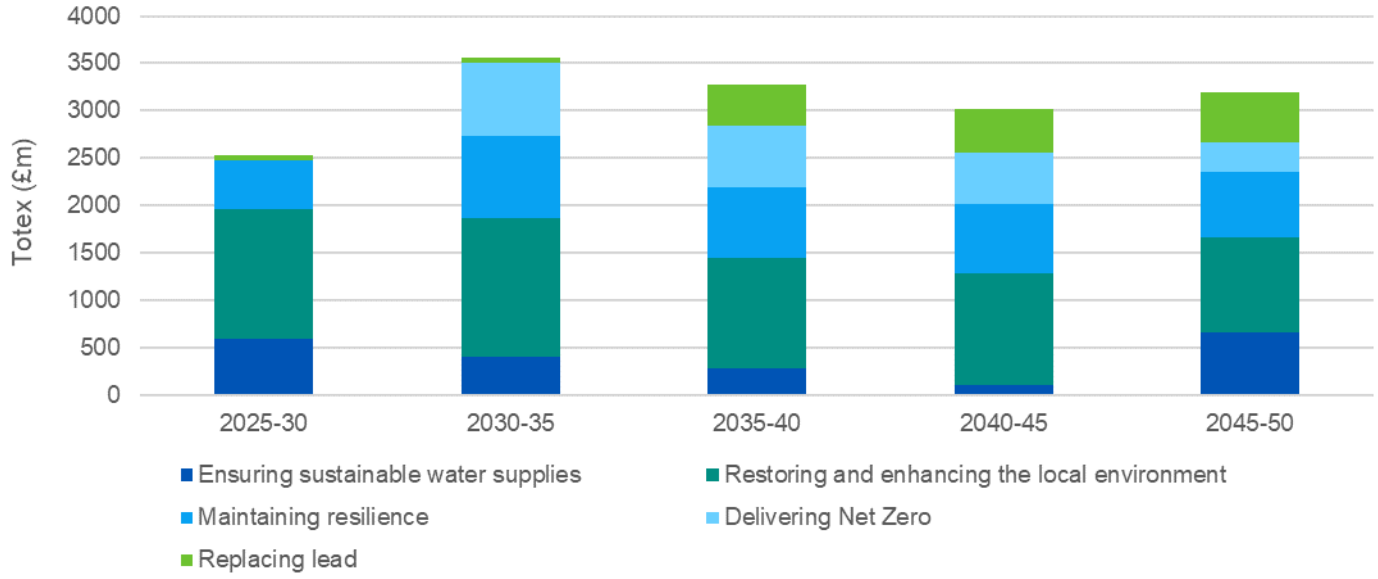
## Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies.
- Increased demand on Teesside does not result in additional investment requirements in the North East, but it does reduce the amount of water available for export and so a lower export to United Utilities is selected with WReN over a larger trade with Yorkshire Water, although this is not needed until after 2050.
- Improvements in economic conditions mean customers are in a better position to afford bills increases.
- Bills and expenditure are higher due to greater investment in interventions.

## Long-term outcomes

- We expect we would deliver all our long-term targets under this scenario except for internal and external sewer flooding where we do not make the required investments.

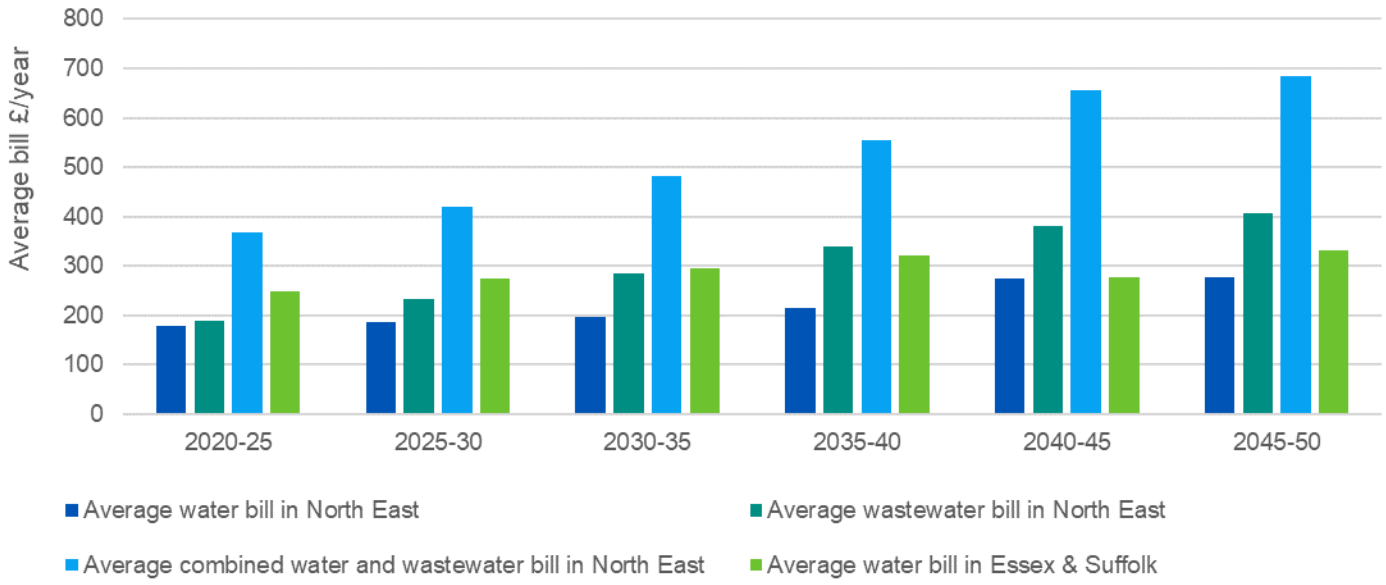
**FIGURE 7: REGIONAL GROWTH TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)**



### Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 83% by 2050. This could be 1.3% to 2.9% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 34% by 2050. This would be 0.5% to 1.2% of average incomes in the South East.
- This scenario would result in significant variation in bill increases for all customers, and very high variation for water only customers.

**FIGURE 8: REGIONAL GROWTH AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)**




## Environmental challenges scenario

**This future sees the need to invest in more advanced wastewater treatment, water treatment, sludge incineration and sewer flooding to align with more stringent environmental legislation.**

Whilst there is increasing pressure to address environmental ambitions, the ability to affordably invest in solutions is limited by slow economic growth and slow technological advancement.

This leads to solutions being more costly to customers in the long term compared to other scenarios e.g. the sustainable future scenario. However, legislation ensures customers benefit from better environmental outcomes such as improvements in water quality.

The need to improve the environmental performance of the network coupled with slower technological progress results in a major increase in capital maintenance expenditure to replace assets that cannot meet tighter environmental requirements.

Water demand in the North East and Essex and Suffolk continues to grow at a moderate level and the impacts of extreme weather are also considered moderate in this scenario. Customers also benefit in this scenario from avoiding the need to build as many water supplies compared to other scenarios. This is in part due to slower economic growth meaning industrial demand does not grow.

This scenario requires significant expenditure increases. This is due to legislation requiring investment in many interventions, coupled with low technology growth and innovation, which reduces our ability to find cost-efficient solutions.

### Key assumptions - differences from core pathway

- The government and society focus on environmental improvements over affordability.
- Economic conditions deteriorate, increasing affordability pressures for customers, but reducing the pressure on supply chains.
- We build the Lowestoft water-reuse scheme and need to investment in the Canvey Island desalination plant and the Southend reuse scheme. This scenario aligns with the WRMP best environment plan.
- We provide a 140Ml/d transfer to Yorkshire Water.
- We are required to accelerate investments to reduce discharges from storm overflows.
- We increase investment on addressing environmental issues such as persistent organic pollutants.
- Technological progress slower than core pathway: 0.3% productivity improvement per year.

### Adaptation under the scenario: decision and trigger points

**TABLE 11: ENVIRONMENTAL CHALLENGES DECISION AND TRIGGER POINTS**

| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| **1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir** | 1B: Lowestoft water reuse built. | 2027 | 2028 |
| **2. The need for Southend water re-use plant** | 2C: Southend water reuse complete project built. | 2027 | 2031 |
| **3. The need for Canvey Island de-salination plant** | 3B: Canvey Island de-salination plant built. | 2027 | 2031 |
| **4. The need for other water supply, transfer and demand-side options** | See Annex 2: Plausible futures scenario analysis - Table 6: Water resource investments under plausible futures scenarios | 2024-46 | 2027-46 |
| **5. The impact of new demand on Teesside** | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |

| | | | |
|---|---|---|---|
| **6. A potential trade of raw water from Kielder reservoir** | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| **7. Speed of delivering storm overflow programme and scale of surface water separation** | 7Bi: DWMP alternative pathway 1 – accelerated storm overflows pathway – addressed by 2040. Higher outturn climate change impacts (RCP8.5) no additional impact on costs – (DWMP adaptive pathway 3). | 2024, 2028 | 2026, 2030 |
| **8. Future environmental challenges** | 8B: WINEP spend from 2030/31 falls to 40% of 2025-30 average with an additional investment from 2031 to address anti-microbial resistance and persistent organic pollutants. | 2027 | 2031 |
| **9. Potential for a technology step change** | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| **10. Reduction in storm overflow discharge reduction costs from monitoring data** | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | 2030 |
| **11. The need for investment in sludge incineration** | 11C: Invest in bioresources cake storage barn in 2025-30 and high quality dewatering with additional 50% cake storage capacity in 2030-35, incinerator constructed by 2040 (with 10 year lead time) and alternative solutions implemented from 2045. | 2026 | 2030 |
| **12. Level of sustainable long-term capital maintenance expenditure** | 12C: Increase of 123% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| **13. Timing of Net zero investment** | 13A: Central case decarbonisation delivering Net zero by 2050. | 2028 | 2030 |
| **14. Timing of lead replacement** | 14A: All lead replaced by 2050. | 2033 | 2035 |

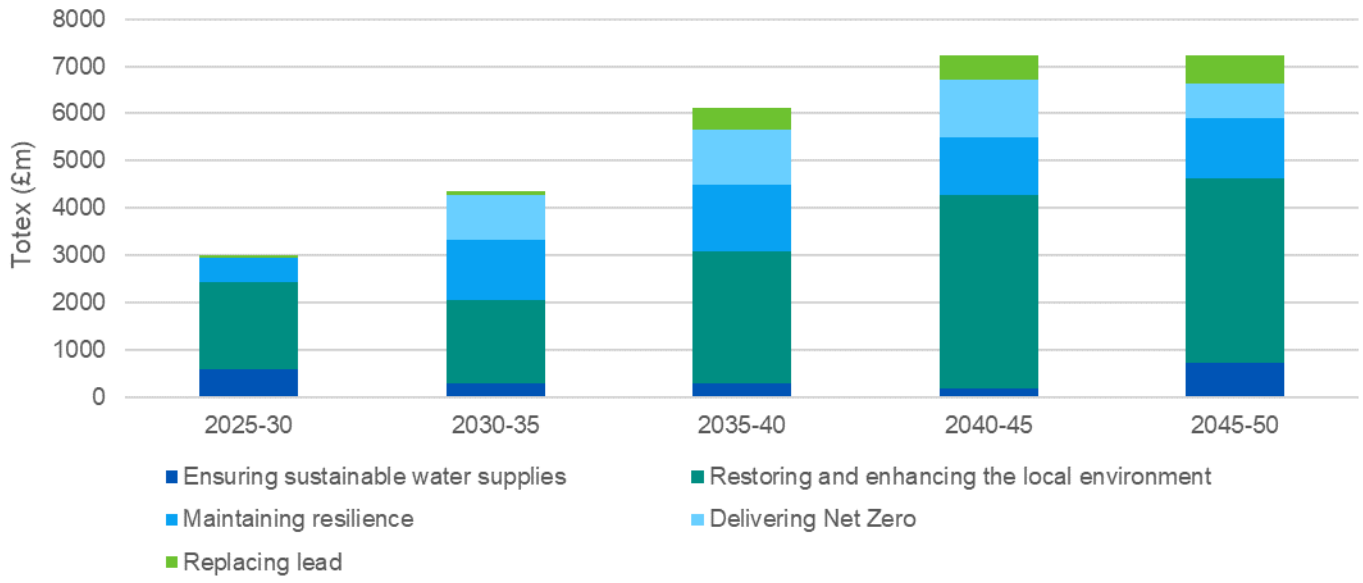
## Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies.
- Legislation ensures greater environmental benefits for customers.
- Customers experience greater environmental benefits.
- Customers experience environmental benefits sooner.
- Bills and expenditure are higher due to greater investment in interventions.

## Long-term outcomes

- We expect we would deliver all of our long-term targets under this scenario except for internal and external sewer flooding where we do not make the required investments.
- Demand reduction outcomes may be more at risk due to increased business growth and employment in our regions.
- Although customers support environmental investment, slower technological progress combined with the realisation of more environmental issues, such as from microplastics, antimicrobial resistance and persistent organic pollutants means that our long-term target to have leading levels of water quality in the natural environment may be more at risk.

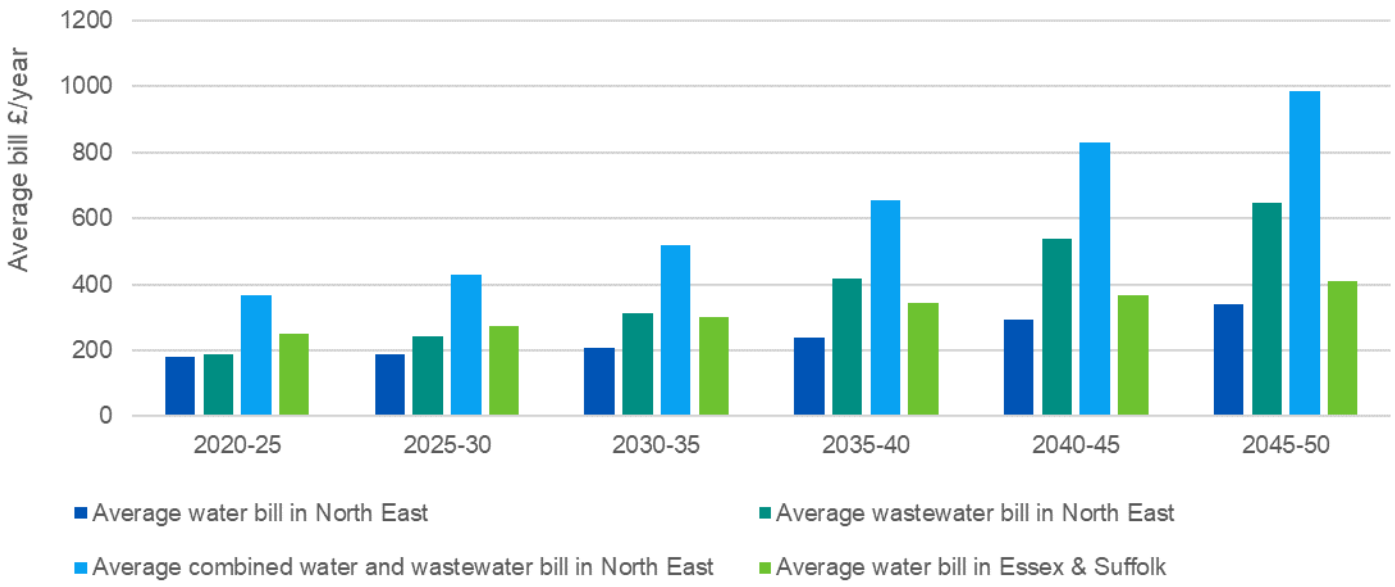
FIGURE 9: ENVIRONMENTAL CHALLENGES TOTAL EXPENDITURE (TOTEX) 2025-50 (22/23 PRICES)




## Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 171% by 2050. This could be 2.0% to 4.3% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 67% by 2050. This would be 0.6% to 1.5% of average incomes in the South East.
- This scenario would result in lower variation in changes in water bills in Essex and Suffolk. This is in line with current customer preferences. However, all customers in the North East would see significant variation in bill increases.
- In the North East, this scenario is the most expensive and results in the highest bill increases, putting the most pressure on lower income customers.

FIGURE 10: ENVIRONMENTAL CHALLENGES AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)




## Technological advance

**This future considers how a step change in technologies such as AI could reduce costs and improve service.**

This scenario is characterised by rapid technology uptake and high levels of innovation across the economy.

Market freedom combined with effective and rapidly evolving product and cyber security regulation rapidly increase technology use due to the perceived economic benefits. This creates an environment of sustained, stable economic growth. This economic security allows citizens to prioritise environmental improvements, and new technologies allow greater use of green/blue technologies.

Government funding and incentives result in widespread application of a systems thinking approach to infrastructure investment. Asset health investment is a priority across the water sector and is supported by advances in asset health monitoring and data science that enable us to more efficiently maintain our assets.

Our regions experience strong growth. As technology supports higher levels of home working demand increases in Essex and Suffolk so we need to invest in more water resources, although this is tempered by the improved water efficiency of domestic and commercial appliances. In the North East the Teesside Hydrogen Hub develops as a major industry, and creates additional water demand. However, we can still meet this

demand through existing water resources and have sufficient spare capacity to supply Yorkshire Water 140Ml/d from 2040.

A proactive approach to supporting technological solutions through changes to product regulations ensures environmental benefits of technology are realised rapidly. For example, microplastic filters are developed and required on commercial and domestic appliances, enabling bioresources to continue to be safely spread to land.

Innovations in AI enable a step change reduction in our costs in the mid-2030s, coupled with rapid technology growth across the economy, which increases our ability to find cost-efficient solutions. This is offset to some extent by increasing costs of cyber-security also driven by AI.

### Key assumptions - differences from core pathway

- We build the North Suffolk reservoir, in advance of the Lowestoft water-reuse scheme (but we avoid investment in Canvey Island desalination plant and the Southend reuse scheme). This scenario aligns with the WRMP central plan, least cost and best value plans.
- We provide a 140Ml/d transfer to Yorkshire Water.
- We investment is required to address environmental issues such as persistent organic pollutants.
- Smart water supply network by 2035:
    - automatic detection of potential leaks; and
    - robust real-time asset condition information – including telemetry, robotic and drone inspection – enabling a risk-based maintenance approach across the business.
- Full smart meter penetration by 2035.
- New wastewater approach by 2040:
    - monitoring and advance forecasting of localised surface water rainfall and related pollution/wastewater stresses, including intelligent sewer technology, enabling rapid response and/or prior action; and
    - automatic monitoring and enhanced sampling of environmental water quality.
- Low-emission heavy goods vehicle (HGVs) and fleet by 2030 and carbon-free baseload electricity by 2035.
- Full open access to datasets across water companies and other utilities, through common data sharing protocols by 2035.
- The whole-life financial cost of low-carbon construction materials equals that of conventional building materials by 2035.
- Increasing reliance on technology produces progressively higher risks of failure and threats from cybercrime, creating possible need for non-digital backups throughout the period to 2050.

- Increased industrial demand on Teesside.
- Technological progress at a higher rate than core pathway: 1.1% productivity improvement per year.

## Adaptation under the scenario: decision and trigger points

**TABLE 12: TECHNOLOGICAL ADVANCE DECISION AND TRIGGER POINTS**

| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| **1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir** | 1E: Lowestoft water reuse and North Suffolk winter storage (7500) built. | 2027 | 2028 (Lowestoft) 2036 (North Suffolk) |
| **2. The need for Southend water re-use plant** | 2A: Southend water reuse not built. | 2027 | |
| **3. The need for Canvey Island de-salination plant** | 3A: Canvey Island de-salination plant not built. | 2027 | |
| **4. The need for other water supply, transfer and demand-side options** | See Annex 2: Plausible futures scenario analysis - Table 6: Water resource investments under plausible futures scenarios | 2024-46 | 2027-46 |
| **5. The impact of new demand on Teesside** | 5B: Demand on Teesside grows faster than other regional non-household demand. | Annually | Annually |
| **6. A potential trade of raw water from Kielder reservoir** | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| **7. Speed of delivering storm overflow programme and scale of surface water separation** | 7A: DWMP preferred pathway – storm overflows addressed by 2050, bathing water sites prioritised. | 2024 | 2026 |
| **8. Future environmental challenges** | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2031 |
| **9. Potential for a technology step change** | 9B: Technological step change in wastewater (5% reduction in wastewater protecting the local environment costs from 2040) and water (resilience) reducing costs, but alongside an increased requirement for investment in cyber security. | 2033 | 2035 |
| **10. Reduction in storm overflow discharge reduction costs from monitoring data** | 10B: Additional reduction in costs from improved storm overflow monitoring data – starting from 2030/31 rising to 10% reduction in costs from 2034/35. | 2030 | 2030 |
| **11. The need for investment in sludge incineration** | 11B: Invest in bioresources cake storage barn in 2025-30 and high quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| **12. Level of sustainable long-term capital maintenance expenditure** | 12A: Increase of 40% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| **13. Timing of Net zero investment** | 13B: Accelerated decarbonisation delivering Net zero before 2050. | 2028 | 2030 |
| **14. Timing of lead replacement** | 14A: All lead replaced by 2050. | 2033 | 2035 |

## Sensitivity of the core pathway to the scenario

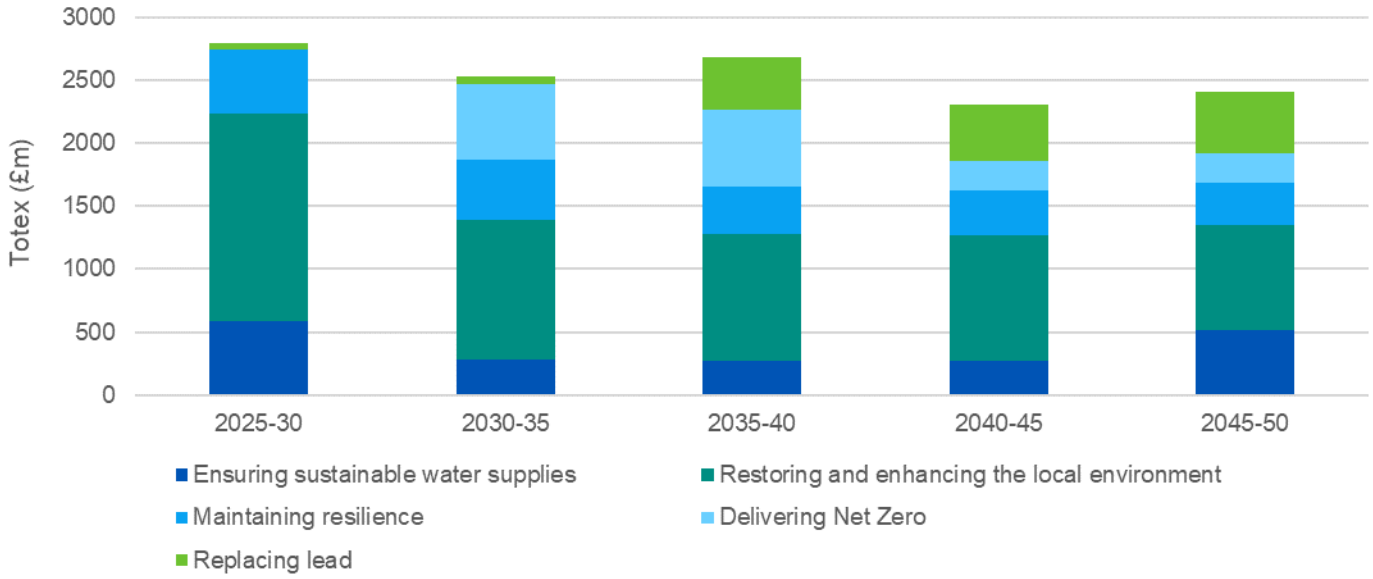
- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies.
- Legislation and technological progress ensures environmental benefits for customers are delivered at a lower cost than in other scenarios.

- Bills and expenditure are lower relative to scenarios that deliver the same benefits and risks due to technological progress.
- The development of AI in this scenario creates opportunities but also cyber security challenges that must be addressed.

### Long-term outcomes

- We expect we would deliver all our long-term targets under this scenario.

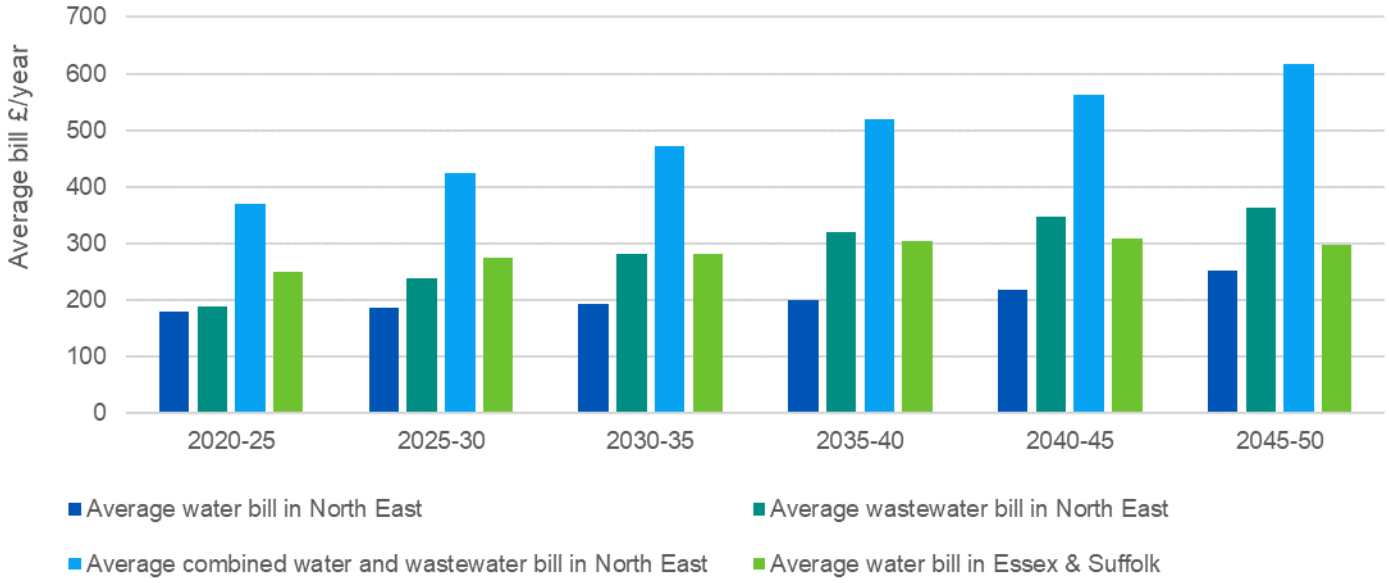
**FIGURE 11: TECHNOLOGICAL ADVANCE TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)**




### Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 64% by 2050. This could be 1.2% to 2.6% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 18% by 2050. This would be 0.4% to 1.1% of average incomes in the South East.
- This scenario would result in lower variation in changes in combined bills in the North East. This is in line with current customer preferences. However, single service customers in the North East and water customers in Essex and Suffolk would see significant variation in bill increases.

FIGURE 12: TECHNOLOGICAL ADVANCE AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)



# 3. ANNEX 3: COMMON REFERENCE SCENARIO ANALYSIS

In this annex we assess the impact of the assumptions set out in Ofwat's common reference scenarios. We consider the key assumptions that differ to the core scenario, the differences that arise because of these assumptions, the adaptation required, and alternative pathways followed as a result and the impact on long-term outcomes and customers.

These scenarios include investments which would be low/no regret in future if the assumptions set out for the scenario come to pass, not just for 2025-30. These scenarios therefore include more investment than the core pathway.

## Water resource investments

One of the main variations between the core pathway and the alternatives is the water resources investment choices that are made. The water resource investments for each scenario are discussed in our WRMPs. The investments over and above those made under the core pathway for each of the common reference scenarios are set out in Table 13. To manage our financing requirements, we will aim to deliver large water resource schemes through DPC wherever possible, as explored in supporting document **A6-01 'Assessment of projects for DPC eligibility at PR24'** (NES38).

**TABLE 13: WATER RESOURCE INVESTMENTS UNDER COMMON REFERENCE SCENARIOS**

| Water resources | High climate change | Low climate change | Slow (Low) technology | Fast (High) technology | High demand | Low demand | High abstraction reductions | Low abstraction reductions |
|---|---|---|---|---|---|---|---|---|
| Langford UV | Active | | Active | | Active | | Active | Active |
| Langham nitrate | Active | | Active | | Active | | Active | Active |
| Langford nitrate | Active | Active | Active | | Active | | Active | Active |
| Langford clarifier and Abberton raw water pumping station | Active | Active | Active | | Active | | Active | Active |
| Linford new Water treatment works | Active | Active | Active | Active | Active | | Active | Active |
| Southend reuse phase A and transfer | Active | | Active | | Active | | | |
| Southend Water reuse and transfer | | | | | | | Active | |
| Canvey Island desalination and transfer | | | | | | | Active | |
| Barsham water treatment works and Saxmundham Tower upgrades | Active | Active | Active | Active | Active | Active | Active | Active |

| Water resources | High climate change | Low climate change | Slow (Low) technology | Fast (High) technology | High demand | Low demand | High abstraction reductions | Low abstraction reductions |
|---|---|---|---|---|---|---|---|---|
| Transfer from Holton water treatment works to Eye Airfield | Active | Active | Active | Active | Active | Active | Active | Active |
| Bungay to Barsham water treatment works pipeline | Active | Active | Active | Active | Active | Active | Active | Active |
| Barsham nitrate scheme | Active | Active | Active | Active | Active | Active | Active | Active |
| Corton desalination infiltration gallery and transfer | Active | Active | | | | | | |
| Corton desalination beach well and transfer | | | | | Active | | Active | |
| Lowestoft water reuse for Ellingham Mill and transfer Holton | Active | Active | Active | | Active | | Active | Active |
| California Caister Desalination IG and transfer Caister tower | | | Active | Active | | Active | | |
| North Suffolk winter storage 3500 and transfer | | | | | | | | |
| Caister water resuse and Ormesby transfer | Active | Active | Active | Active | Active | Active | Active | Active |
| North Suffolk winter storage 7500 and transfer | | | | | | | | |

We make the following assumptions for WRMP ESW. For NW varying scenario assumptions does not change the actions we take.

**TABLE 14: OTHER WATER DEMAND / SUPPLY ASUMPTIONS UNDER COMMON REFERENCE SCENARIOS**

| Common reference scenario | High climate change | Low climate change | Slow technology | Fast technology | High demand | Low demand | High abstraction reductions | Low abstraction reductions |
|---|---|---|---|---|---|---|---|---|
| Leakage reduction | NE: 55% ESW: 40% | NE: 55% ESW: 40% | NE: 55% ESW: 30% | NE: 55% ESW: 50%* | NE: 55% ESW: 30% | NE: 55% ESW: 50%* | NE: 55% ESW: 40% | NE: 55% ESW: 40% |
| Metering | Option 5 - high compulsory | Option 5 - high compulsory | Option 1 - low impact | Option 5 - high compulsory | Option 1 - low impact | Option 5 - high compulsory | Option 5 - high compulsory | Option 5 - high compulsory |
| Water efficiency – household | Medium enhanced | Medium enhanced | Low | High enhanced | Low | High enhanced | Medium enhanced | Medium enhanced |

| Common reference scenario | High climate change | Low climate change | Slow technology | Fast technology | High demand | Low demand | High abstraction reductions | Low abstraction reductions |
|---|---|---|---|---|---|---|---|---|
| Water efficiency – non-household reduction | 9% | 9% | 2% | 9% | 2% | 9% | 9% | 9% |
| Growth data source | Local authority | Local authority | ONS | ONS | Housing need | Local authority | Local authority | Local authority |
| Government led interventions included | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes |
| Supply forecast | RCP8.5 | | RCP2.6 | | | RCP8.5 scaled to RCP6 | | |
| Environmental destination scenario | BAU+ | BAU+ | BAU+ | BAU+ | BAU+ | BAU+ | BAY | Enhanced |
| Sustainability reductions start | When expected to be applied | | | | | | | |
| New non-household demand profile | New non-household delayed to 2031/32 in Hartismere | | | | | | | |

* In these scenarios we assume a leakage reduction of 50% in Essex and Suffolk; however, we do not consider that this deliverable / cost effective.

For definitions, please see our ESW WRMP.

## Climate change

The reference scenarios for climate change are set based on the Representative Concentration Pathways (RCPs) as adopted by the Intergovernmental Panel on Climate Change (IPCC) and the latest UK Climate Projections (UKCP18).[1] [2] The RCPs specify different future concentrations of greenhouse gases to create a wide range of plausible future emissions scenarios.

We use the 50th percentile probability level for each projection. This is because the probability of RCP2.6 and RCP8.5 coming to pass in the future is low but possible. Adding in a much lower or higher probability level to

[1] IPCC, '**Climate Change 2014: Synthesis Report**', November 2014.
[2] Met Office, '**UKCP18 Guidance: Representative Concentration Pathways**', November 2018.

describe the impacts of each scenario would in effect combine two low-probability scenarios into an extreme scenario that is less useful for long-term planning.

## High climate change scenario

### This scenario considers the impact of higher, more adverse, climate change.

#### Key assumptions

- Land: UKCP18 probabilistic projections, RCP8.5, 50th percentile probability level.
- Sea level: UKCP18 marine projections, RCP8.5, 50th percentile probability level.
- Technological progress at the same rate as core pathway: 0.8% productivity improvement per year.

#### Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies.
- Water supplies, particularly in Essex and Suffolk, would be at higher risk due to higher expected variation in rainfall.

#### Adaptation under the scenario: decision and trigger points

**TABLE 15: HIGH CLIMATE CHANGE DECISION AND TRIGGER POINTS**

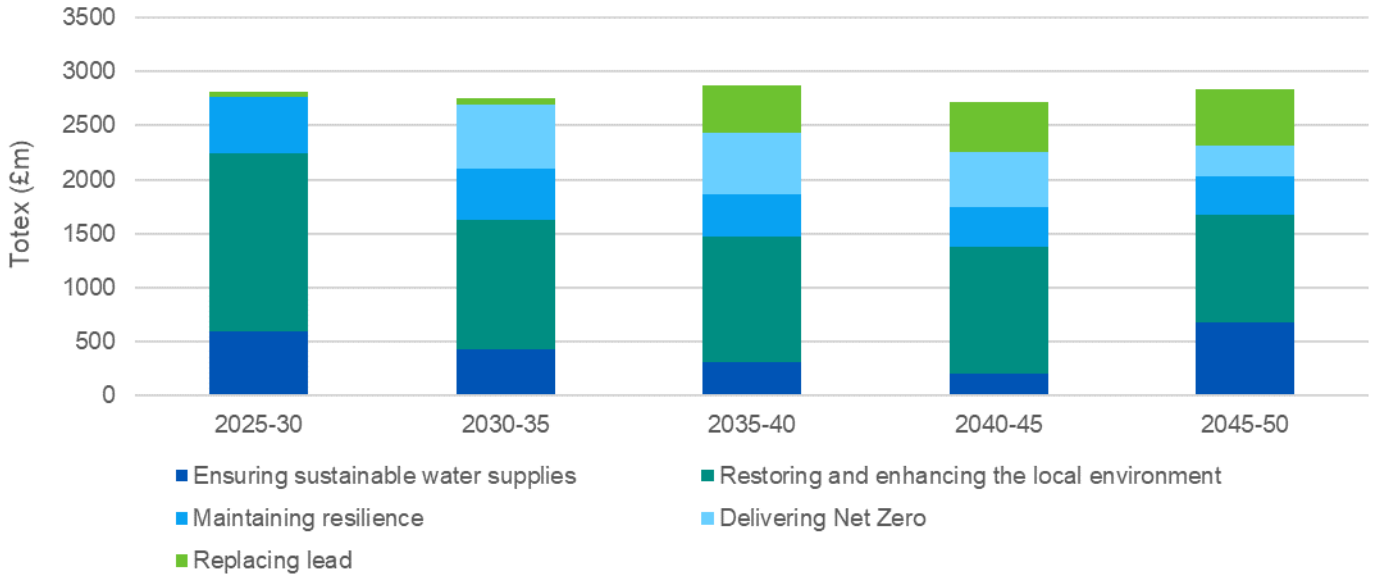
| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| 1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir | 1B: Lowestoft water reuse built. | 2027 | 2028 |
| 2. The need for Southend water re-use plant | 2B: Southend water reuse phase A built. | 2027 | 2031 |
| 3. The need for Canvey Island de-salination plant | 3A: Canvey Island de-salination plant not built. | 2027 | |
| 4. The need for other water supply, transfer and demand-side options | See Annex 3: Common reference scenario analysis - Table 13: Water resource investments under common reference scenarios | 2024-46 | 2027-46 |
| 5. The impact of new demand on Teesside | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |
| 6. A potential trade of raw water from Kielder reservoir | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| 7. Speed of delivering storm overflow programme and scale of surface water separation | 7Ai: DWMP preferred pathway – storm overflows addressed by 2050, bathing water sites prioritised. Higher outturn climate change impacts (RCP8.5) no additional impact on costs – (DWMP adaptive pathway 3). | 2024, 2028 | 2026, 2030 |
| 8. Future environmental challenges | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2031 |
| 9. Potential for a technology step change | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| 10. Reduction in storm overflow discharge reduction costs from monitoring data | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | 2030 |

| | | | |
|---|---|---|---|
| **11. The need for investment in sludge incineration** | 11B: Invest in bioresources cake storage barn in 2025-30 and high quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| **12. Level of sustainable long-term capital maintenance expenditure** | 12A: Increase of 40% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| **13. Timing of Net zero investment** | 13A: Central case decarbonisation delivering Net zero by 2050. | 2028 | 2030 |
| **14. Timing of lead replacement** | 14A: All lead replaced by 2050. | 2033 | 2035 |

## Long-term outcomes

- We expect we would deliver all our long-term targets under this scenario, however delivery of some may be at greater risk.
- Whether long-term targets for net zero would be at greater risk under this scenario would depend on the reason why we have higher climate change – if technology fails to develop to deliver emission reductions or the social climate is such that customers are not willing to pay to reduce emissions and politicians are not able to legislate to require us to invest, then we may not deliver these targets.
- Higher climate change would increase the pressure on the wastewater network. Additional investment would be needed to reach our 60% sewer flooding reduction targets, and our long-term targets for storm overflow discharge reductions would be at greater risk under this scenario.
- The risks to water supply would be mitigated through additional water resources and demand side interventions.

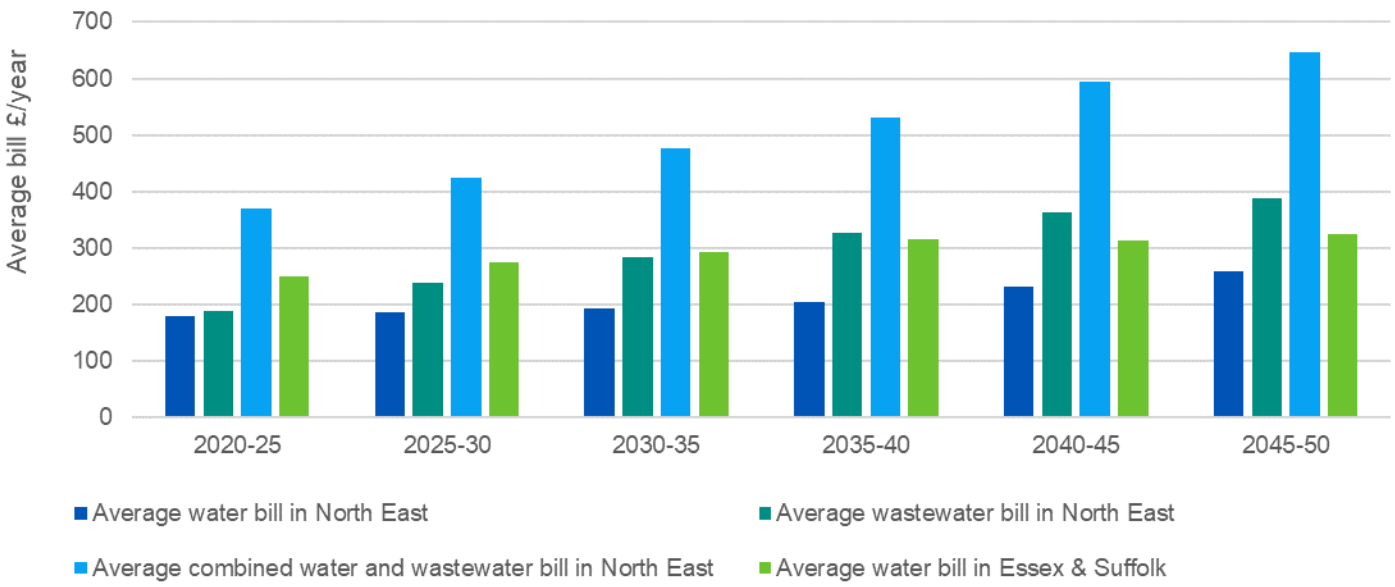
**FIGURE 13: HIGH CLIMATE CHANGE TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)**



### Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 73% by 2050. This could be 1.3% to 2.7% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 30% by 2050. This would be 0.5% to 1.2% of average incomes in the South East.
- This scenario would result in lower variation in changes in combined bills in the North East. This is in line with current customer preferences. However, single service customers in the North East and water customers in Essex and Suffolk would see significant variation in bill increases.
- Climate change impacts may not affect all parts of England equally, and so relative incomes in our regions may differ – meaning that the impact on water poverty may also differ, so this target would be at greater risk.

**FIGURE 14: HIGH CLIMATE CHANGE AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)**




## Low climate change scenario

**This scenario considers the impact of lower, more benign, climate change.**

### Key assumptions

- Land: UKCP18 probabilistic projections, RCP2.6, 50th percentile probability level.
- Sea level: UKCP18 marine projections, RCP2.6, 50th percentile probability level.
- Technological progress at the same rate as core pathway: 0.8% productivity improvement per year.

## Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies.
- Water supplies resilience would be at lower risk than in the core scenario due to lower expected variation in rainfall.

## Adaptation under the scenario: decision and trigger points

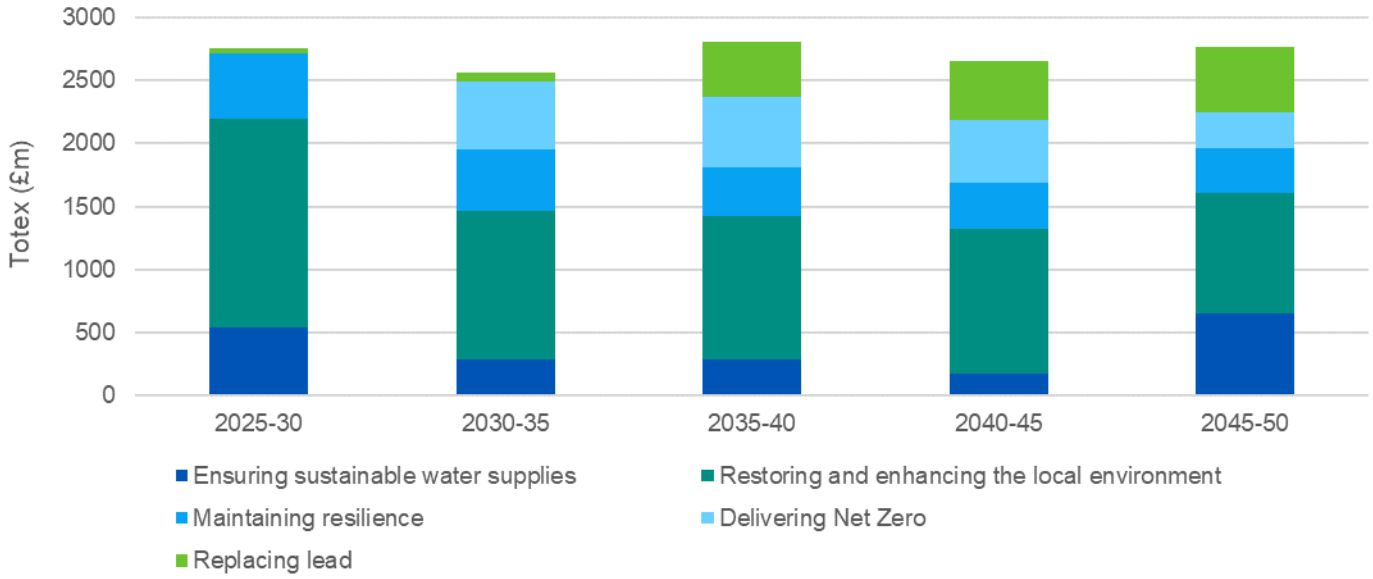
**TABLE 16: LOW CLIMATE CHANGE DECISION AND TRIGGER POINTS**

| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| **1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir** | 1B: Lowestoft water reuse built. | 2027 | 2028 |
| **2. The need for Southend water re-use plant** | 2A: Southend water reuse not built. | 2027 | |
| **3. The need for Canvey Island de-salination plant** | 3A: Canvey Island de-salination plant not built. | 2027 | |
| **4. The need for other water supply, transfer and demand-side options** | See Annex 3: Common reference scenario analysis - Table 13: Water resource investments under common reference scenarios | 2024-46 | 2027-46 |
| **5. The impact of new demand on Teesside** | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |
| **6. A potential trade of raw water from Kielder reservoir** | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| **7. Speed of delivering storm overflow programme and scale of surface water separation** | 7Aii: DWMP preferred pathway – storm overflows addressed by 2050, bathing water sites prioritised. Lower costs to deliver sewer flooding reductions through surface water separation due to lower outturn climate change impacts (RCP2.6) – (DWMP adaptive pathway 4). | 2024, 2028 | 2026, 2030 |
| **8. Future environmental challenges** | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2031 |
| **9. Potential for a technology step change** | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| **10. Reduction in storm overflow discharge reduction costs from monitoring data** | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | 2030 |
| **11. The need for investment in sludge incineration** | 11B: Invest in bioresources cake storage barn in 2025-30 and high quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| **12. Level of sustainable long-term capital maintenance expenditure** | 12A: Increase of 40% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| **13. Timing of Net zero investment** | 13A: Central case decarbonisation delivering Net zero by 2050. | 2028 | 2030 |
| **14. Timing of lead replacement** | 14A: All lead replaced by 2050. | 2033 | 2035 |

## Long-term outcomes

- We expect we would deliver all of our long-term targets under this scenario.
- Long-term targets would not be at greater risk under this scenario.

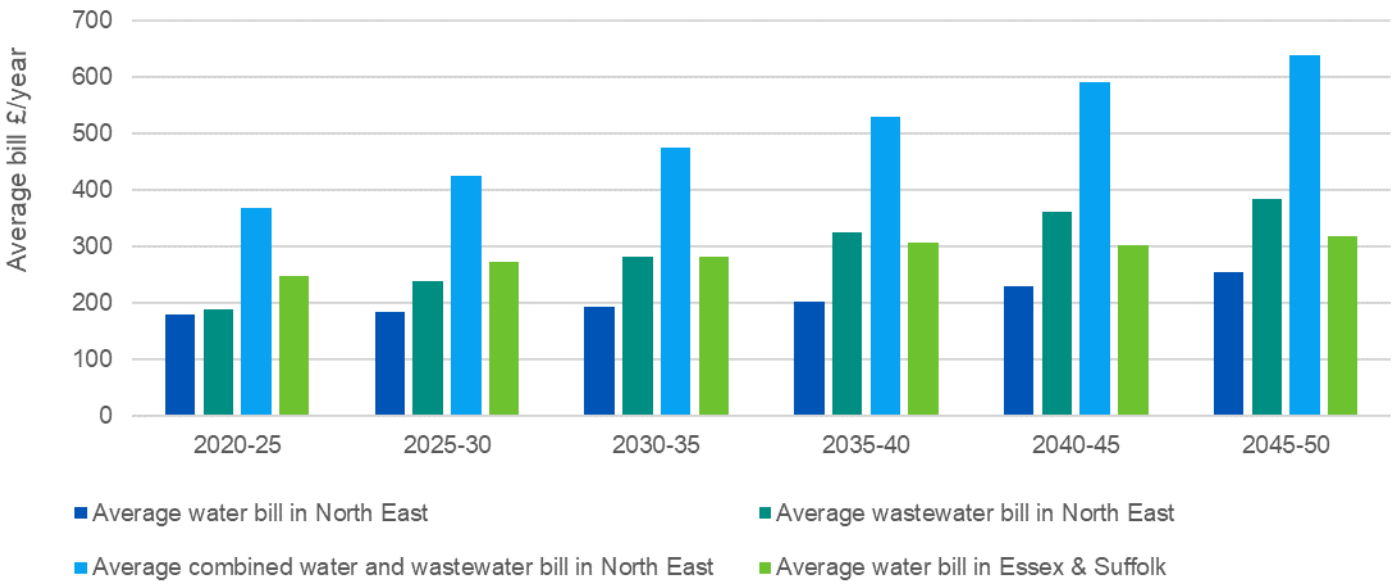
FIGURE 15: LOW CLIMATE CHANGE TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)




## Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 71% by 2050. This could be 1.2% to 2.7% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 28% by 2050. This would be 0.5% to 1.1% of average incomes in the South East.
- This scenario would result in lower variation in changes in combined bills in the North East. This is in line with current customer preferences. However, single service customers in the North East and water customers in Essex and Suffolk would see significant variation in bill increases.

FIGURE 16: LOW CLIMATE CHANGE AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)




## Technology

The costs and availability of key technologies influence the options we can employ to meet our objectives. Technological development and adoption can play a significant role in increasing efficiency by reducing costs and improving outcomes. This has implications for what options should be selected in the short term, given uncertainties around how technologies might develop in future.

We have considered technological progress in two key ways in our modelling. Firstly, we assume that technology will continue to develop and allow us to become more efficient across all our activities every year. In our core scenario we assume we can deliver a stretching but achievable level of 0.8% efficiency improvements every year. But the outturn gains may be higher or lower than this in future, and these scenarios consider this.

Secondly, technology can result in step changes – in cost, performance or both. It is not possible to predict what these game changing technologies might be, but for our scenarios we can make assumptions for illustrative purposes to demonstrate what the impact of these step changes might be.

## Slow technology scenario

**This scenario considers the impact of slower, adverse, technological progress.**

## Key assumptions

- Smart water supply network by 2040:
    - Automatic detection of potential leaks.
    - Robust real-time asset condition information – including telemetry, robotic and drone inspection – enabling a risk-based maintenance approach across the business.
- Full smart meter penetration by 2035.
- New wastewater approach by 2045:
    - Monitoring and advance forecasting of localised surface water rainfall and related pollution/wastewater stresses, including intelligent sewer technology, enabling rapid response and/or prior action.
    - Automatic monitoring and enhanced sampling of environmental water quality.
- Low-emission HGVs and fleet by 2040 and carbon-free baseload electricity by 2035.
- Progress on open data across the sector is limited throughout the period to 2050, with only a handful of water companies (including ourselves) opening up large numbers of their datasets, beyond those required for regulatory purposes.
- The whole-life financial cost of low-carbon construction materials continues to fall, but conventional building materials remain cheaper throughout the period to 2050.
- Cyber and digital protection stays ahead of cybercrime and digital networks remain resilient throughout the period to 2050.
- Technological progress slower than core pathway: 0.3% productivity improvement per year.

## Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies.
- Slower technological progress increases costs.

## Adaptation under the scenario: decision and trigger points

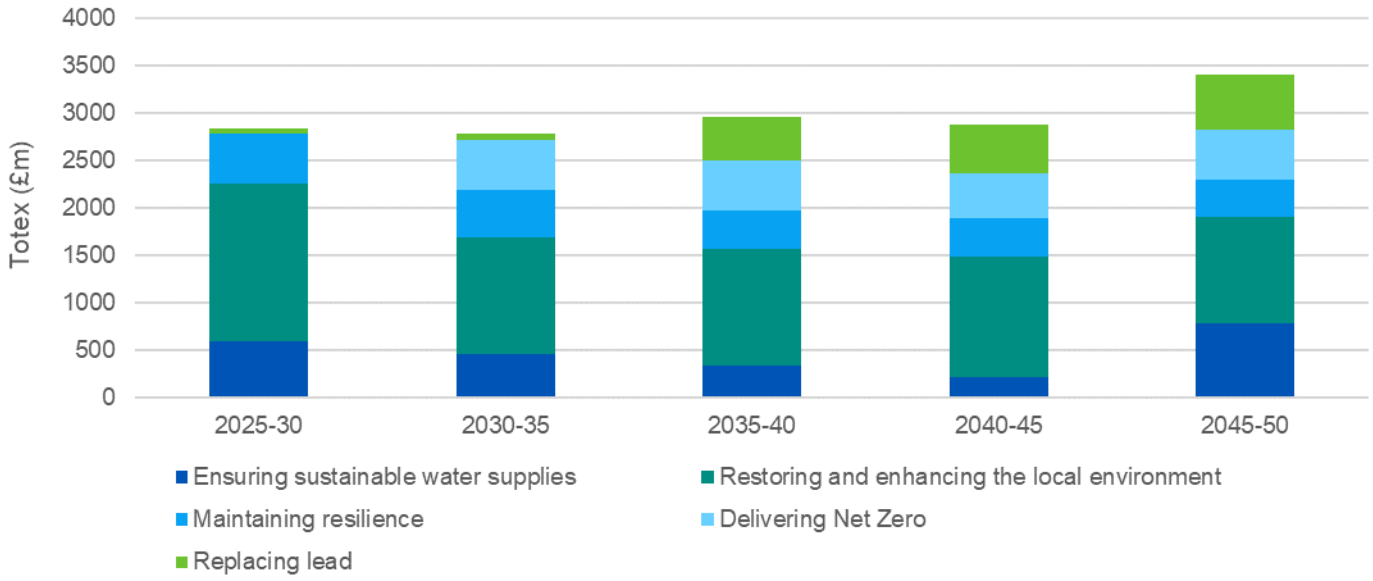
TABLE 17: SLOW TECHNOLOGY DECISION AND TRIGGER POINTS

| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| 1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir | 1B: Lowestoft water reuse built. | 2027 | 2028 |
| 2. The need for Southend water re-use plant | 2B: Southend water reuse phase A built. | 2027 | 2031 |
| 3. The need for Canvey Island de-salination plant | 3A: Canvey Island de-salination plant not built. | 2027 | |
| 4. The need for other water supply, transfer and demand-side options | See Annex 3: Common reference scenario analysis - Table 13: Water resource investments under common reference scenarios | 2024-46 | 2027-46 |
| 5. The impact of new demand on Teesside | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |
| 6. A potential trade of raw water from Kielder reservoir | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| 7. Speed of delivering storm overflow programme and scale of surface water separation | 7A: DWMP preferred pathway – storm overflows addressed by 2050, bathing water sites prioritised. | 2024 | 2026 |
| 8. Future environmental challenges | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2031 |
| 9. Potential for a technology step change | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| 10. Reduction in storm overflow discharge reduction costs from monitoring data | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | 2030 |
| 11. The need for investment in sludge incineration | 11B: Invest in bioresources cake storage barn in 2025-30 and high quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| 12. Level of sustainable long-term capital maintenance expenditure | 12A: Increase of 40% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| 13. Timing of Net zero investment | 13C: Delayed decarbonisation delivering Net zero after 2050. | 2028 | 2030 |
| 14. Timing of lead replacement | 14A: All lead replaced by 2050. | 2033 | 2035 |

## Long-term outcomes

- We expect we would deliver most of our long-term targets under this scenario, however some targets may be at greater risk.
- A failure to develop technologies to address problematic areas of emissions reductions may increase the need to use robust offsets to reduce emissions. We do not deliver our net zero targets in this scenario.
- We do not deliver our long-term targets for leakage, PCC, or business demand in this scenario.

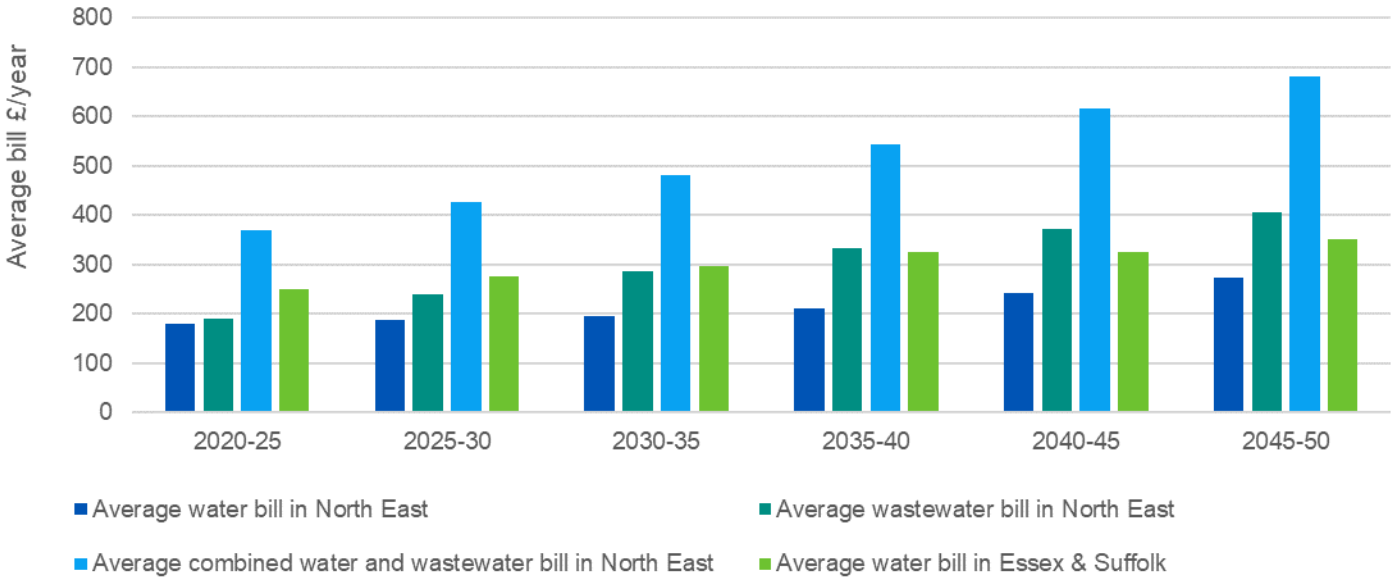
FIGURE 17: SLOW TECHNOLOGY TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)




## Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 83% by 2050. This could be 1.3% to 2.9% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 43% by 2050. This would be 0.5% to 1.3% of average incomes in the South East.
- This scenario would result in lower variation in changes in combined bills in the North East. This is in line with current customer preferences. However, single service customers in the North East and water customers in Essex and Suffolk would see significant variation in bill increases.

FIGURE 18: SLOW TECHNOLOGY AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)




## Fast technology scenario

**This scenario considers the impact of fast, benign, technological progress.**

### Key assumptions

- Smart water supply network by 2035:
    - Automatic detection of potential leaks.
    - Robust real-time asset condition information – including telemetry, robotic and drone inspection – enabling a risk-based maintenance approach across the business.
- Full smart meter penetration by 2035.
- New wastewater approach by 2040:
    - Monitoring and advance forecasting of localised surface water rainfall and related pollution/wastewater stresses, including intelligent sewer technology, enabling rapid response and/or prior action.
    - Automatic monitoring and enhanced sampling of environmental water quality.
- Low-emission HGVs and fleet by 2030 and carbon-free baseload electricity by 2035.
- Full open access to datasets across water companies and other utilities, through common data sharing protocols by 2035.
- The whole-life financial cost of low-carbon construction materials equals that of conventional building materials by 2035.

- Increasing reliance on technology produces progressively higher risks of failure and threats from cybercrime, creating possible need for non-digital backups throughout the period to 2050.
- Technological progress faster than core pathway: 1.1% productivity improvement per year.

### Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies.
- Technological progress reduces costs.

### Adaptation under the scenario: decision and trigger points

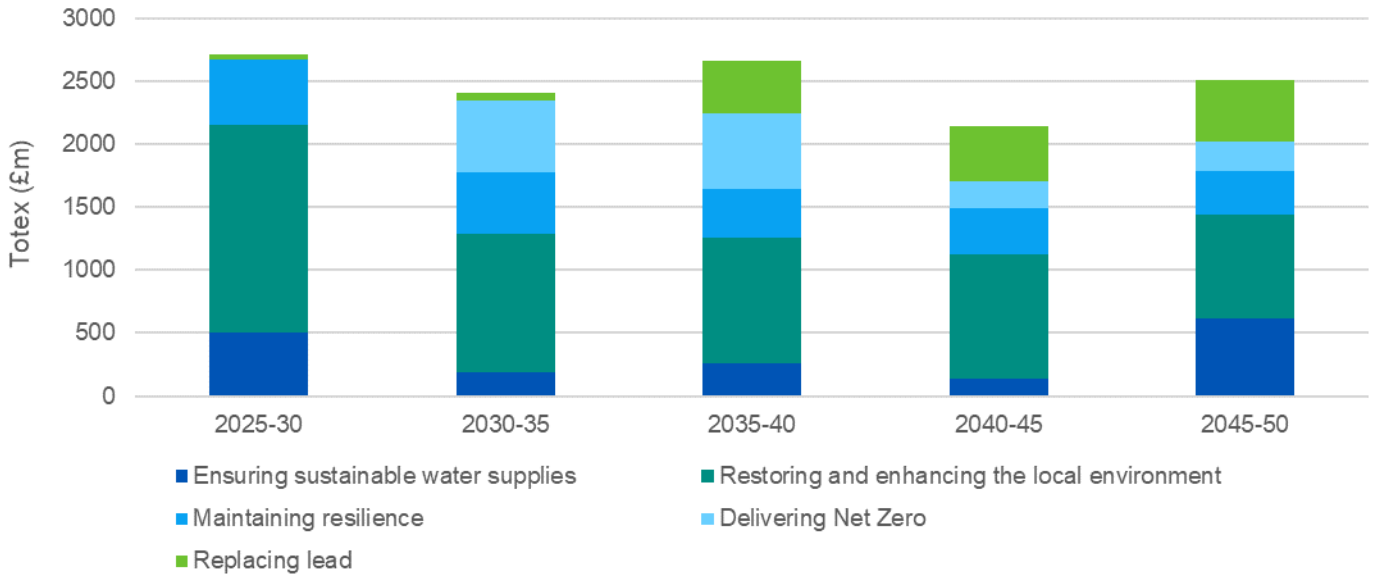
**TABLE 18: FAST TECHNOLOGY DECISION AND TRIGGER POINTS**

| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| **1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir** | 1A: Neither Lowestoft water reuse nor North Suffolk reservoir built. | 2027 | |
| **2. The need for Southend water re-use plant** | 2A: Southend water reuse not built. | 2027 | |
| **3. The need for Canvey Island de-salination plant** | 3A: Canvey Island de-salination plant not built. | 2027 | |
| **4. The need for other water supply, transfer and demand-side options** | See Annex 3: Common reference scenario analysis - Table 13: Water resource investments under common reference scenarios | 2024-46 | 2027-46 |
| **5. The impact of new demand on Teesside** | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |
| **6. A potential trade of raw water from Kielder reservoir** | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| **7. Speed of delivering storm overflow programme and scale of surface water separation** | 7A: DWMP preferred pathway – storm overflows addressed by 2050, bathing water sites prioritised. | 2024 | 2026 |
| **8. Future environmental challenges** | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2031 |
| **9. Potential for a technology step change** | 9B: Technological step change in wastewater (5% reduction in wastewater protecting the local environment costs from 2040) and water (resilience) reducing costs, but alongside an increased requirement for investment in cyber security. | 2033 | 2035 |
| **10. Reduction in storm overflow discharge reduction costs from monitoring data** | 10B: Additional reduction in costs from improved storm overflow monitoring data – starting from 2030/31 rising to 10% reduction in costs from 2034/35. | 2030 | 2030 |
| **11. The need for investment in sludge incineration** | 11B: Invest in bioresources cake storage barn in 2025-30 and high quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| **12. Level of sustainable long-term capital maintenance expenditure** | 12A: Increase of 40% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| **13. Timing of Net zero investment** | 13B: Accelerated decarbonisation delivering Net zero before 2050. | 2028 | 2030 |
| **14. Timing of lead replacement** | 14A: All lead replaced by 2050. | 2033 | 2035 |

## Long-term outcomes

- We expect we would deliver all of our long-term targets under this scenario.
- Technological advances may enable us to go further in some areas of customer service and environmental improvement than we currently envisage being possible.

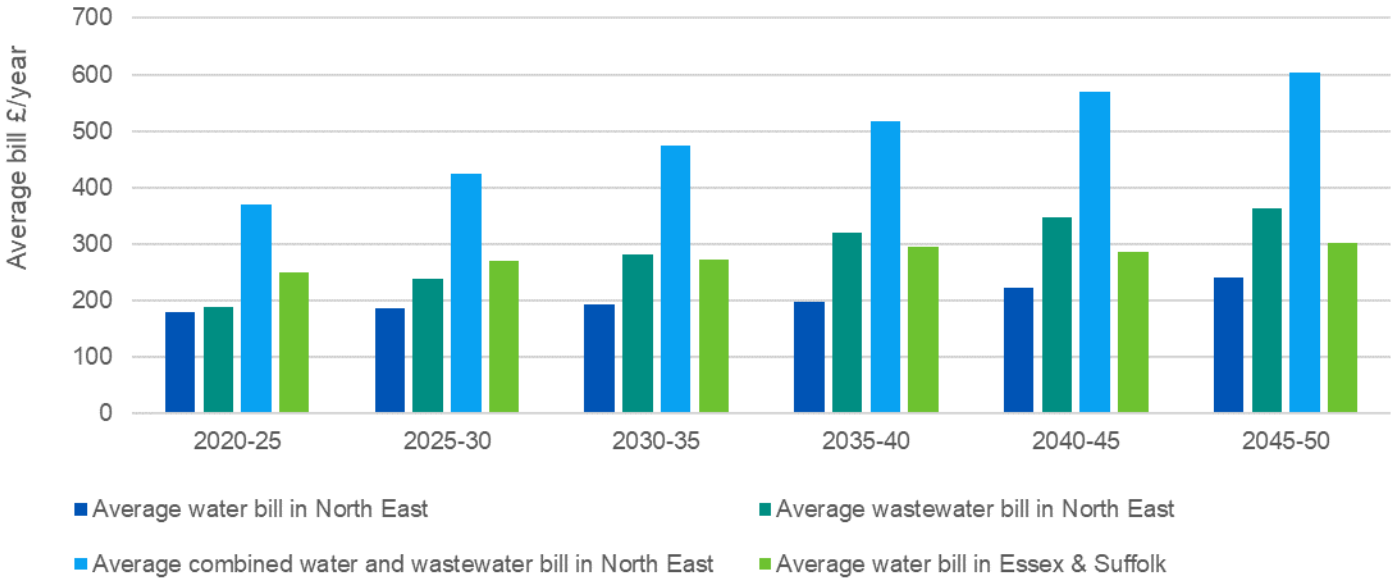
**FIGURE 19: FAST TECHNOLOGY TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)**




## Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 61% by 2050. This could be 1.2% to 2.5% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 20% by 2050. This would be 0.4% to 1.1% of average incomes in the South East.
- This scenario would result in lower variation in changes in combined bills in the North East. This is in line with current customer preferences. However, single service customers in the North East and water customers in Essex and Suffolk would see significant variation in bill increases.

FIGURE 20: FAST TECHNOLOGY AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)




## Demand

These scenarios explore the main drivers of uncertainty around long-term demand that Ofwat considers are beyond our control. These scenarios are aligned to those explored in our WRMPs for the North East and Essex & Suffolk.

## High demand scenario

### This scenario considers the impact of high, adverse, demand.

#### Key assumptions

- No change in building regulations and product standards over the period to 2050.
- Demand forecasts based on housing need. This is a Housing-led scenario, with population growth underpinned by the trajectory of housing growth associated with each local authority's Local Housing Need (LHN) or Objectively Assessed Housing Need (OAHN) plans.
- Technological progress at the same rate as core pathway: 0.8% productivity improvement per year.

#### Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies. Note that although our core scenario is required to meet the high demand scenario, it is also required to only include

low/no regret investment. As there are choices to be made in the future about the best way to meet that demand, our core scenario only includes the enabling investment for the alternatives.

## Adaptation under the scenario: decision and trigger points

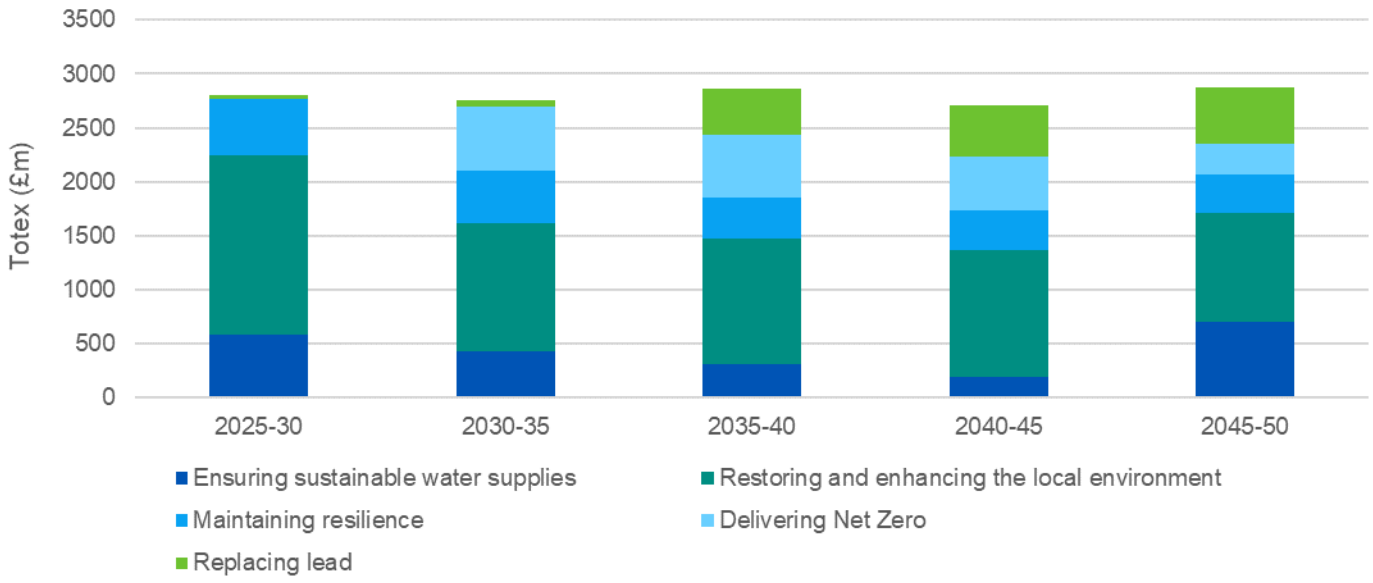
**TABLE 19: HIGH DEMAND DECISION AND TRIGGER POINTS**

| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| 1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir | 1B: Lowestoft water reuse built. | 2027 | 2028 |
| 2. The need for Southend water re-use plant | 2B: Southend water reuse phase A built. | 2027 | 2031 |
| 3. The need for Canvey Island de-salination plant | 3A: Canvey Island de-salination plant not built. | 2027 | |
| 4. The need for other water supply, transfer and demand-side options | See Annex 3: Common reference scenario analysis - Table 13: Water resource investments under common reference scenarios | 2024-46 | 2027-46 |
| 5. The impact of new demand on Teesside | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |
| 6. A potential trade of raw water from Kielder reservoir | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| 7. Speed of delivering storm overflow programme and scale of surface water separation | 7A: DWMP preferred pathway – storm overflows addressed by 2050, bathing water sites prioritised. | 2024 | 2026 |
| 8. Future environmental challenges | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2031 |
| 9. Potential for a technology step change | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| 10. Reduction in storm overflow discharge reduction costs from monitoring data | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | 2030 |
| 11. The need for investment in sludge incineration | 11B: Invest in bioresources cake storage barn in 2025-30 and high-quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| 12. Level of sustainable long-term capital maintenance expenditure | 12A: Increase of 40% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| 13. Timing of net zero investment | 13A: Central case decarbonisation delivering Net zero by 2050. | 2028 | 2030 |
| 14. Timing of lead replacement | 14A: All lead replaced by 2050. | 2033 | 2035 |

## Long-term outcomes

- We expect we would deliver most of our long-term targets under this scenario, however some targets may be at greater risk – in particular, emissions.
- We do not deliver our long-term targets for leakage, PCC, or business demand in this scenario.

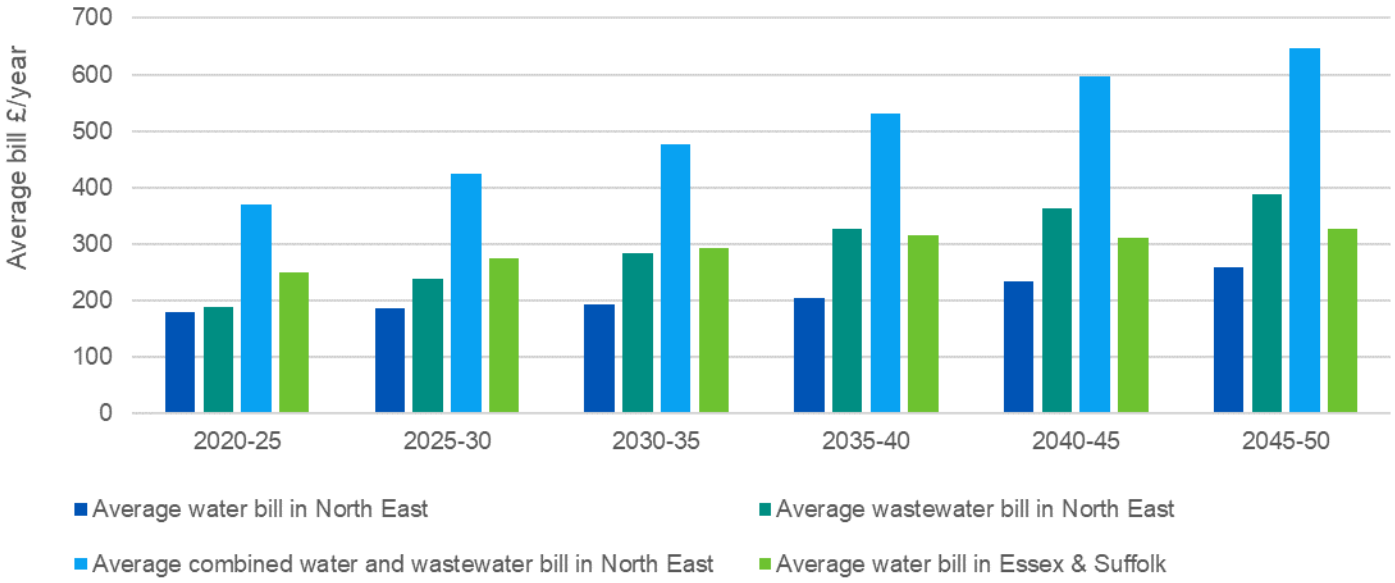
FIGURE 21: HIGH DEMAND TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)




## Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 72% by 2050. This could be 1.3% to 2.7% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 32% by 2050. This would be 0.5% to 1.2% of average incomes in the South East.
- This scenario would result in lower variation in changes in combined bills in the North East. This is in line with current customer preferences. However, single service customers in the North East and water customers in Essex and Suffolk would see significant variation in bill increases.

FIGURE 22: HIGH DEMAND AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)




## Low demand scenario

### This scenario considers the impact of low, benign, demand.

#### Key assumptions

- Introduction in 2025 of a mandatory government-led scheme to label water-using products, linked to tightening building regulations and water supply fittings regulations as per the 'Water labelling only (with minimum standards)' scenario used in the Water UK study, '**Pathways to long-term PCC reduction**', August 2019, pp. 3, 15, 54-55.
- Demand forecasts based on ONS data.
- Technological progress at the same rate as core pathway: 0.8% productivity improvement per year.

#### Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies. Note that although our core scenario is required to meet the high demand scenario, it is also required to only include low/no regret investment. As there are choices to be made in the future about the best way to meet that demand, our core scenario only includes the enabling investment for the alternatives.

#### Adaptation under the scenario: decision and trigger points

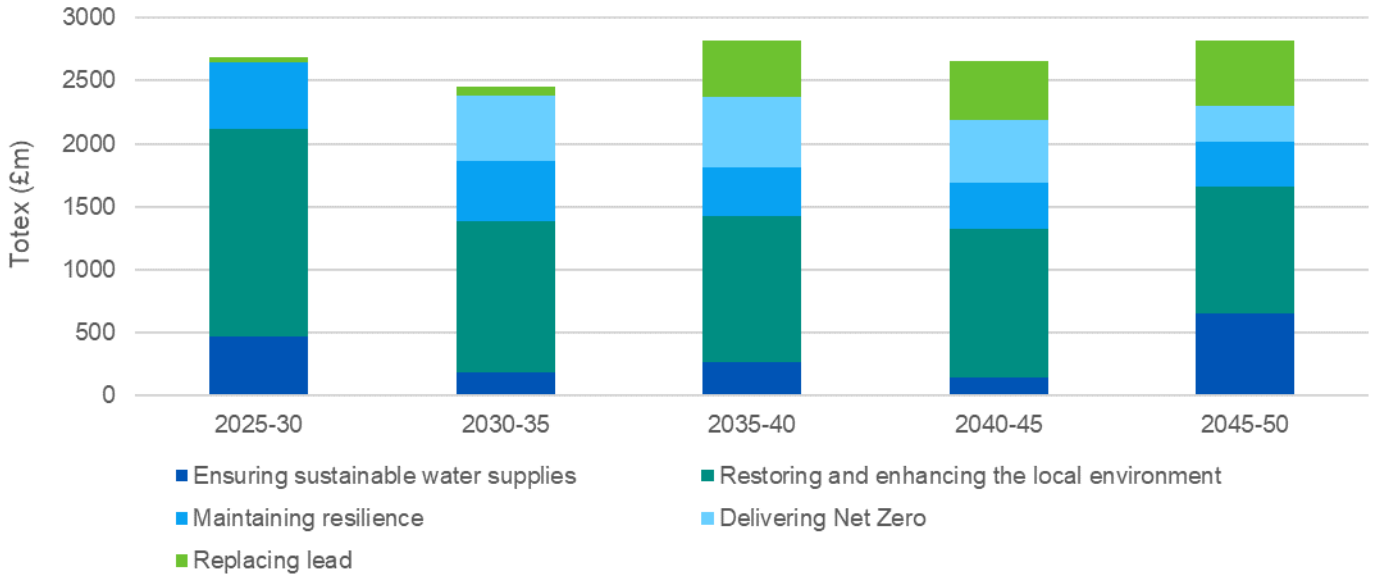
TABLE 20: LOW DEMAND DECISION AND TRIGGER POINTS

| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| 1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir | 1A: Neither Lowestoft water reuse nor North Suffolk reservoir built. | 2027 | |
| 2. The need for Southend water re-use plant | 2A: Southend water reuse not built. | 2027 | |
| 3. The need for Canvey Island de-salination plant | 3A: Canvey Island de-salination plant not built. | 2027 | |
| 4. The need for other water supply, transfer and demand-side options | See Annex 3: Common reference scenario analysis - Table 13: Water resource investments under common reference scenarios | 2024-46 | 2027-46 |
| 5. The impact of new demand on Teesside | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |
| 6. A potential trade of raw water from Kielder reservoir | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| 7. Speed of delivering storm overflow programme and scale of surface water separation | 7A: DWMP preferred pathway – storm overflows addressed by 2050, bathing water sites prioritised. | 2024 | 2026 |
| 8. Future environmental challenges | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2031 |
| 9. Potential for a technology step change | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| 10. Reduction in storm overflow discharge reduction costs from monitoring data | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | 2030 |
| 11. The need for investment in sludge incineration | 11B: Invest in bioresources cake storage barn in 2025-30 and high quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| 12. Level of sustainable long-term capital maintenance expenditure | 12A: Increase of 40% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| 13. Timing of Net zero investment | 13A: Central case decarbonisation delivering Net zero by 2050. | 2028 | 2030 |
| 14. Timing of lead replacement | 14A: All lead replaced by 2050. | 2033 | 2035 |

## Long-term outcomes

- We expect we would deliver all our long-term targets under this scenario.

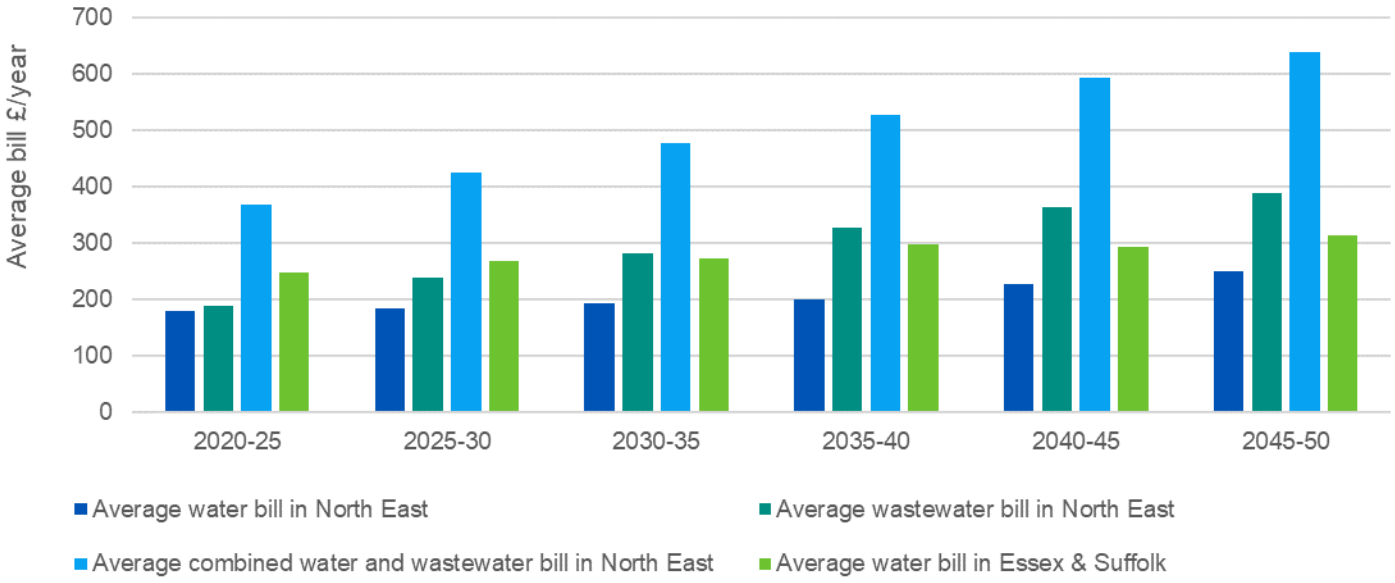
FIGURE 23: LOW DEMAND TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)




## Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 71% by 2050. This could be 1.2% to 2.7% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 27% by 2050. This would be 0.5% to 1.1% of average incomes in the South East.
- This scenario would result in lower variation in changes in combined bills in the North East. This is in line with current customer preferences. However, single service customers in the North East and water customers in Essex and Suffolk would see significant variation in bill increases.

FIGURE 24: LOW DEMAND AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)




## Abstraction reduction

The rate at which we will need to reduce abstraction in future to protect the environment is uncertain. It is dependent on how climate change and demand affect the environment, as well as the policy changes that regulators enforce.[3]

The Environment Agency has published scenarios describing different levels of potential abstraction recovery required in the future. Ofwat has determined that we should consider the Environment Agency's 'enhanced' scenario as a plausible extreme high reduction in abstraction, and the low scenario should represent the lowest plausible abstraction reductions that meet currently known legal requirements.

## High abstraction reduction scenario

### This scenario considers the impact of high, adverse, abstraction reductions.

#### Key assumptions

- Abstraction reductions aligned with the Environment Agency's 'enhanced' scenario.
- For North region BAU is the statutory minimum and is what we have included in our core pathway.

[3] Environment Agency, 'Water resources national framework, Appendix 4: Longer term environmental water needs', March 2020, pp. 4-5.

- Technological progress at the same rate as core pathway: 0.8% productivity improvement per year.

### Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies including the Canvey Island desalination plant.

### Adaptation under the scenario: decision and trigger points

**TABLE 21: HIGH ABSTRACTION REDUCTION DECISION AND TRIGGER POINTS**

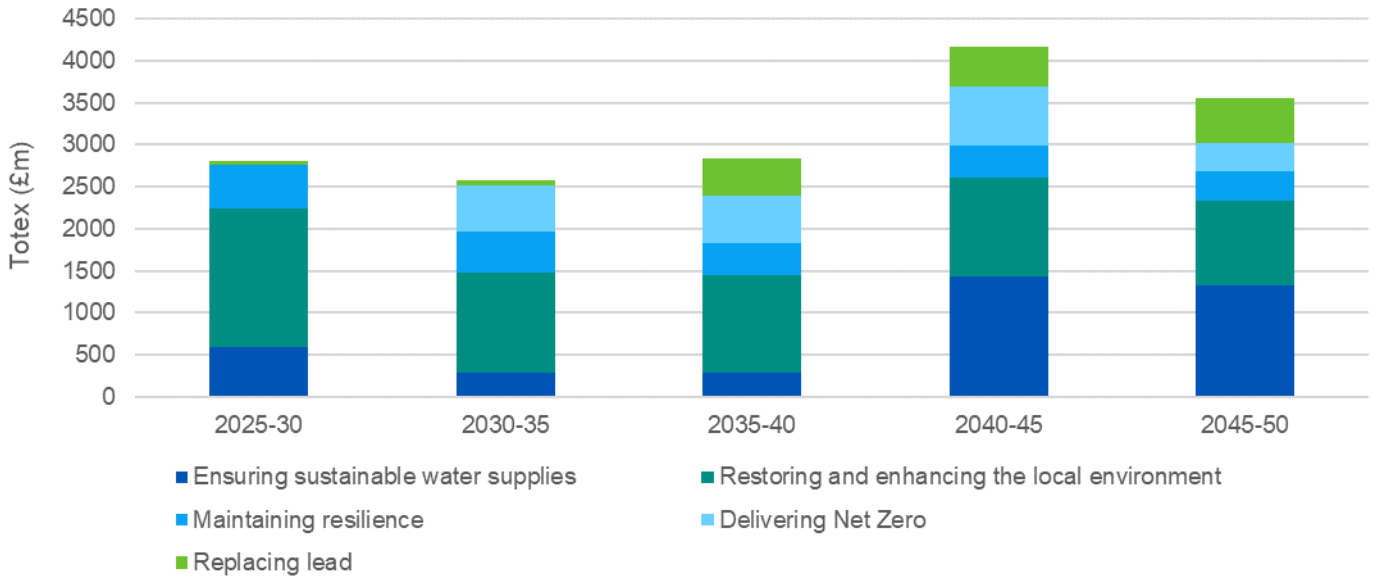
| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| **1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir** | 1B: Lowestoft water reuse built. | 2027 | 2028 |
| **2. The need for Southend water re-use plant** | 2C: Southend water reuse complete project built. | 2027 | 2031 |
| **3. The need for Canvey Island de-salination plant** | 3B: Canvey Island de-salination plant built. | 2027 | 2031 |
| **4. The need for other water supply, transfer and demand-side options** | See Annex 3: Common reference scenario analysis - Table 13: Water resource investments under common reference scenarios | 2024-46 | 2027-46 |
| **5. The impact of new demand on Teesside** | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |
| **6. A potential trade of raw water from Kielder reservoir** | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| **7. Speed of delivering storm overflow programme and scale of surface water separation** | 7A: DWMP preferred pathway – storm overflows addressed by 2050, bathing water sites prioritised. | 2024 | 2026 |
| **8. Future environmental challenges** | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2031 |
| **9. Potential for a technology step change** | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| **10. Reduction in storm overflow discharge reduction costs from monitoring data** | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | 2030 |
| **11. The need for investment in sludge incineration** | 11B: Invest in bioresources cake storage barn in 2025-30 and high-quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| **12. Level of sustainable long-term capital maintenance expenditure** | 12A: Increase of 40% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| **13. Timing of Net zero investment** | 13A: Central case decarbonisation delivering Net zero by 2050. | 2028 | 2030 |
| **14. Timing of lead replacement** | 14A: All lead replaced by 2050. | 2033 | 2035 |

### Long-term outcomes

- We expect we would deliver all of our long-term targets under this scenario; however some targets may be at greater risk.

- Under this scenario we would need to invest in the Canvey Island desalination plant, and other smaller desalination plants. This would have a significant additional energy demand, which would make achieving our net zero targets more difficult and so increase the risk of non-delivery.

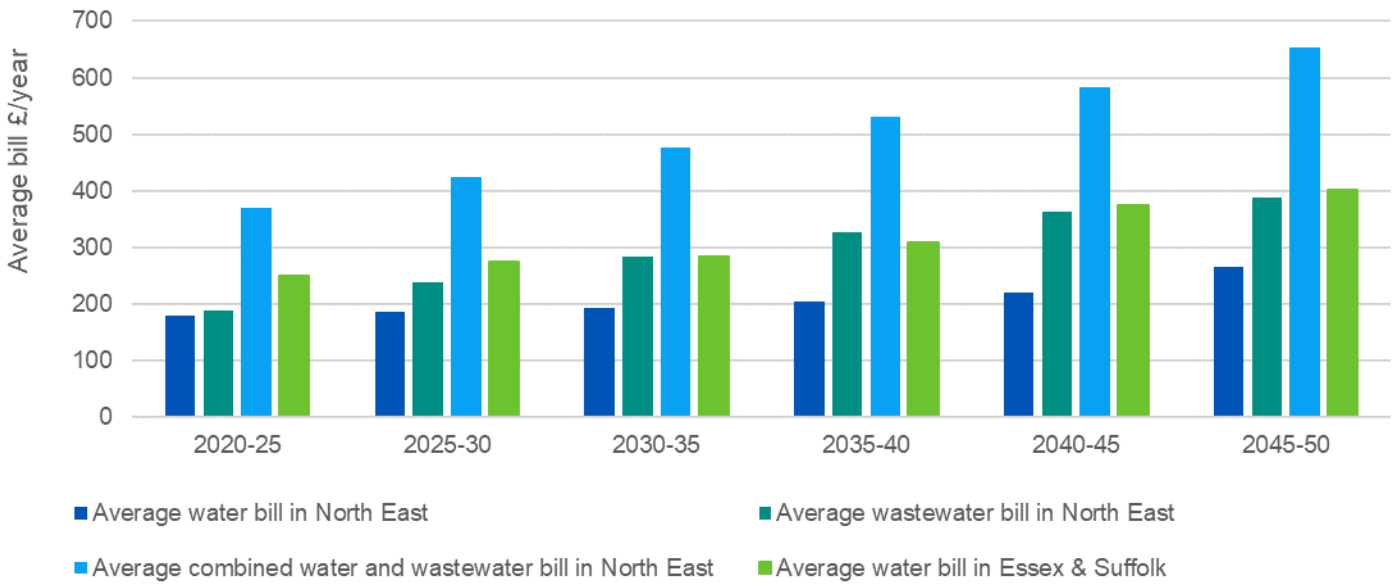
FIGURE 25: HIGH ABSTRACTION REDUCTION TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)




## Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 74% by 2050. This could be 1.3% to 2.8% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 65% by 2050. This would be 0.6% to 1.5% of average incomes in the South East.
- This scenario would result in low variation in changes in combined bills in the North East. This is in line with current customer preferences. However, single service customers in the North East and water customers in Essex and Suffolk would see significant variation in bill increases.

FIGURE 26: HIGH ABSTRACTION REDUCTION AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)




## Low abstraction reduction scenario

### This scenario considers the impact of low, benign, abstraction reductions.

#### Key assumptions

- Abstraction reductions in line with currently known legal requirements up to 2050.
- For North region BAU is the statutory minimum and is what we have included in our core pathway.
- Technological progress at the same rate as core pathway: 0.8% productivity improvement per year.

#### Sensitivity of the core pathway to the scenario

- Additional investment will be needed in Essex and Suffolk to ensure sustainable water supplies.

#### Adaptation under the scenario: decision and trigger points

TABLE 22: LOW ABSTRACTION REDUCTION DECISION AND TRIGGER POINTS

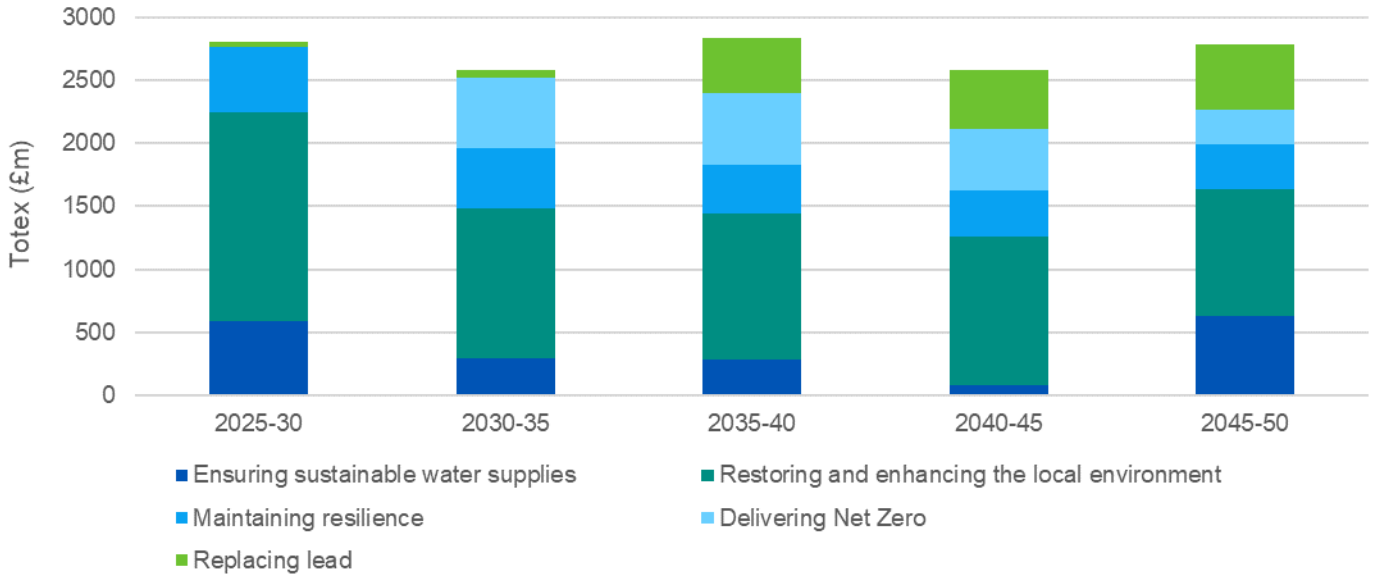
| Decision | Option | Decision point | Trigger point |
|---|---|---|---|
| 1. Prioritising Lowestoft water re-use plant or North Suffolk reservoir | 1B: Lowestoft water reuse built. | 2027 | 2028 |
| 2. The need for Southend water re-use plant | 2A: Southend water reuse not built. | 2027 | |

| | | | |
|---|---|---|---|
| **3. The need for Canvey Island de-salination plant** | 3A: Canvey Island de-salination plant not built. | 2027 | |
| **4. The need for other water supply, transfer and demand-side options** | See Annex 3: Common reference scenario analysis - Table 13: Water resource investments under common reference scenarios | 2024-46 | 2027-46 |
| **5. The impact of new demand on Teesside** | 5A: Demand on Teesside grows in line with other regional non-household demand. | Annually | Annually |
| **6. A potential trade of raw water from Kielder reservoir** | 6B: 140 Ml/d Tees to York transfer from 2040. | 2029 | 2040 |
| **7. Speed of delivering storm overflow programme and scale of surface water separation** | 7A: DWMP preferred pathway – storm overflows addressed by 2050, bathing water sites prioritised. | 2024 | 2026 |
| **8. Future environmental challenges** | 8A: WINEP spend from 2030/31 falls to 40% of 2025-30 average. | 2027 | 2031 |
| **9. Potential for a technology step change** | 9A: No adoption of new technology significant enough to create a step change in costs. | 2033 | |
| **10. Reduction in storm overflow discharge reduction costs from monitoring data** | 10A: DWMP assumptions for reduction in costs from improved storm overflow monitoring data. | 2030 | 2030 |
| **11. The need for investment in sludge incineration** | 11B: Invest in bioresources cake storage barn in 2025-30 and high-quality dewatering with additional 50% cake storage capacity in 2030-35 and drying and pelletisation capacity at Howdon and Bran Sands. | 2026 | 2030 |
| **12. Level of sustainable long-term capital maintenance expenditure** | 12A: Increase of 40% in capital maintenance from 2030 relative to 2020-25 levels. | 2028 | 2030 |
| **13. Timing of Net zero investment** | 13A: Central case decarbonisation delivering Net zero by 2050. | 2028 | 2030 |
| **14. Timing of lead replacement** | 14A: All lead replaced by 2050. | 2033 | 2035 |

## Long-term outcomes

- We expect we would deliver all our long-term targets under this scenario.

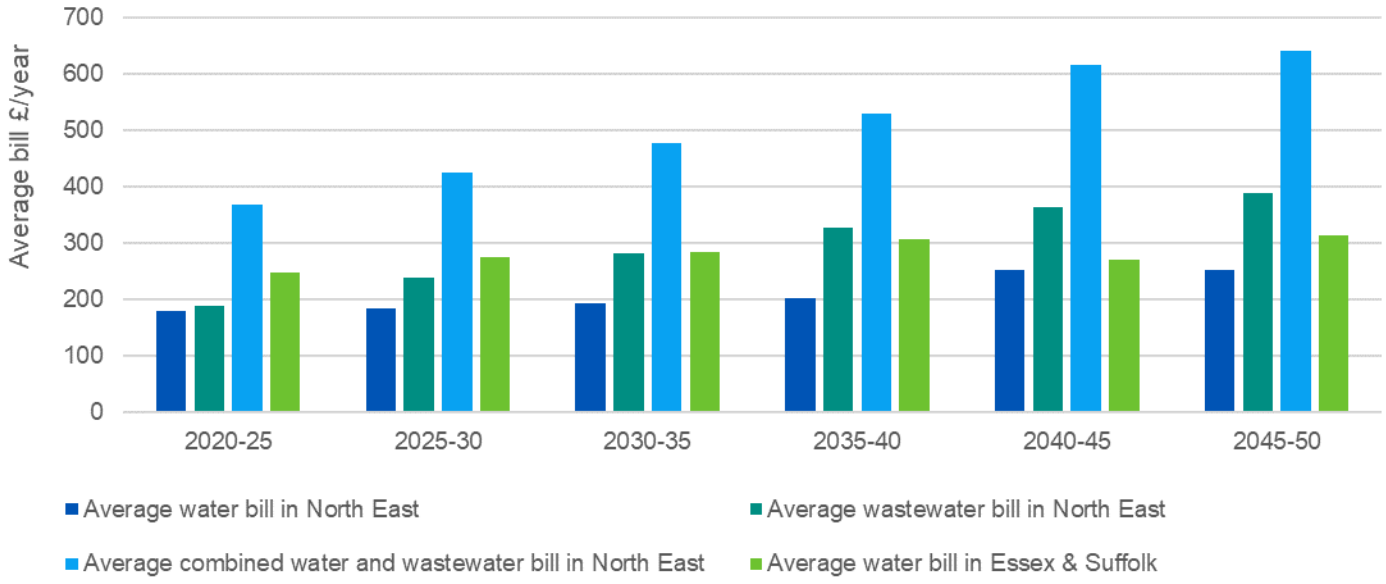
**FIGURE 27: LOW ABSTRACTION REDUCTION TOTAL EXPENDITURE (TOTEX) 2025-2050 (22/23 PRICES)**




## Customer impact

- Combined water and wastewater customers in the North East would see their bills increase by 72% by 2050. This could be 1.3% to 2.7% of average incomes in the North East.
- Water only customers in Essex and Suffolk would see their bills increase by 27% by 2050. This would be 0.5% to 1.1% of average incomes in the South East.
- This scenario would result in high variation in changes in combined bills in the North East. Single service customers in the North East and water customers in Essex and Suffolk would see even higher variation in bills than in other scenarios.

**FIGURE 28: LOW ABSTRACTION REDUCTION AVERAGE HOUSEHOLD BILLS FOR EACH FIVE-YEAR PERIOD 2020-2050 (22/23 PRICES)**



## 4. ANNEX 4: DELIVERING OUR GOALS – OUR PERFORMANCE COMMITMENTS

In this long-term strategy we discuss the performance commitments (PCs) we include in our Business Plan that relate to the long-term targets. Table 23 maps our long-term targets to our PCs for 2025-30 that align with the common PCs Ofwat specifies in '**Creating tomorrow, together: consulting on our methodology for PR24 Appendix 6 – Performance commitments**', July 2022.

### TABLE 23: LONG-TERM TARGETS AND PERFORMANCE COMMITMENTS

| Long-term target | Measure | Alignment between long-term target and 2030 Performance Commitment Level |
|---|---|---|
| **Water** | | |
| Reduce household water per capita consumption – to 122 l/p/d by 2038 and 110 l/p/d by 2050. | Per capita consumption | Our WRMP / PCL of 136 litres (3 year average) by 2030 aligns with reaching the 110 litres by 2050. |
| Reduce non-household (NHH) water demand – by 9% by 2038, excluding growth (from 2019/20 levels). | Business use | Our target is to reduce NHH demand by 1.8% (three-year average) over the period 2025-2030, excluding growth, increasing the pace of improvement from 2030. A linear trajectory would to 2038 would be approximately 3.2%. |
| Halve leakage – achieve a 55% reduction in leakage in our North East levels by 2050 (61.1 Ml/d) and a 40% reduction in leakage in our Essex and Suffolk regions by 2050 (40.1 Ml/d), to achieve the national target of 50% companywide (from 2017/18 baseline). | Leakage NW<br>Leakage ESW<br>Mains repairs | Our WRMP targets for 2025-2030 align with our long-term target of 55% NW and 40% ESW reductions by 2050. |
| Consistently deliver high quality water – Compliance Risk Index (CRI) of zero. | CRI (water quality compliance)<br>Water quality contacts | Our PCL for CRI is 0, which aligns to our long-term ambition. We acknowledge our current performance and that it will take tie to achieve our PCL.<br>We also set a challenging water quality contact PCL to support our vision of delivering high quality water. |
| Leading asset management practices – achieve AMMA assessment of leading or optimising for all measures of asset management maturity by 2030 and leading by 2035. | Mains repairs<br>Unplanned outage | In the long-term we consider a mature asset management approach is a more appropriate measure than existing asset health measures. We consider our proposed PCLs are consistent with a mature approach to asset health management. |
| Reliable water supplies – reduce interruptions to supply greater than three hours to less than two minutes/customer/year on average by 2050. | Interruptions to supply (three hours) | Our proposed target for AMP8 aligns with our ambition to achieve less than two minutes by 2050. However any ambition maybe restricted by severe weather year to year. |
| **Wastewater** | | |

| | | |
|---|---|---|
| Reduce internal sewer flooding – by 60% (from our 2024/25 performance commitment levels). | Internal sewer flooding<br>Sewer collapses | Our proposed target of 1.17 per 10,000 connections by 2030 aligns with our long-term target. |
| Reduce external sewer flooding – by 60% (from our 2024/25 performance commitment levels). | External sewer flooding<br>Sewer collapses | 16.25 per 10,000 connections by 2030 puts us ahead of our linear trend to the 60% reduction on 2024/25 performance by 2050. (18.94 per 10,000 required by 2030.) |
| Leading levels of pollution incidents – zero serious pollutions now and always, zero pollutions as a result of our assets and operations and reduce the number of category 1 – 3 pollutions by 50% by 2040 (from 2022 baseline). | Pollutions<br>Serious pollution incidents. | Our PCL follows the assessment from WISER, which is a 30% reduction on the 2024-25 PCL, this targets 13.3 per 10,000 km, ahead of the 15.87 we need to target on a linear trend to our 2040 target.<br>We set a PCL of 0 for serious pollutions which aligns with our long-term strategy. |
| Protect water environments – target 100% discharge permit compliance and maintain at least 99%. | Discharge permit compliance | Our PCL is consistent with our long-term target as our ambition is to maintain current level of service in the long term. |
| Environment | | |
| Leading levels of water quality – eliminate the detrimental impacts of our operations and assets on waterbodies as soon as is practical. Work with partners so that, where possible, waterbodies in our regions can achieve good ecological status. | River water quality | Our PCL reduces the level of phosphorus by 7.52% by 2030, including the impact of growth on our treatment works. |
| Eliminate harm from storm overflow discharges – year on year reductions in number of storm overflows operating more than ten times a year on average, and none doing so by 2050. | Storm overflows | Our PCL of 16.61 average storm overflows aligns to achieving less the ten average spills by 2035. |
| Enhance biodiversity – all our construction activities, including those that do not require planning permission, will result in a net gain in biodiversity of 10% or the local requirement where higher. | Biodiversity | Our PCL proposed is to increase the level of biodiversity units by 29.67 by 2030. |
| Deliver net zero – achieve net zero Scope 1, 2 and 3 emissions by 2050.<br>Halve carbon impact of new assets – reduce embodied carbon by 50% for new assets by 2040 (from 2025/26 baseline).<br>Increase renewable generation – 100% of our electricity will come from additional* renewable generation by 2040. | Greenhouse gas emissions | Ofwat's proposed PCL does not align with our long term target. In response to Ofwat's proposed commitment, we have set a PCL to reduce our emissions from a 2021/22 baseline for water by 9.5% and by 22% for wastewater. |
| Excellent bathing waters – all bathing waters at good or excellent status by 2030. | Bathing water quality | Our forecasted PCL is set to achieve all bathing waters as good or excellent in 2030. (with the final poor classified bathing water being removed in 2030). |

Table 24 summarises our long-term outcomes performance projections. For more information see our **business plan table** LS1 (NES_BPT01).

**TABLE 24: LONG-TERM OUTCOME PERFORMANCE**

| Common performance commitments (PCs) | Units | 2029/30 | 2034/35 | 2039/40 | 2044/45 | 2049/50 |
|---|---|---|---|---|---|---|
| Water supply interruptions | Time | 00:04:03 | 00:03:32 | 00:02:55 | 00:02:31 | 00:02:00 |
| Compliance risk index (CRI) | Numerical score | 3.82 | 0 | 0 | 0 | 0 |
| Customer contacts about water quality | Number | 0.94 | 0.78 | 0.78 | 0.78 | 0.78 |
| Internal sewer flooding | Number | 1.17 | 1.05 | 0.85 | 0.66 | 0.46 |
| External sewer flooding | Number | 16.25 | 12.38 | 10.9 | 9.47 | 8.08 |
| Biodiversity | Biodiversity units | 0.23 | 0.97 | 0.97 | 0.97 | 0.97 |
| Operational greenhouse gas emissions (water) [1] | Tonnes | 106711.73 | 98551.76 | n/a | n/a | n/a |
| Operational greenhouse gas emissions (wastewater) [1] | Tonnes | 101226.38 | 97539.01 | n/a | n/a | n/a |
| Leakage | % | 20.7 | 26.7 | 32.7 | 40.1 | 47.8 |
| Per capita consumption | % | 9.7 | 16.8 | 22.6 | 27.3 | 28.5 |
| Business demand | % | -22.4 | -25.7 | -21.2 | -20.9 | -20.3 |
| Total pollution incidents | Number | 13.32 | 11.66 | 9.99 | 9.99 | 9.99 |
| Serious pollution incidents | Number | 0 | 0 | 0 | 0 | 0 |
| Discharge permit compliance | % | 100 | 100 | 100 | 100 | 100 |
| Bathing water quality | % | 87.1 | 91.8 | 91.8 | 91.8 | 91.8 |
| River water quality (phosphorus) | Number | 0.0752 | 0.2008 | 0.2294 | 0.2294 | 0.2294 |
| Storm overflows | Number | 16.61 | 10.55 | 9.45 | 8.35 | 7.29 |
| Mains repairs [2] | Number | 123.4 | 123.4 | n/a | n/a | n/a |
| Unplanned outage [2] | % | 3.69 | 3.35 | n/a | n/a | n/a |
| Sewer collapses | Number | 7.12 | 7.08 | 7.04 | 7 | 6.96 |

Note 1: We expect that by 2035/36 or earlier our operational greenhouse gas emissions performance commitments will be replaced with a total greenhouse gas emissions performance commitment.

Note 2: Mains repairs and unplanned outages are measures used as a proxy for asset health. We will continue to work with the sector to develop more effective measurement of asset health and so do not expect to have performance commitments measured in this way in future price reviews.

Table 25 summarises projections of long-term outcomes performance to be delivered from base expenditure. For more information see our **business plan table** LS2 (NES_BPT01).

TABLE 25: LONG-TERM OUTCOMES PERFORMANCE DELIVERED FROM BASE EXPENDITURE

| Common performance commitments (PCs) | Units | 2029/30 | 2034/35 | 2039/40 | 2044/45 | 2049/50 |
|---|---|---|---|---|---|---|
| Water supply interruptions | Time | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Compliance risk index (CRI) | Numerical score | 3.82 | 2.89 | 2.18 | 1.45 | 0.60 |
| Customer contacts about water quality | Number | 1.02 | 0.87 | 0.87 | 0.87 | 0.87 |
| Internal sewer flooding | Number | 1.24 | 1.27 | 1.36 | 1.45 | 1.49 |
| External sewer flooding | Number | 16.43 | 12.38 | 12.25 | 12.16 | 12.09 |
| Biodiversity | Biodiversity units | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Operational greenhouse gas emissions (water) | Tonnes | 106840.00 | 98551.76 | n/a | n/a | n/a |
| Operational greenhouse gas emissions (wastewater) | Tonnes | 103416.2 | 97539.0 | n/a | n/a | n/a |
| Leakage | % | 0.2 | 0.2 | 20.9 | 20.9 | 20.9 |
| Per capita consumption | % | 0.1 | 0.1 | 17.4 | 22.2 | 23.3 |
| Business demand | % | -0.27 | -0.33 | -32.40 | -32.10 | -31.50 |
| Total pollution incidents | Number | 15.48 | 11.66 | 11.66 | 11.66 | 11.66 |
| Serious pollution incidents | Number | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Discharge permit compliance | % | 99.5 | 99.5 | 100.0 | 100.0 | 100.0 |
| Bathing water quality | % | 80.1 | 80.1 | 80.1 | 80.1 | 80.1 |
| River water quality (phosphorus) | Number | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Storm overflows | Number | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| Mains repairs | Number | 123.40 | 123.40 | n/a | n/a | n/a |
| Unplanned outage | % | 0.04 | 0.03 | n/a | n/a | n/a |
| Sewer collapses | Number | 7.12 | 7.08 | 7.04 | 7.00 | 6.96 |

Table 26 assesses the consistency of our performance projections for our 2025-30 business plan outcomes with our 2020-25 outcome projections.

TABLE 26: CONSISTENCY OF LONG-TERM OUTCOMES PROJECTIONS WITH PREVIOUS LONG-TERM PROJECTIONS

| 2025-30 Performance commitment | 2020-25 Performance commitment | Previous long-term forecasts | Commentary on consistency |
|---|---|---|---|
| Water supply interruptions | Water supply interruptions | Upper quartile performance | Our current forecast is consistent with upper quartile performance. |
| Compliance risk index (CRI) | Water quality compliance (CRI) | No forecast | N/A |
| Customer contacts about water quality | Discoloured water contacts Taste and smell contacts | Specification has changed. | New targets not directly comparable due to being linked to DWI information letter. This change results in a higher number of contacts being included in the measure and so our performance projections are for a higher absolute number of contacts than under the previous measure. However, we consider that our performance projections are consistent in terms of customer experience. |
| Internal sewer flooding | Internal sewer flooding | Upper quartile performance | Our current forecast is consistent with upper quartile performance. We have set an ambitious long-term target to reduce internal sewer flooding by 60% by 2050. |
| External sewer flooding | External sewer flooding | Upper quartile performance | Our current forecast is consistent with upper quartile performance. We have set an ambitious long-term target to reduce external sewer flooding by 60% by 2050. |
| Biodiversity | N/A | New target | N/A |
| Operational greenhouse gas emissions (water) | Greenhouse Gas Emissions | Target defined in a different way for new PC. Previously set as a single bespoke PC, with ambition to reach zero emissions by 2027/28. | As discussed in our Long-term strategy (NES_LTDS) due to improvements in the approach to measuring emissions, we no longer consider that we will be able to achieve net zero operational emissions by 2027. However, we continue to be committed to reduce our operational emissions by at least the quantity of emissions originally calculated to meet this target in absolute terms and therefore we consider the two targets are consistent. |
| Operational greenhouse gas emissions (wastewater) | | | |
| Leakage | Leakage | Previous target defined as absolute number, not as a % reduction. | Our revised annual targets are consistent with the national 50% reduction by 2050 (from a 2017/18 baseline, which differs from the baseline used to calculate the presented % reduction for the new performance commitment). For 2025-50 we have set a glidepath to achieve the 55% and 40% long-term targets for Northumbrian Water and Essex & Suffolk Water respectively. This results in a 50% leakage reduction overall. Our revised targets result in slightly lower reductions in leakage in Essex & Suffolk and slightly higher reductions in the North East. |

| 2025-30 Performance commitment | 2020-25 Performance commitment | Previous long-term forecasts | Commentary on consistency |
|---|---|---|---|
| Per capita consumption | Per capita consumption (PCC) | Previous target defined as absolute number, not as a % reduction. | In appendix A4 Outcomes (p.102) we discuss the impact of Covid-19 on PCC. PCC has risen considerably from pre-pandemic levels and so our revised targets are higher than previous targets. However, we consider these to be consistent in terms of the level of stretch. |
| Business demand | N/A | New target | N/A |
| Total pollution incidents | N/A | New target | N/A |
| Serious pollution incidents | N/A | New target | N/A |
| Discharge permit compliance | Treatment works compliance | Full compliance | New target is consistent with previous target of full compliance. |
| Bathing water quality | Bathing water compliance | Target defined in a different way for new PC. Previously a bespoke PC. | The new measure is more stretching as it differentiates between good and excellent bathing water status. We consider that our forecast performance is consistent with previous levels. |
| River water quality (phosphorus) | N/A | New target | N/A |
| Storm overflows | N/A | New target | N/A |
| Mains repairs | Mains bursts | Reduced levels of mains bursts to 2034/35. | We have developed a revised target for this measure as further analysis showed that our previous target was not deliverable. We set out our plans for improving asset health in A3-21 Base uplift case - asset health (NES35). |
| Unplanned outage | Unplanned outage | No reduction in unplanned outages | New target is more stretching in the long-term as we are projecting to reduce unplanned outages. |
| Sewer collapses | Sewer collapses | Upper quartile performance | Our current forecast is consistent with upper quartile performance. |

Note: previous long-term performance projections taken from table App1 in our 2020-25 business plan tables.

# 5. ANNEX 5: REVIEW OF NET ZERO TECHNOLOGIES

## Introduction

Jacobs' '**Net zero Technology Review**', August 2022, was commissioned by Ofwat in light of Water UK's '**Net zero 2030 Routemap**'. When making investments companies addressing their net zero plans would need to take the messages from this report into account.

A methodology for a technology review has been thoroughly applied with a short-listing of those technologies deemed to be better than others. Equally importantly they provide a set of underlying principles as to what constitutes an appropriate (net) zero technology. As with all such reviews, they can become dated, as new technology is developed and more is learnt above those already existing.

## Commentary

We have already carried out significant work with many of the identified technologies as well as with those not listed. We have joined the Community of Practice of water companies working on fugitive emissions and would be willing to share its findings in respect of work.

The net zero target is extremely important to our company, to our society and the planet. Our research with future customers found that they believe it to be the highest priority issue (see **Long-Term Delivery Strategy – Young People Panel and Innovation Festival (August 2023)** NES_LTDS8). The cost of achieving zero or net zero remains unknown since the method of measuring zero, or net zero, remains unknown. We are actively researching better means of carbon accounting and will continue to work towards this end.

It's likely that the development of fully appropriate carbon accounting will extend for some years and the target "zero" will move with that development. This is to be expected. Within this context creating measurable value from individual abatement projects would seem to be important. Delivering schemes to address the largest emissions efficiently rather than rushing to spend chasing the last tonne of carbon, perhaps very expensively, would seem to be important. The last tonne, inevitably, will be found not to be the last.

Zero carbon, as a compliance target, differs from many of our others. There is no underpinning legislation to which we can refer for clarity or direction. There is no technical regulator providing development working groups, guidance, monitoring regimes, or specific measurable compliance limits. We are committed to working to address these matters in collaboration with other water companies.

A complete and accurate representation of our scope 1 emissions (fugitive emission, process emissions) is some way off. At present the scale of the problem is not directly measured. We currently rely on emissions factors that are applied to our process influent flows and then a generic overall emission estimated. The factors are believed to be wrong, maybe an underestimate of 400-600%.

Scope 3 emissions, those arising from our supply chain, or our discharges and service provision were not included in Water UK's 2030 Route map. A discharge to the environment thereby avoiding Scope 1 emissions, may for example, only result in an even greater environmental burden (scope 3 emissions) being created outside of what an organisation considers to be their remit of concern.

A mechanism by which the effectiveness of a given abatement investment intervention could be appraised and subsequently measured would be helpful. Generic emissions factors do not allow for such appraisal at a project level. We would seek to address this. However, the company operates 450 sewage works. These are taken to be the primary emitters of fugitive greenhouse gases. Monitoring airborne emission from each would be costly. We may more likely choose to directly monitor asset classes; trickling filters, activated sludge plants, AD facilities, etc. and infer from a smaller number of works directly measured what the likely emission is from the wider asset base.

We have a couple of concerns with Jacobs' approach. They suggested lifetime assessments and international protocols be applied. We worry that up front project development costs may thereby increase and preclude some smaller, but effective, schemes being put forward. As their fixed cost of development would be too high to justify.

Jacobs does not appear to be in favour of carbon offsetting. We agree, simply buying a solution to our problem, or expecting it to be solved by others is not an approach we will adopt. But who can most efficiently deliver a solution may be determined by factors not within a water company's control? It may cost more to achieve zero for a single entity acting alone. We would like collaboration to remain as a key facet of our delivery.

We are further committed to supporting the circular economy and recovering value from our waste where we can. This can be evidenced with our biomethane to grid projects. In a similar manner green ammonia stripping may recover nitrogen, phosphorus recovery the same for P. The recovery the waste produced by others we see as part of our role.

Jacobs suggest we would not report biogenic emissions of carbon dioxide. Carbon dioxide has the same effect however it's formed. If we can remove our CO2 emissions more readily than those of others, we should do so. What should be addressed is the cost of its recovery. Such a focus on what constitutes zero rather than what

constitutes is reasonable cost to the customer of approaching zero will be inefficient. What if, for example, it was cheaper to capture a tonne of biogenic CO2 from the Gas to Grid plant than reducing the equivalent methane slip from the same plant?

## NWL and Jacobs' shortlisted technologies

1) **Water efficiency across urban water cycle**

We have had a system called Derceto Aquadapt installed for many years. It seeks to minimise pumping costs in the potable network by pumping at tomes of low electricity tariff and using our intermediate storage capacity. Since we buy "green" (renewable) electricity through the market the impact will be on cost and reported emissions under different requirements, not on greenhouse gas emissions under a net zero approach. This comment applies to technologies below seeking solely to reduce electricity consumption.

2) **Pump efficiency**

We have run multiple pump efficiency programmes. We have a reasonable idea how we would improve pump efficiency with more funds. It's not just the pumps, their drives and controls need addressing, as do the air valves along the associated pipelines.

3) **Power Purchase Agreements (PPAs)**

This is well established. We have a ten-year corporate PPA in place with **Ørsted**, the first of its kind in the UK. The agreement sources 30% of our renewable electricity directly from the Race Bank offshore wind farm, off the coast of Norfolk.

As well as supporting the growth of our renewable energy activity, the agreement helps to drive down our operation costs through a long-term fixed price for electricity. The agreement also provides an innovative balancing service of the wind output, so that the electricity can be delivered to us under their existing supply agreement.

By taking renewable energy from a specific wind farm, we are supporting the development of new renewable generation. Renewable Electricity Guarantee of Origin certificates (REGOs) enable the company to report zero carbon emissions for this electricity under our existing ODI.

**4) $CH_4$ monitoring & mitigation**

We do not do this, and we need to, in common with other wastewater companies. It's becoming a requirement of wastewater permitting. There's no established technology or technique for doing so, although there are several suppliers proffering potential solutions. This needs to be established for find and fix as part of our wastewater permitting anyway. It would also need to target our advanced anaerobic digestors (AADs), gas-to-grid plants, and sludge storage.

**5) Membrane aerated biofilm reactor (MABR)**

There are many alternatives to activated sludge (AS) plants for secondary treatment. There is nothing wrong with highlighting MABR as one. AS plants are well established for good reason, alternatives have always existed. Fixed film systems are inherently more energy efficient than AS. But traditionally they occupy a large footprint and have not been deemed suitable for many constrained urban locations. We continue to research improved more intense fixed film systems with Newcastle University at the BEWISE Research facility we jointly developed.

**6) N2O setpoint optimisation**

We have two very large sewage treatment works. Howdon and Bran Sands each with an estuarial location. As such nutrient consents are more relaxed. By and large we prefer them not to nitrify. The direct control of nitrification/denitrification has not been a major focus as a result. We control for carbonaceous treatment and energy reduction. Water companies with large inland treatment works have carried out control based on N2O but again more for energy reduction than N2O control. This area and the one suggestion directly below (7) would seem to show reasonable promise. At our BEWISE facility at Birtley we continue to work with Newcastle University on our understanding of the biology. We but remain some distance away from a workable control system.

**7) Real-time N2O control**

**8) Thermal hydrolysis process (THP) AAD**

Already in place - we have CAMBI THP plants at both Howdon and Bran Sands, our two bioresources treatment centres.

**9) Enzymic hydrolysis (EH) or acid phase digestion (APD) AAD**

When we chose to invest in AAD at Howdon and Bran Sands we reviewed the alternatives, EH, APD etc and chose a THP front end to our AD. We could carry out AD in one big pot, or break down the process stages into differing intermediate steps to try squeeze greater efficiency. All that comes at a greater capital cost and when we appraised, for robustness and energy value, (not minimal process emissions) AAD was selected as the best option for us at the time of the investment. When the plants need to be replaced, we will be able to

reassess the best alternative, but as 100% of our sewage sludge is currently processed by THP AAD there are no current economic opportunities for us to make this investment.

**10) Intermediate thermal hydrolysis (ITHP)**

See the note above about intermediate steps.

**11) Co-digestion**

Co-digestion is the mixing of sewage sludge with other organic waste (for example, food waste) to be processed together in anaerobic digestors.

Co-digestion is not practical in the water industry. This is because the industry relies on its ability to recycle sewage sludge to land, which is not allowed when other waste material is co-digested with sewage sludge.

Sewage sludge is defined as a waste and put to land under a protocol developed by DEFRA. If any other waste material is added to sewage sludge in any quantity, then the whole volume becomes a waste and has to be put to land under the Waste Regulations and, as well as a huge administrative cost, it may well change the way sewage sludge to land is viewed and make it even more probable that sludge to land will be prevented.

There are also practical considerations of the optimal microbial mix needed differing based on the feedstock for digestion, but this is secondary to the regulatory barrier.

**12) Gasification/pyrolysis**

There is no affordable and environmentally beneficial alternative to recycling sewage sludge to land.

Of the unaffordable alternatives to putting sludge to land, two commonly mentioned are gasification and pyrolysis. They have not been made to work for either screenings or sewage sludge. Yorkshire Water has in the past built a gasifier, but it was not commercially or practically successful. It required 70% wood chip to be added to their sewage sludge. The sewage sludge had to be pre-dried, and the energy balance was negative. That is, sludge drying, and wood chip addition made it pointless.

United Utilities has tried gasification for screenings and Severn Trent is proposing to try it again on screenings as part of an Ofwat Innovation competition bid. However, we expect these technologies will be hugely costly to develop.

We therefore do not consider at present that these technologies offer a viable alternative and should only be considered if recycling sludge to land is prohibited by law.

**13) Bio-drying (sludge)**

**14) Low-energy drying (sludge)**

We consider these two technologies together.

If you cannot put sewage sludge, at ~25% dry solids, to land it will need to be disposed of in another way. Incineration, gasification, pyrolysis etc all require pre drying to the sludge driving off that 75% water. This has a huge cost and energy burden. We previously had a dryer at Bran Sands running on fossil gas. Instead of fossil gas it is suggested a dryer could be capable of using waste-heat or some other non-fossil source. This is far from certain.

Sludge drying by whatever means is going to be technically challenging. The sludge is full of grit and will therefore erode whatever technology we apply, meaning even low-energy drying processes will likely still have high operational and maintenance costs as parts will need regular inspection and replacement.

We therefore do not consider at present that these technologies offer a viable alternative and should only be considered if recycling sludge to land is prohibited by law.

**15) N stripping (liquors) Stripping ammonia**

We have won an Ofwat innovation competition bid for a pilot plant ammonia stripper at Howdon. It will begin trials in early 2023.

Ultimately (possibly in the next five years) we may be obliged to treat ammonia at Bran Sands and potentially at Howdon. The capital cost of doing so will be significant. Without any other impetus the most likely option to maximise cost-benefits would be biological treatment. It's the traditional "safe" approach. The technology produces nitrogen, that is harmless and useless, but consumes energy in the form of ethanol and electricity. An alternative, stripping the ammonia, produces a green fuel ammonia that has a value and could:

- Run a fuel cell.
- Be sold to fertiliser companies.
- Be cracked to make green hydrogen.

Stripping ammonia needs steam and energy. Getting the energy balance correct, so this can be economic, will be the key. We are investigating the potential for this technology through the pilot plant we are trialling at Howdon, and we have continued research at Cranfield University into more energy efficient technology in a project in collaboration with Severn Trent and Anglian.

We do not know the overall effect of biological nitrogen treatment on our N2O process emissions, neither do we yet know the comparative effect on emissions from ammonia stripping. Further study will be required to understand the total impact of this technology on process emissions.

**16) Tanker (biomethane)**

We receive green gas certificates for our biomethane and can use them to offset currently, so would have to buy biomethane in to fuel our tankers. We have considered doing so from local anaerobic digestion (AD) plants, but the economic case is not strong. We are considering hydrotreated vegetable oil (HVO) as an alternative.

We have also included an investigation in the Water Industry National Environment Programme (WINEP) to explore the possibility of operating our bioresource haulage fleet using hydrogen, which could be produced at our two Sewage Treatment Centres (Brand Sands and Howdon). This will explore the feasibility and the associated capital investment that would be needed to produce and store hydrogen and provide refuelling capability and as a bridging technology. Since December 2022 we have been operating our heavy goods vehicles (HGVs) on biodiesel using our new onsite fuel stores.

**17) Heat recovery (onsite)**

The CAMBI AAD plants both recover waste heat from the CHP units to partially meet the steam demand for the thermal hydrolyser. We have further considered Organic Rankine Cycle engines to recover low grade heat, also growing tomatoes, for example. We do what is economic. Further process integration maybe possible for ammonia stripping or sludge drying but there is only so much waste heat available, and it is of low grade.

**18) Biomethane to grid**

This is practiced at both Howdon and Bran Sands. All our sewage sludge is treated at these two sites. Currently the biomethane we produce is treated to grid standard and injected, subject to operational constraints.

**19) Stormwater separation & treatment with NBS**

More stormwater separation will have high capital cost and be disruptive to those currently making the discharge to sewer. Whereas storm water segregation is very good approach. How much its segregation would affect carbon is debatable. It’s clean water and therefore other than pumping incurs low treatment cost, especially if it by-passes the works through overflows. It also must go somewhere. Taking the problem from our networks puts it somewhere else. Other stakeholders may be highly resistant. We have carried out several more sustainable drainage schemes in the north of Newcastle.

We support the NBS research at Cranfield University. Wastewater contains a range of micropollutants from, for example, pharmaceutical metabolites, domestic insecticides, microplastics, etc. NBS are unlikely to be a solution to such pollutants, more of a sponge. NBS need to be used appropriately.

**20) Process Energy Efficiency in wastewater treatment**

We employ process control at activated sludge plants (for example Perceptive Engineering). We are developing from a previous PhD and now through a knowledge transfer partnership an exciting control protocol on biogas scheduling at our CAMBI plants that will optimise for both cashflow and carbon.

**21) Vacuum Extraction of Methane**

We trialled the technology (Eliquo Elovac) at Howdon this summer (2022) and are still considering its further use. Presently there is no carbon emissions incentive as, if installed, it would not be accounted for in reported emissions against the CAW.

## Non-shortlisted technologies

Jacobs has a list of non-shortlisted technologies, not passing their appraisal. Some of these may have similar merits to the technologies listed above.