2025 – 2050
Bioresources Strategy

Anglian Water

October 2023

Executive Summary

This document outlines Anglian Water's bioresources strategy for the period 2025 to 2050, replacing the previous 2020-2045 strategy. The strategy is based on collaboration, aligns with adaptive planning principles, and sets ambitious goals.

Anglian Water's key ambitions for Bioresources include:

- Safe, sustainable treatment of sewage sludge to meet demands, with an expected increase in sludge production as a result of population growth and tightening environmental standards.
- Production of high-quality bioresource products that support the circular economy and Net Zero goals.
- Embracing innovation, diversifying product types, and enhancing operational resilience across the bioresources value chain.
- Ensuring adaptability to change through adaptive planning and collaborating with stakeholders in emerging bioresources markets.

The company actively participated in the development of the National Long Term Bioresources Strategy and emphasises the need for cross-sector collaboration. We fully support its conclusions and will continue to collaborate closely with stakeholders, regulators, academia and the wider supply chain on future phases.

Anglian Water currently manages bioresources by treating wastewater sludge and recycling over 95% to agricultural land as a biosolids cake. However, challenges such as landbank loss, climate change impacts, and evolving regulations pose both risk and opportunity.

To address these challenges and opportunities, Anglian Water's strategy includes a core pathway with estimated required investment of £400 million for AMP9 and AMP10. It aims to meet ambitions under various future scenarios, including climate change, demand, and technology trends.

Alternative pathways are considered based on specific challenges and triggers, allowing flexibility in response to changing conditions.

Anglian Water also actively engages with bioresources markets, exploring trading, joint ventures, and third-party arrangements to support its strategic goals. We have issued Prior Information Notices for additional treatment capacity and biomethane upgrading in spring 2023.

In conclusion, Anglian Water's bioresources strategy for 2025-2050 focuses on sustainability, innovation, and adaptability while addressing challenges and opportunities in the evolving bioresources landscape.

Contents

Introduction

This document sets out the bioresources strategy for Anglian Water for the 2025 – 2050 period. This replaces the previously published 2020-2045 strategy.

The document builds upon a collaborative national bioresources long term strategy commissioned by Water UK and produced by CIWEM (Chartered Institution of Water and Environmental Management). Anglian Water have been key contributors and stakeholders in the development of the national long term bioresources strategy report.

Our strategy follows the principles of adaptive planning and includes a core pathway, with alternative pathways to meet our 2050 ambition.

Our Ambition

Our key ambitions for bioresources over the period are;

1. Safe, efficient, sustainable treatment of sewage sludge to meet future demands, reflecting population growth and tightening environmental standards that lead to forecast increased sludge production of up to 173.1 thousand tonnes per annum (TTDS) by 2030.
2. Production of high quality biosolids and associated products for onward beneficial use. This will align with principles of the circular economy, zero waste and positively support our wider business goal on Net Zero.
3. Embrace innovation, enable diversification of product types to open new markets, strengthening operational resilience, exploiting opportunities and mitigating risks across the bioresources value chain.
4. To ensure our bioresources activities are resilient and adaptable to change, this is achieved through a systemic adaptive planning approach, embracing markets and pursuing low regret, best value investment strategies.
5. Support enablement and growth of emerging bioresources markets, collaborating with the supply chain, water companies, wider waste sector and regulators to ensure robust, resilient market solutions can be offered and contracted meeting the current and future needs of the sector.

Bioresources – the national and global position

The global bioresources sector finds itself at the centre of a societal shift in priorities around both attitudes to environmental stewardship and circularity of resources. The benefits and consequences of current biosolids practices employed are under increased scrutiny as a result.

As the sewer system collects such a diverse range of discharges from homes and businesses, the resulting bioresources offer a rich and varied range of constituent elements and compounds. Some of these offer a significant source of valuable compounds such as phosphate, ammonia, and acetic acid. Others such as heavy metals, "forever chemicals" such as per/poly-fluroalkyl substances (PFAS), and microplastics contaminate the flow and potentially limit the onward use of the solid residual. This balance of risk and opportunity is coming into sharp focus as scientific advancement gives improved resource recovery technologies, but also improved analytical methods for detecting contaminants.

There is no international consensus on bioresources management, nor on the direction of travel. This is due to a wide range of local factors such as societal attitudes to biosolids use, incentive availability for different outputs and historic practices. Currently the majority of the biosolids produced by the UK are beneficially applied to agriculture ***(87%, ADAS 2021)****. However, recent increased stringency on organic fertiliser and manure application, to prevent eutrophication and leaching of nutrients into watercourses, has reduced the potential land available to the water sector. The concurrent emergence of significant human and environmental health concerns regarding the presence of PFAS and microplastics in the wider environment has meant the industry urgently needs to explore alternative products and outlets for bioresources to diversify its end-products / outlets. These are common drivers globally, but there is currently not a consensus on the best solution to balance risk and affordability. There is a significant need for ongoing cross sector collaboration from academia, innovators, industry experts, markets and regulators who share a desire to aid definition of a sustainable strategy for bioresources management*

The development of Resource Production and Thermal Conversion as alternatives to agricultural application of biosolids is fast gaining traction across the world. The English sector has made tentative steps into both areas, but this is sporadic. If recovery to agriculture is rendered no-longer viable, and there is no appetite for large scale deployment of incineration facilities, this would lead to the sector not having a deployable strategy available as the two most utilised strategies globally (recovery to agriculture and incineration) are at risk of being driven towards low deployability and low alignment. This highlights the need for the sector and wider collaborators to develop viable alternatives.

Resource Production as currently practiced involves the extraction of as many valuable resources as possible from the bioresources process, however it still has a solid residual requiring management by another of these strategies. It is currently therefore only viable to pursue as part of a mixed approach. Thermal Conversion on the other hand creates a range of residuals that are materially different to biosolids, and therefore offers the potential for the sector to diversify away

from sole reliance on agriculture. Both strategies offer diversification of bioresources into new markets and outlets, and development will be required to ensure these are both appropriately regulated and encouraged for the sector to pursue

Extract from CIWEM National Bioresources Strategy summary report

Water UK, CIWEM, Atkins

We continue to play a lead role, with Water UK, in the development of the National Bioresources Strategy, with representation in the various technical steering groups. The work has identified a significant need for ongoing cross sector collaboration from academia, innovators, industry experts, markets and regulators to aid definition of a sustainable national strategy for the future. We welcome the challenge this poses and the opportunity to collaborate with others to find a sustainable long-term solution. The work to date on the national strategy forms the foundation for our update of the Anglian Water 25-year plan.

Bioresources – the Anglian Water position

Bioresources derived products are a valuable resource produced from the treatment of wastewater. Our current approach to managing bioresources involves the treatment of wastewater sludge from 1,122 water recycling centres at 10 sludge treatment centres (STCs). The STCs treat the wastewater sludge to generate a high-quality biosolids cake product for use in agriculture as a soil conditioner. This allows our agricultural customers to reduce their use of artificial fertilisers and return valuable nutrients and organic matter to farmland. This circular process improves soil and plant health and in turn, helps to ensure a resilient national food supply. Over 95% of the biosolids cake we produce are recycled to agricultural land, higher than the quoted 2021 industry figure of 87%.

The regulatory regime for bioresources reflects its interactions with land, air and water and we are required to meet a diverse range of evolving and uncertain regulatory requirements. Other external factors such as climate change also have the potential to affect the area of agricultural land over which our bioresources products can be recycled (we refer to this as our landbank). These issues influence all water and sewerage companies in England and Wales, indeed bioresources are often recycled outside the source WaSC (Water and Sewerage Companies) region, and so we have collaborated with the other WaSCs to conduct national-scale studies and modelling to inform our respective long-term strategies.

Our long-term strategy for bioresources meets our vision for a resilient asset base and operation by promoting innovation in how bioresources are managed to deliver adaptive, best value solutions. Our strategy addresses the significant uncertainties in the external factors that influence bioresources management in England and presents a core pathway of investments which delivers ambition under most scenarios of the future. It will therefore deliver ambition under the most plausible future that we have identified. Through adaptive planning we have also developed a number of alternative pathways to address specific, more extreme future scenarios, should clearly defined decision and trigger points be reached.

The challenges we face in managing bioresources

Reflecting on the outcome of the national strategy the key challenges we face are;

Loss of landbank - access to a sufficiently large agricultural landbank, this is critical for our existing approach to bioresources management. We will continue to conduct regular analysis and modelling to forecast changes in landbank availability and will use this insight to inform decisions with regards to the timing for accelerating strategic change or changing to an alternative adaptive pathway.

Our current analysis, aligned to national landbank modelling, indicates it is likely that we will have insufficient landbank available to sustainably recycle all our bioresources product within the next 10 years.

Climate change projections of sea level rise, warmer and wetter winters and more intense rainfall events mean that weather conditions and flood events are more likely to restrict application of bioresources product to land, which must be restricted when runoff to watercourses is more likely.

The regulatory frameworks that allow bioresources product to be sustainably recycled to agriculture are changing, with the Environment Agency's interpretation of Farming Rules for Water, which if implemented in its current form, will restrict spreading of biosolids in the Autumn. There are other pending reviews and changes that may further restrict bioresources product application to agricultural land including policy and the guidance related to nutrient neutrality, a Defra review of the Farming

Rules for Water (FRfW), a Defra review of the statutory guidance issued in relation to applying the FRfW (still planned by 2025) and potential restrictions related to micro-pollutants (for example, micro-plastics, PFAS, PFOS). There is currently no regulatory framework for the use of sewage sludge derived biochar in agriculture, but it's expected that this will be developed through joint industry-regulator collaboration in future.

Population growth - over the long-term, we will need to increase our STC capacity to cater for population growth. We base our population growth forecasts on office of national statistics (ONS) forecasts.

Increasing treatment standards - changes in legislation and guidance associated with biosolids/raw cake storage areas and the management of sludge treatment processes (through the Industrial Emissions Directive) mean that we need to invest to meet the latest standards and to provide additional storage capacity. Continued tightening standards for wastewater treatment effluent through the WINEP (Water Industry National Environment Programme) programmes also lead to increased production of raw sludge requiring treatment and safe recycling Forecast increases in sludge production factor into our forecast needs for additional sludge treatment capacity.

Achieving net zero - our corporate net zero strategy is highly reliant on a sustainable low carbon approach to treating and recycling our sludge through our bioresources activities, it assumes a continuation of our existing strategy of maximising production of biogas for beneficial use as a renewable energy source, this through either the generation of renewable heat and power (CHP engines), or as biomethane with upgrading and grid injection. The production of high quality biosolids products to agriculture. Loss of landbank would require alternative or additional treatment steps, many of which are carbon intensive and would likely limit the carbon benefits expected from bioresources management.

Opportunities for doing things differently

We recognise and embrace opportunities to do things differently across activities across the bioresources price control where these align with our ambition, business objectives and outcomes. We are open to all ideas from the wider supply chain that can support these strategic ambitions and have published a bid assessment framework that facilitates this engagement.

We support the idea that bioresources can add value and support us and the wider world in solutions that are beneficial in delivering net zero and the circular economy.

Examples of work we have recently completed or are actively engaged in include;

Lead partner in Ofwat Innovation Fund projects for 'Unlocking Bioresources Markets' as project working with a modelling specialist and four other water companies to explore opportunities for trading of sludge.

Unlocking-Bioresources-Market-Growth (businessmodelling.com)

Anglian Water are led on Unlocking Bioresources Market Growth, and are partners on SENECA, Biopolymers in Circular Economy, and Catalysing a Net Zero Future.

We are currently actively engaged with exploring alternative outlets for bioresources products. This includes an exciting opportunity to potentially use sewage sludge as a feedstock for production of

sustainable aviation fuel to help the UK meet targets to decarbonise the aviation industry.

Looking forward we see potential in moving towards a full bio-refinery approach for the treatment, recovery and beneficial use of a range of products derived from sewage sludge. Whilst we recognise many of these options are still at research and development stage and work is required with regulators and end users to ensure there are sustainable pathways to market, we are encouraged by the progress that is being made. We fully support the findings and recommendations identified in the national bioresources strategy development report and will continue to be at the forefront of further work in this area both with the supply chain, academic partners and our regulators.

Summary of challenges and opportunities

National landbank modelling shows there is a risk of insufficient agricultural landbank for around 2.5 million tonnes of biosolids per year. Should this risk materialise, the only viable technology currently available for the management of bioresources is incineration. We would need to start investing in this technology from AMP8 as we estimate the lead time is 6-10 years to allow for design, planning and construction.

Adoption of incineration as the primary means of bioresources management has several significant disadvantages and is not aligned to our long-term ambitions for bioresources to provide high quality products for beneficial use supporting circular economy initiative and the drive to achieve net zero, as such, we do not consider it to be a best value solution:

- It would result in foregoing the significant natural capital benefits, through recycling of nutrients, that bioresources product recycling to agriculture provides to national food security.
- It would jeopardise our net zero strategy.
- It would lock us in to a low value solution into the long term.

In the face of this significant and sector-wide issue, we have and continue to work closely with our regulators, stakeholders and other WaSCs to develop a long-term strategy that invests in research and innovation in the near-term to reduce, as far as is possible, the need to deploy incineration as a bioresources management technology and recognising our long term goal of moving to a position where we are not solely reliant on agriculture as the outlet for bioresources products in the current form, will would like to transition over time to a position where we have a range of sustainable outlets and markets available.

Our bioresources strategy 2025 – 2050

Beyond 2030 to 2050

We anticipate that any adaptation to our chosen core pathway or switch to an alternative pathway will happen from 2030 as set out within the challenges and opportunities section of this document, however it remains a possibility that there will be a need to adapt within the 2025-2030 period, resulting in the need to accelerate our strategy for 2030 and beyond.

Our core pathway

An estimate of approximately £400 Million has been allocated to AMP9 and AMP10 to deploy this innovative technology. A further investment of £90 Million in the innovative technology is forecasted for AMP11 to manage additional wastewater sludge arising from growth and quality enhancements from 2030. The Core Pathway also includes investment in additional STC capacity to address growth.

The Core Pathway delivers the bioresources ambition under the following future scenarios:

- Benign Climate Change CRS
- Benign Demand CRS
- Benign and Adverse Technology CRS
- Benign and Adverse Abstraction Reductions CRS
- Benign and Adverse Water for Energy wider scenario

Though the specific wording of Ofwat's CRS for technology does not include factors related to bioresources management, the development of technology and its associated trends have important influences on our long-term strategy. We have considered these by testing a wider scenario for technology. This testing process found that:

- Improved condition-based maintenance in 2030 would mean better optimisation of maintenance to improve uptime – make better use of existing capacity. This would mean we can deliver more through base expenditure.
- We already use basic digital twins through our production and tactical system models and transport logistics models however the addition of live data (assumed in 2027 in our wider scenario) would provide further benefits.
- Extending digital twins to incorporate natural assets (assumed from 2027) has the potential to improve the representation and management of available landbank. The potential for a national bioresources system twin with landbank included has already been discussed with Ofwat and we continue to promote it.
- Wastewater treatment innovation has the potential to impact on the quantity and quality of sludges produced in treatment that are treated and recycled by bioresources. This could have both positive and negative impacts across the price control in the longer term but in near to medium term we consider them unlikely to be significant.

Alternative Pathway BIO-D would be followed from the middle of AMP8 if the Resilient Bioresources research project fails to identify a viable alternative to incineration. Investment in incineration would then occur in AMP9 and 10 (approximately £400 Million) and again in AMP11 (approximately £90 Million) to manage growth. Alternative Pathway BIO-D is only required to be followed under the Adverse Landbank wider scenario.

Alternative Pathway BIO-C would be followed from the middle of AMP8 if the landbank availability risk fails to materialise. This would principally be associated with a revision to the Environment Agency's interpretation of Farming Rules for Water that enable the Autumn spreading of bioresources to agricultural land and in addition, confirmation that there will be no additional restrictions on the recycling of biosolids to agricultural land within the period. Under this alternative pathway, no investment in technology to manage landbank risk is required and the existing approach to managing bioresources is broadly continued. **Alternative Pathway BIO-C** is only required to be followed under the Benign Landbank wider scenario.

Climate change has a significant impact on landbank availability and our analysis of Ofwat's CRS for climate change indicates that under the adverse version of the CRS, there is a risk that our core pathway of investment is insufficient to deliver our ambition. An alternative pathway is required commencing in AMP10 which would expand our preferred technology, either a new technology (to be developed and refined) or incineration. **Alternative Pathway BIO-A** is only required to be followed under the Adverse Climate Change CRS.

Our final alternative pathway (**Alternative Pathway BIO-B**) is required under the Adverse Demand CRS only. It involves the acceleration of investment to manage growth from AMP12 and AMP11.

The most significant factors that result in a change to the core pathway are monitored through changes to agricultural land bank availability. We continually monitor access to available land bank for the recycling of our biosolids products through a number of metrics, these include but are not limited too;

- Farmer satisfaction
- Price point of products
- Input costs to farmers of conventional and other fertiliser/soil conditioner products
- Distance travelled from production to application site (work done to access land)

Recognising these could generally be considered lag measures, we will also;

Work with the wider water industry and relevant stakeholders to progress and refine national land bank scenario modelling at agreed points within the AMP period

Regularly review and update our own land bank modelling, to test the impact of regulatory changes and/or other scenarios, as statutory guidance and regulatory changes occur, or as other information becomes available.

We have assessed the landbank available and landbank required by Anglian Water, under the five scenarios included in the latest landbank modelling, as follows -

Scenario	Landbank available	Landbank required	Headroom %
1	866,000 Ha	204,200 Ha	76.4%
2	712,000 Ha	415,100 Ha	41.7%
3	635,000 Ha	505,800 Ha	20.3%
4	597,000 Ha	2,142,400 Ha	N/a
5	399,000 Ha	3,863,100 Ha	N/a

Table 1 – Landbank & Headroom

We currently have access to a total of c.712,000 Ha of agricultural land in our operational area and have a requirement for a total of c.415,000 Ha (i.e., Scenario 2 above).

We assess under the core pathway that our land bank requirement will increase from 415,100 Ha to 505,800 Ha and that our available landbank will reduce from 712,000 Ha to 635,000 Ha by 2030. This represents a reduction in headroom from c41.7% to c.20.3% by 2030.

We have set a trigger for any decision to commence investment for alternative pathway (Bio-D) when we have declining headroom and assessed this to drop below 20%.

This same method will also be used to defer investment in the benign scenario (BIO-C) or the adverse climate change scenario (Bio-A).

Our extensive benefits mapping programme has identified that our long-term bioresources strategy would have a number of direct links to the delivery of performance commitments and other targets:

- Pollution incidents (total and serious)
- Storm overflows
- Bathing water quality
- Discharge compliance
- Net zero commitments
- Operational process emissions
- Transport emissions
- Energy demand

The areas of significant contribution from the benefits mapping exercise include;

- improvements in discharge compliance as providing a robust and sustainable outlet for sludge produced at our WRC's for treatment and onward recycling allows sludge stocks to be managed on sites, mitigating risks associated with carrying high sludge levels in process tanks and high mixed liquor in aeration processes for example.
- A robust and sustainable bioresources strategy also significantly contributes to our targets for energy demand by maximising energy that we can recover and use beneficially from our sludge treatment processes, such as generating green heat and electricity from our CHP engines or transitioning to biomethane upgrading and grid injection. This in turn supports our net zero, operational carbon and process emission targets

Bioresources Markets

We are actively engaged with promotion and development of bioresources markets. We support the idea that use of markets can help companies deliver against their strategic ambitions for bioresources. To promote better understanding of markets for bioresources we have recently completed an Ofwat Innovation Fund catalyst competition project titles 'Unlocking Bioresources Markets', we were the lead water company, partnering with Business Modelling Applications and four other WASC's, Northumbrian Water, Yorkshire Water, Thames Water and Southern Water. The project explored a wide range of scenarios using a systemic approach and compared outcome of both closed (constrained by existing operational borders) and open networks (no border constraints) to understand the 'art of the possible'.

For more information on the project and the key finding can be accessed on the Business Modelling Applications website

www.businessmodelling.com/bioresources-market-growth

Supporting development of a sludge market

We support Ofwat's view that the development of a sludge market will provide a range of potential benefits. Whilst there are a number of barriers to the development of this market, we have been working with other water companies and our environmental regulators (EA & Defra) to resolve these issues, in addition to publishing our Market Monitoring Information and Bid Assessment Framework, to facilitate the successful development of the sludge market.

With the right conditions, a market will help the sector to meet its potential to create economic and environmental value, by enabling and incentivising:

- technological changes, making treatment more cost effective and enabling greater generation of renewable energy;
- economies of scale;

- inter-company optimisation – such as through trading or development of joint capacity; and
- co-digestion of sludge with other organic waste.

Jacobs categorised the constraints associated with the development of the sludge market into three key types. Some constraints pass across the categories as shown in Figure 2.

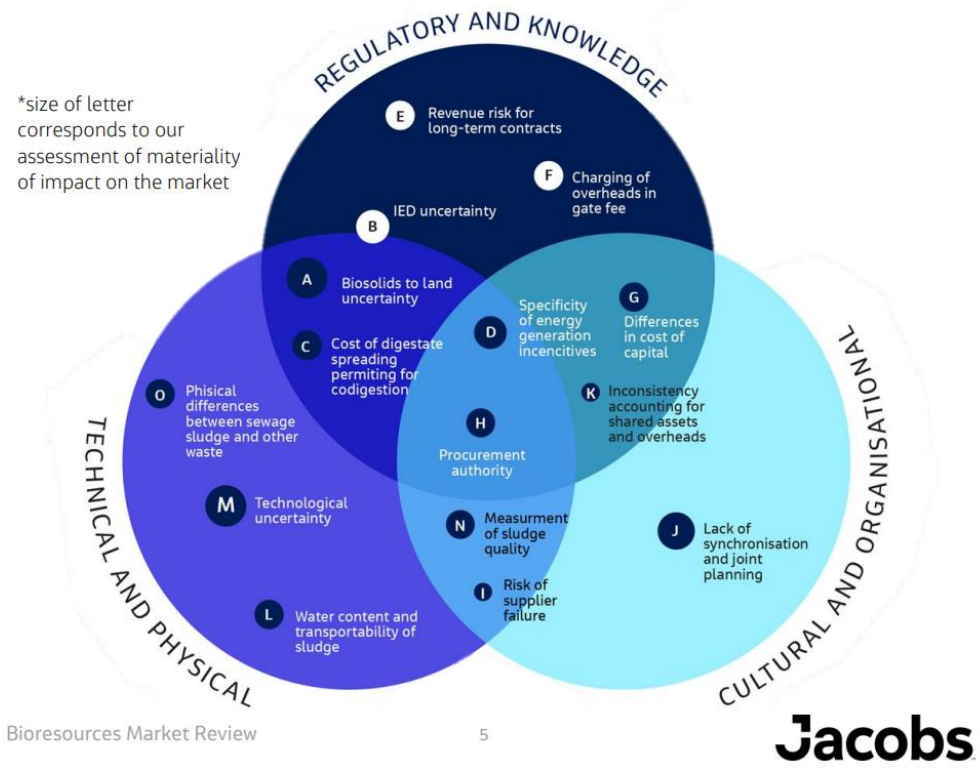

Figure 2 – Extract from Bioresources Markets Review Report by Jacobs for Ofwat

1. **Regulatory (and knowledge).** These constraints predominantly relate to the impact of uncertainty on decision making in the sector and are driven mainly by environmental regulation change.

   We continue to play a leading role in discussions with our environmental regulators (EA & Defra) over the uncertainty surrounding environmental legislation and how this may affect biosolids recycling to agricultural land in future. We engaged with the Industry, environmental regulators and stakeholders over the interpretation of Farming Rules for Water, playing a lead role in the development and agreement of the Industries 20 Measures in autumn 2021. This allowed biosolids recycling to agricultural land to continue delivering the significant circular economy benefits associated with the return of nutrients and organic matter to land and the generation of renewable energy.

   We promoted development of the Biosolids Assurance Scheme, gaining support for its initial development from Water UK Board and its ongoing evolution to meet changes in the legislation and best practice associated with the agricultural recycling of biosolids. The scheme seeks to ensure continued confidence in the safety and sustainability of recycling

biosolids to land. More recently we have been working to ensure the latest version of the BAS standard includes the requirements associated with the industries 20 Measures (Farming Rules for Water), whilst considering further changes associated with the development of the EA Sludge Strategy, which includes use of the BAS Scheme as earned recognition under light touch EPR. Whilst transition to light touch EPR will add additional cost to the industry's operations, use of the BAS scheme as earned recognition provides an opportunity to minimise the overall cost, whilst opening the opportunity for co-digestion, trading with third AD (Anaerobic Digestion) operators and a reduction in the overall level of uncertainty.

We promoted the development of a PFAS sampling & analysis protocol for biosolids, in response to concerns over agricultural recycling being a significant route for PFAS into the wider environment. This work will allow companies to investigate and potentially apply further trade effluent controls where appropriate, based on the results obtained.

We are committed to working with our environmental regulators on the Chemicals Investigation Programme (CIP4 (Chemicals Investigation Programme 4)), with appropriate representation on all working groups and funding included in our WINEP programme. It's essential that the industry continues to research the fate and impact of chemicals and microplastics in biosolids, so that appropriate controls can be applied to ensure both food safety and that the practice still is sustainable for the future.

2. **Cultural and organisational.** These relate to the activities and actions of the water companies and other market participants and how they are incentivised.

   We have taken the lead role, with four other water companies, to develop a collaborative strategic planning capability, underpinned by Business Modelling Associates' adaptive systems planning software. This has identified opportunities to trade bioresources across existing assets and determine the optimal blend of future inter-company investments; tackling shared challenges and maximising environmental and customer value. The project challenges the traditional siloed business planning approach for bioresources and clearly demonstrates the benefits of collaboration and adaptive systems planning, applied to strategic asset management decision making.

   We are now reviewing the potential to expand the project, to include all UK water and sewerage companies, allowing the full benefit associated with trading bioresources across company boundaries and the full network of assets to be assessed.

   We continue to engage in short-term trades with our neighbouring water companies as required and attend industry bioresources market discussions facilitated by Jacobs, to share opportunities and discuss further actions to promote development of the market. We publish our bioresources market information annually, responding to enquiries and have approached the market recently in relation to the need for additional sludge treatment capacity in AMP8.

   We remain committed to the development of the sludge market and will continue to work

with the industry, third parties and Ofwat where appropriate.

3. **Technical and physical.** These are dominated by the physical properties of sludge and its effect on the market as well as shortfalls in technological solutions for future environmental risk.

   We continue to focus on reducing the volume of sludge transported, through thickening and dewatering. We have developed a fleet of mobile sludge thickeners, capable of moving from site to site to thicken sludge prior to collection by road tanker. This innovative approach provides a solution for small to medium water recycling sites, where it is not practical to install fixed thickening/dewatering equipment, as a result of the volume of sludge produced.

   Through a greater focus on operational control, we are ensuring sludge stocks are managed more effectively, with fresher sludge moved to STC's for treatment, providing a greater level of biogas production and higher value in terms of potential trades.

   At STC's we are capturing a greater level of operational information, to allow processes to be managed more effectively, ensuring compliance with legislation, whilst maximising the generation of renewable energy.

Engaging with Bioresources Markets

We continue to actively engage with the supply chain and neighbouring WASC's exploring potential market solutions. This is for both trading sludge out of area, into our sludge treatment asset base and in the longer term potential third party or joint venture arrangements.

In spring 2023 we issues Prior Information Notices (PIN) on Find a Tender for;

- Sludge Treatment Management Services – Provision of up to 23,000 TDS (Tonnes Dry Solids) of additional treatment capacity to cater for our needs through to 2030
- Biomethane Upgrading – Provision of 3No Biomethane upgrading plants to support our transition from CHP in support of our net zero plans

We have also positively responded to a contract notice from our neighbouring WASC, Yorkshire Water and are open to provision of up to 5,000 TDS per annum of sludge treatment and disposal services. However, it must be noted that due to limitations within our own capacity it is likely that we could only offer a contract where we were successful and trading out elsewhere in our region. The Innovation Fund Catalyst 'Unlocking Bioresources Markets' project has shown that there are potential benefits that can be unlocked through cascade effects of traded across company networks and we continue to actively explore these opportunities.

In September 2022 we published our Bid Assessment Framework for Bioresources. We welcome and encourage companies to engage with us to support our strategic ambitions for bioresources. Companies wishing to engage are encouraged to make contact through email to BBAT@anglianwater.co.uk

For links to our Bioresources Bid Assessment Framework, our latest bioresources markets information and other useful links please visit the doing business with others section of Anglian Water website

Doing our business with others (anglianwater.co.uk)

For further detail into our assets, risk, challenges and opportunities for each sub section of the Bioresources price control activities please see the appropriate appendix.

APPENDIX 1 – General Overview

Bioresources price control

The bioresources price control included the collection, transport, treatment of sewage sludge and the onward recycling and beneficial use of products produced through treatment. For example, biosolids cake for use as a soil conditioner and biogas for renewable energy generation or upgraded support the de-carbonisation of heat networks through biomethane injection to the gas grid.

The bioresources price control can be considered as three sub streams, logistics, sludge treatment and recycling. Our business and operations are structured in this manner. These appendices provide more information on the challenges, opportunities and strategy direction in each area aligning to our ambitions.

What we do now

Our current strategy for bioresources was set in 2005. It centres on the treatment of sewage sludge produced at 1,122 water recycling sites at centralised sludge treatment centres (STC). The STC's are designed to treat sludge and produce high quality biosolids products for use in agriculture, as a sustainable alternative to artificial fertiliser, providing nutrients and organic matter to crops throughout the rotation. We sell our biosolids products to farmers on the basis of its phosphate fertiliser equivalent value, under the established Nutri-bio brand, providing significant natural capital benefits.

Figure 3 sets out the Bioresources price control area and the key activities undertaken. These include:

- the collection and transport of raw sludge (untreated) to our Sludge Treatment Centres (STC) or intermediate dewatering hubs
- treatment of the sludge at the STC's
- the production of high quality biosolids products for farmers, and;
- the production of biogas, a valuable renewable fuel we use to fuel combined heat and power (CHP) engines, to generate renewable heat and electricity which is used for our own needs or exported to the grid.

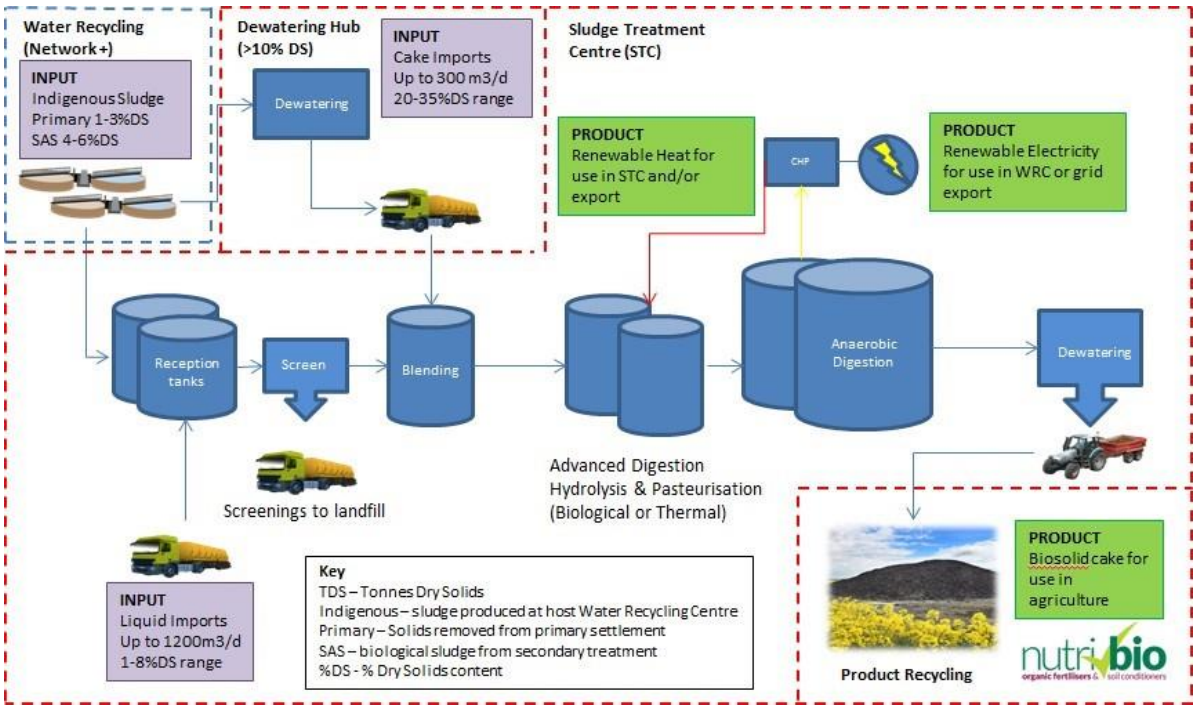

Figure 3 - Activities in the Bio-resources Price Control

For full details of our sludge producing site, our treatment centres and detailed on the bioresources products and services provided can be accessed via our website). The information is updated as a minimum annually. The website also contains links to our Nutri-bio website and the Biosolids Assurance Scheme.

Doing our business with others (anglianwater.co.uk)

APPENDIX 2 - Operational Logistics

Our Asset Base

We operate a fleet of 53 sludge tankers and 22 bulk vehicles, which complete approximately 65% of the planned sludge and biosolids deliveries. The fleet is conventionally fuelled but as part of our Net Zero 2030 plans we are actively exploring alternative fuel options to de-carbonise the operation.

Working closely across our Water Recycling Directorate we use system wide tactical and operational modelling to budget and plan our sludge logistics operations. Our Bioresources team use tactical annual and production planning models that allow us to forecast, plan and optimise raw sludge movements into our bioresources sites for treatment and onward recycling. The outputs of the bioresources production planning are shared with our Operational Logistics team who then use specialist transport planning models to schedule deliveries into individual sites. Figures 4 and 5 are example outputs from our tactical model mapping sludge movements into our bioresources sites.

The tactical and production planning models are digital twins of our bioresources asset base.

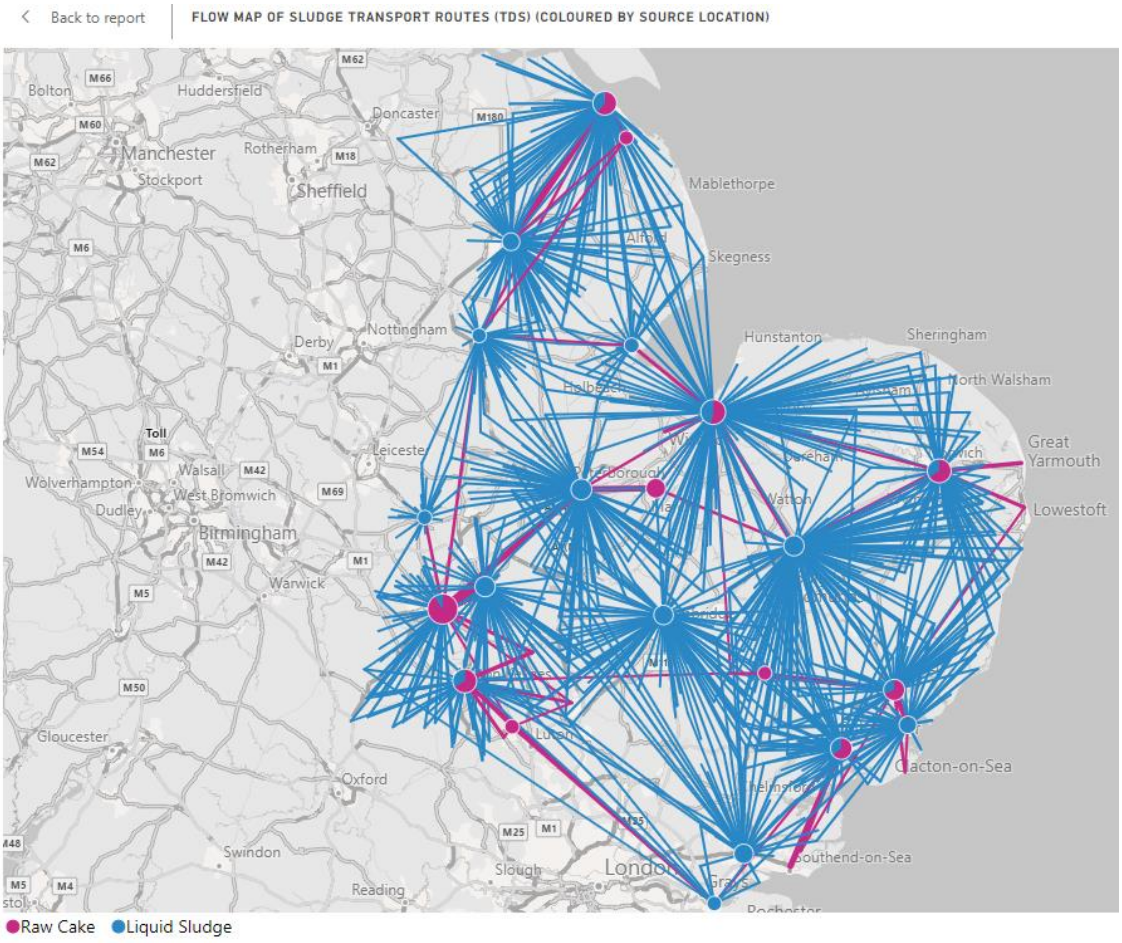

Figure 4 – Model recommended logistics routing, taken from 2025-26 tactical planning model

Figure 5 – Model recommended material movements by site & material type from 2025-26, taken from annual tactical model.

Future strategic direction

All new heavy goods vehicles in the UK will be zero-emission by 2040, the UK (UK government announcement November 2021). The UK will become the first country in the world to commit to phasing out new, non-zero emission heavy goods vehicles weighing 26 tonnes and under by 2035, with all new HGVs sold in the UK to be zero emission by 2040.

Our strategic direction for our operational logistics fleet is being developed in line with this policy and our own stated net zero ambitions.

Transition from conventional diesel fuelled fleet. There is a mix of different technologies coming to the HGV marketplace, with varying levels of readiness and cost;

- Electric Trucks – as of Spring 2023 there are 'manufacturer constructed' vehicles which are market ready. These have suitable range to operate within our fleet. The capital cost is higher than other low carbon alternatives such as HVO (Hydrotreated Vegetable Oil) or CNG/LNG technology, however the overall whole life cost, considering lower fuel costs and reduced maintenance – is attractive versus other options. Four of these vehicles have been ordered for incorporation into the fleet in AMP7 to kickstart this journey and build our infrastructure
- Compressed Natural Gas (CNG)/Liquified Natural Gas (LNG) vehicles are market ready, most comparable to conventional engines in terms of capital cost. The volatility in the gas price has meant this is currently a less favourable business case since fluctuations in the energy markets

- Hydrogen, the current technology is coming to the market as a hydrogen fuel cell, this currently has a very high capital cost option, giving high ranges that are far more than those required in the Operational Logistics operation. We have assessed this technology is not yet viable for our fleet but will re-assess as the technology develops and 'direct' hydrogen fuels become available
- Hydro-treated Vegetable Oil (HVO) – limited additional capital investment needed compared with conventional options, but higher fuel prices meaning an uplift in the whole life cost of vehicles, combined with limited supply of fuel creating a supply chain risk, particularly the procurement of sustainable sources.

Key Risks

- New emerging technologies presenting uplifts in upfront capital expenditure

Key Opportunities

- Reduced fuel prices versus conventional fuels – means benefit presents in lower whole life cost of operation.
- Reduced maintenance on new technologies, meaning reduced maintenance costs and improved vehicle uptime.

Market Engagement

The remaining workload is completed by a number of locally based 3rd party subcontractors, under framework contracts which are tendered at 5-7 year intervals.

The overall sludge haulage workload is tendered on a regular basis to test market costs and drive efficiencies. Our in-house team recharges costs on a unit cost (e.g. £.m3) basis for raw sludge / biosolids cake moved, to ensure alignment with our subcontractors approach. Our long term strategy has been to maintain a cost effective split between in-house and 3rd party subcontracted resource, which in turn helps to minimise the overall risk and cost of these critical operations.

Innovation

Within the current AMP investment period we have continued to work closely with network plus operational teams to support initiatives to improve the dry solids of raw sludge produced at our source WRC (Water Recycling Centre) sites. An example of this is development of mobile sludge thickening technology where we are able to deploy a self served truck mounted machine to small sites where fixed mechanical thickening is not financially viable. We operate a scheduled milk round style system where the mobile thickener visits sites in advance of tanker collections, reducing the volume of sludge requiring movement to our STC sites.

In addition, we continue to develop and evolve our digital tools and systems to enhance our scheduling and planning activities and provide improved in day planning, improving the productivity of our fleet.

As sensing and monitoring technology evolves and connectivity options through IoT (Internet of Things) platforms improve we envisage improved flow of data and information directly into our digital twins we use to plan and schedule our logistics work. This includes current work to move to a a 'click and collect' approach to scheduling collections as sludge is ready, dewatered with sufficient volume in tanks

Digital tools and models with near live data inputs will help improve the dry solids of sludge collected for transport and will improve scheduling, leading to reduced volumes moved and increase fleet productivity, this will also reduce unit cost and carbon emissions through reduced miles travelled.

Decarbonisation of the logistics fleet is a priority. Innovation in the area covering our sludge tankers, tipper trucks and other large machinery is fast moving. Our plan for 2025 – 2030 is to reduce carbon emissions from our logistics fleet by 4,624 tonnes CO2e per annum by replacing our conventionally fuelled diesel trucks with electric, however we must remain alert to technological advances in the sector, adapting our plans to maximise the opportunity to support our net zero ambitions and deliver an efficient, robust and reliable logistics service for bioresources.

APPENDIX 3 - Sludge Treatment

Our asset base

Our sludge treatment asset base consists of 10 centralised Sludge Treatment Centres (STC) and 23 dewatering centres. The STC's are all co-located on a Water Recycling Centre (WRC) and receive indigenous sludge, nine of the STC's also receive raw liquid sludge imports and seven of the nine are also able to receive dewatered raw cake. The STC asset base is based on advanced anaerobic digestion at nine sites and pasteurisation followed by conventional digestion at one STC. At our raw dewatering centres (RDW) and Intermediate dewatering centres (IDW), the 11 RDW sites import raw liquid sludge for dewatering, the 12 IDW sites receive no imports. The dewatered cake is then transported to one of the seven STC's that receive raw cake for treatment and onward recycling.-The map in Figure 6 shows the location of our STC's, RDW and IDW sites and Figure 7 is a representation of a typical STC.

Figure 6 – Map of our Bioresources Asset Base

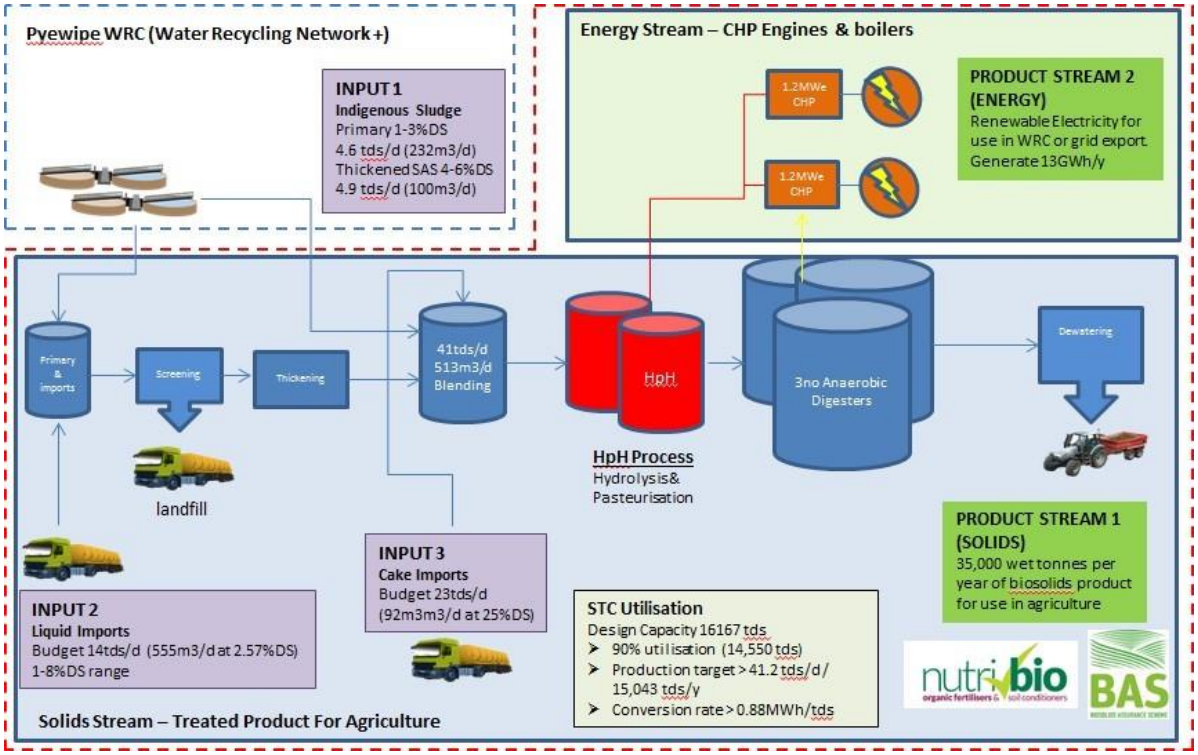

Figure 7 – Pyewipe STC

Future Strategic Direction

Additional capacity – To cater for population growth and additional sludge production arising from proposed AMP8 WINEP schemes we required access to additional sludge treatment and recycling capacity. Table 2 tabulates our forecast sludge production from our water recycling assets that require treatment through sludge treatment centres.

		Sludge Production Profile 2025-2030					
		25/26	**26/27**	**27/28**	**28/29**	**29/30**	**total**
Population	**TTDS**	**162.419**	**163.037**	**163.656**	**164.274**	**164.893**	**818.28**
WINEP	**TTDS**	**0**	**0.459**	**0.459**	**3.876**	**8.211**	**13.005**
Total	**TTDS**	**162.419**	**163.496**	**164.114**	**168.151**	**173.104**	**831.284**

Table 2 – Forecast Sludge Production to 2030

To cater for this increased sludge production, we require capacity to treat an additional 11.304TTDS of sludge by 2030.

Resilience – In order to increase levels of resilience across the end to end bioresources value chain, removing the need to increase raw cake buffer storage we intend to increase our available STC capacity. The intention is to increase our operational headroom by seeking an additional 11.696TTDS per annum of sludge treatment by 2030.

To satisfy this need and the additional capacity need we have included plans for a new 23TTDS per annum STC at our Colchester site within our PR24 submission.

However, it should be noted that we are actively seeking a market solution alternative to us building all or part of this new capacity 23TTDS requirement. We have issued a PIN notice via Find a Tender in spring 2023, options will be fully assessed during the delivery planning phase post determination as it is clear from discussions with WaSC's, suppliers and through the 'Unlocking Bioresources Markets' project that until there is a level of certainty around respective companies plans it is highly unlikely an optimum long term market alternative can be secured.

In addition to capacity we include a programme of investments under the WINEP programme to improve resilience across the supply chain to agriculture. The investments at our sludge treatment sites include;

- Enhanced dewatering at three of our sites to enable cake to be dewatered to >35% dry solids, reducing the volume requiring storage prior to delivery to farmer customers
- Enhanced storage to provide three months of covered (dutch barn) storage for our treated biosolids products, this to allow treated products to be stored on our sites under cover protected from rain, improving the quality of the product delivered to farms and reducing the risks associated with stockpiles on fields prior to land application. Examples of reducing the risk associated with the Bioresources Supply Chain include foot & mouth outbreaks, adverse weather etc.

We also have identified significant investment in improving our remaining open storage facilities together with extensive improvements to our ten STC sites to ensure compliance with new industrial emissions directive (IED) permits that are being issued by the Environment Agency.

Net zero – Activities undertaken within the bioresources price control is significant when supporting our stated ambitions for Net Zero. Within the sludge treatment area of the price control our strategy to support net zero includes;

- Transition from using biogas to fuel CHP engines to biomethane upgrading and grid injection. Our plan is by 2030 at least 54% of the biogas produced at our STC's will be upgraded to biomethane for grid injection.
- Investments to reduce fugitive emissions from our bioresources treatment operations, investments include covering, vacuum de-gassing and recovery of methane from our post digestion systems. Note this is beyond minimum requirements to meet BAT (Best Available Techniques) under the Industrial Emissions Directive which in the majority of cases requires covering and odour mitigation only.
- Capture and recovery, or treatment of ammonia in high strength dewatering liquors. Reducing the load returning to the host water recycling centre resulting in significant reductions in N20 emissions from the water recycling treatment processes.

Alternative technology pathways – The national bioresources strategy highlighted the continued uncertainty over the long term ability to continue to recycle all treated biosolids to agricultural land. It recommends a rapid acceleration in the development of alternative technology options alongside working collaboratively with academia, regulators and other stakeholders to ensure associated regulatory frameworks are in place for all products produced by these emerging technologies.

Key Risks

We have a significant capacity risk, without investment or guaranteed access to alternative sludge treatment capacity through markets.

The graph in figure 8 shows our forecast sludge production versus available capacity from 2020 to 2050.

It includes our AMP7 scheme to increase capacity at Whitlingham, due for completion in 2024/25, new capacity in 2027/28 at Cambridge linked to the planned relocation of the Milton WRC and our planned capacity increase of 23,000 TDS in AMP8 which we forecast will be available in 2028/29.

Our forecast demonstrates we are only planning increases in available capacity through to the end of AMP8. It is likely further additional capacity will be needed in AMP9.

The additional sludge arising from WINEP programmes is included to 2035, assuming a similar impact from WINEP programme in AMP9 to that forecast in AMP8.

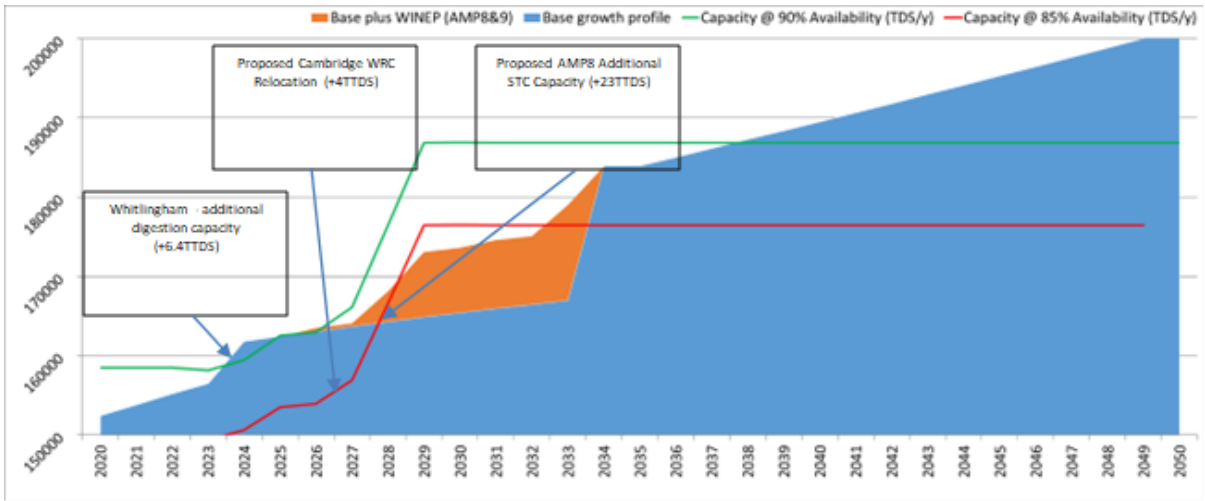

Figure 8 – sludge production vs available capacity

Seasonal variations in sludge production means we require access to significant in year headroom. Figure 9 shows this across the year with significant times of the year where our network needs to operate at greater than 90% uptime to be able to process the volumes of sludge produced by our STC's. This leaves little headroom for undertaking required planned maintenance, learning from recent years means that to ensure we have sufficient resilience across the network whilst we will

continue to target 90% uptime going forward we will plan on 85% uptime. Planning for 85% and targeting 90% is also considered more typical of other similar production processes in other industries.

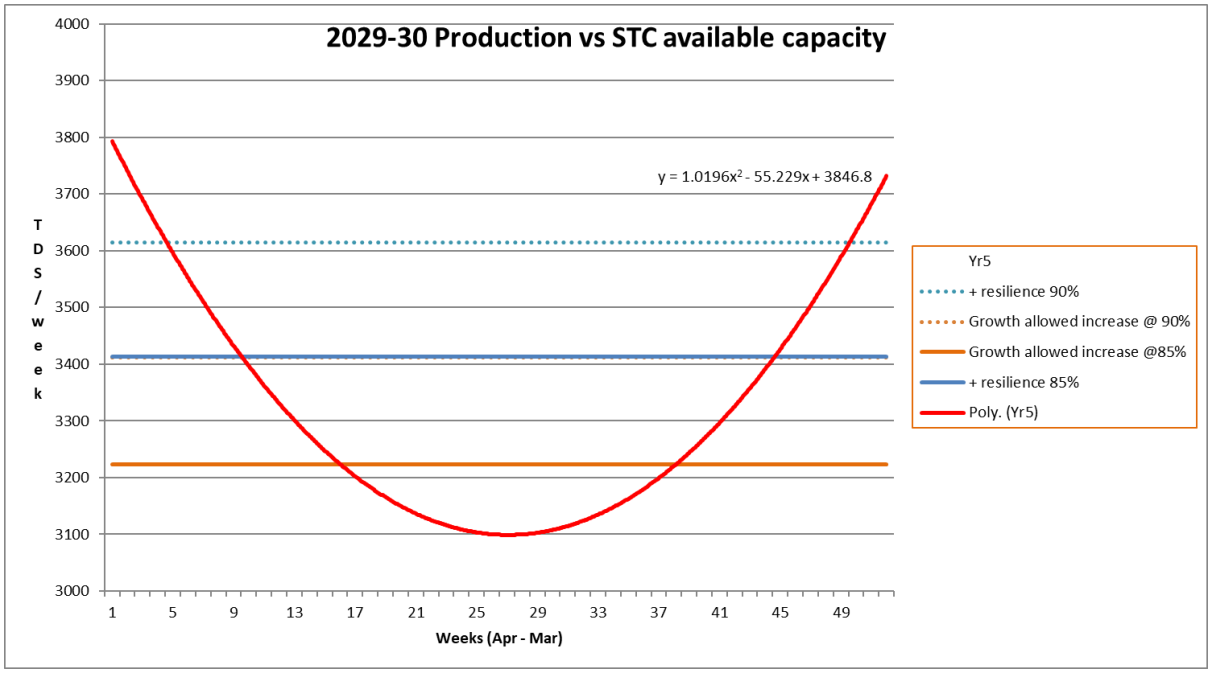

Figure 9 – Seasonal Sludge Production vs Capacity

Available STC treatment capacity is a significant future risk. Our plans for 2025-30 assume additional new treatment capacity of 23,000TDS per annum being made available by 2030. The graph in figures 10 and 11 shows the modelled risk profile with and without this capacity.

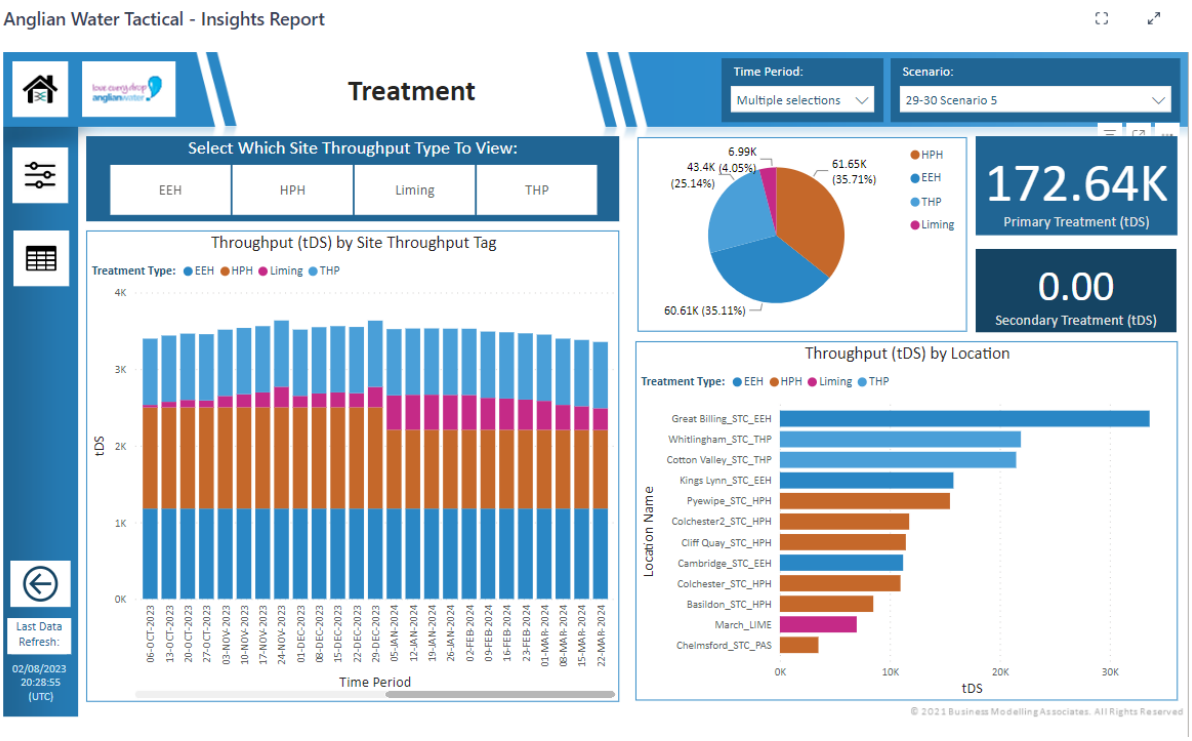

Figure 10 – 2029-30 modelled risk position (no new capacity provided)

This forecasts that at the most optimistic modelled case we would require to export 7TTDS to other treatment outlets. Model assumes that this is mobile lime stabilisation but this could be to a third party or land reclamation. The risk is that there is no guarantee that these alternative outlets are available, therefore our enhancement plan assumes we require the additional 23,000TDS capacity to ensure we have a resilient asset base to manage the forecast sludge production.

Our base plan with the additional capacity is least risk. In this scenario all sludge is modelled to show all sludge produced in area can be recycled and treated throughout installed available capacity as demonstrated in figure 11.

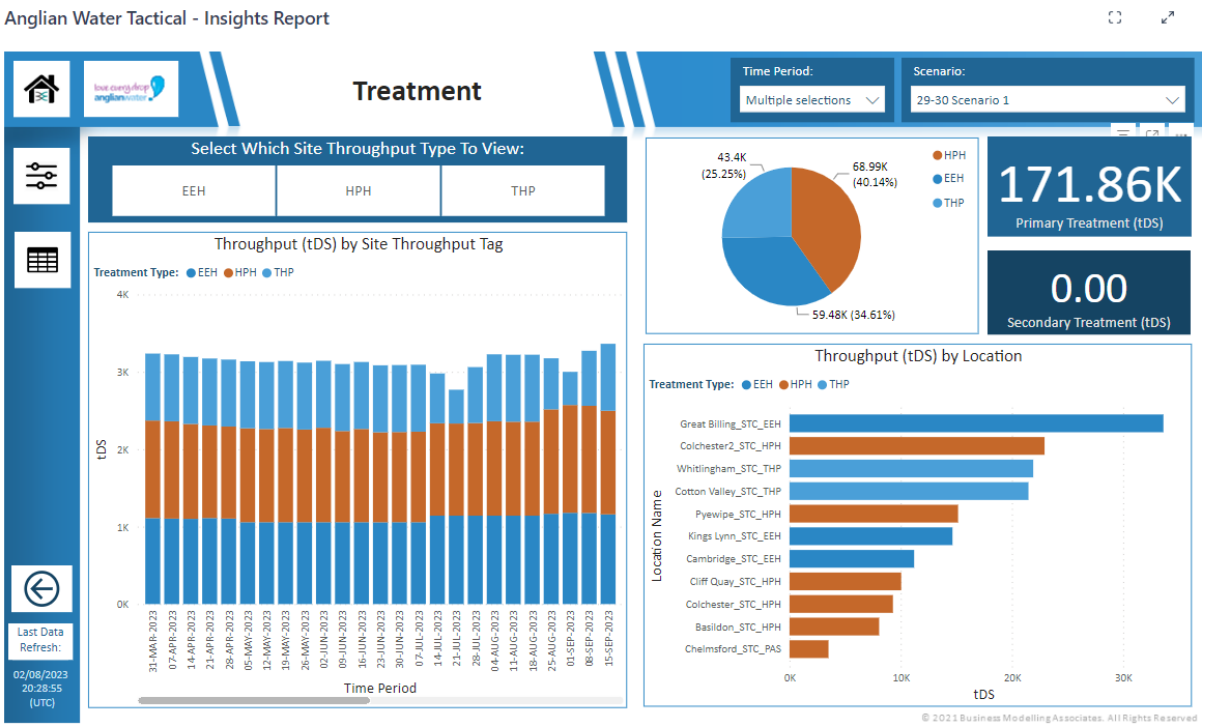

Figure 11 - 2029-30 modelled risk position (with new capacity provided)

Aging asset base

Our four largest STC's were constructed in AMP4 and are approaching 20yrs old. Modern sludge treatment operations include many mechanical / electrical process assets, and many tanks use glass coated steel technology all of which typically have a 15-20 year life span. Whilst it is possible to replace and refurbish some of these assets and maintain the STC operational throughput, many asset inspections, refurbishments or replacements will require a major outage at the STC lasting a number of months. This reinforces the need for additional resilience capacity to be available with our network to allow for this additional planned maintenance and asset refurbishment.

Key Opportunities

Bioresources treatment is a significant contributor to supporting our Net Zero ambitions.

- Biomethane - Our existing asset base uses industry-leading advanced anaerobic digestion technology and we produce more than 55,000,000m3 of raw biogas per annum which is currently used to fuel combines heat and power engines (CHP) and boilers. Our Net Zero strategy is to transition from CHP over to biomethane upgrading. Biomethane upgrading opens wider opportunities beyond that of displacing fossil gas in the national grid, it also opens opportunities to use the gas to fuel vehicles, displacing fossil transport fuels and well as recovery of carbon dioxide for potential beneficial use in manufacturing or other industries, or options to capture for carbon, capture and storage (CCS).
- Liquor Recovery –Liquors from post digestion dewatering are high in ammonia, currently we

either treat this liquor through the host WRC's with the incoming sewage effluent or through dedicated liquor treatment plants located on the STC. Ammonia where it can be cost effectively recovered is a valuable resource with potential to use in many applications such as fertiliser production. This not only can reduce process emissions from our own operations across bioresources and water recycling it also has the potential to help decarbonise other markets.

- Circular economy – there are also wider circular economy opportunities in relation to bioresources treatment. Moving towards a Bio-Refinery approach opens options for phosphorous recovery, bio-polymers, bio-plastics, alternative sewage sludge derived fuels amongst many others.
- Use of markets – In many cases exploitation of these opportunities will likely sit outside of the expertise and normal operations of a water company, opportunities therefore exist across many aspects of bioresources treatment for market entrants to collaborate and partner with companies to unlock this potential. This would be likely be mutually beneficial in delivering against a range of commitments such as net zero and the circular economy.
- Digital - We also recognise the significant role digital and data solutions can offer in supporting us in delivering our ambitions for bioresources. We have over recent years developed digital twin models of our end to end bioresources network that help us plan strategy and our day to day tactical operations. In addition we have created App based tools and dashboards for the collection and sharing of operation data, the collection of the data is currently a mix of telemetered data, site reading and site analysis. Going forward we see a bit opportunity deploying IoT based solutions to improve the breadth data availability and collection across our asset base and for this data to automatically link through to our digital twins that support our in day tactical planning. We are currently rolling out a trial of a Factory Site approach at our Gt Billing STC, this will provide network interconnection across the whole site, full IP enablement, remote access, new SCADA (Supervisory Control and Data Acquisition) systems and enhanced dashboards, enabling us to expand CBM (condition based maintenance) and improve energy monitoring as this will be built in. We anticipate this will grow over time and technology continues to evolve at pace in the sector.

Market Engagement

We are open to market opportunities across bioresources treatment in order to support delivery of our strategic goals and demonstrate delivery of value for our customers.

We have supported market development working with Ofwat and other stakeholders. An example of this is our successful 'Unlocking Bioresources Markets' project funded through the Ofwat Innovation Fund. For further details on this project, the outcomes and recommendations are available on the BMA (Business Modelling Associates) website.

Unlocking-Bioresources-Market-Growth (businessmodelling.com)

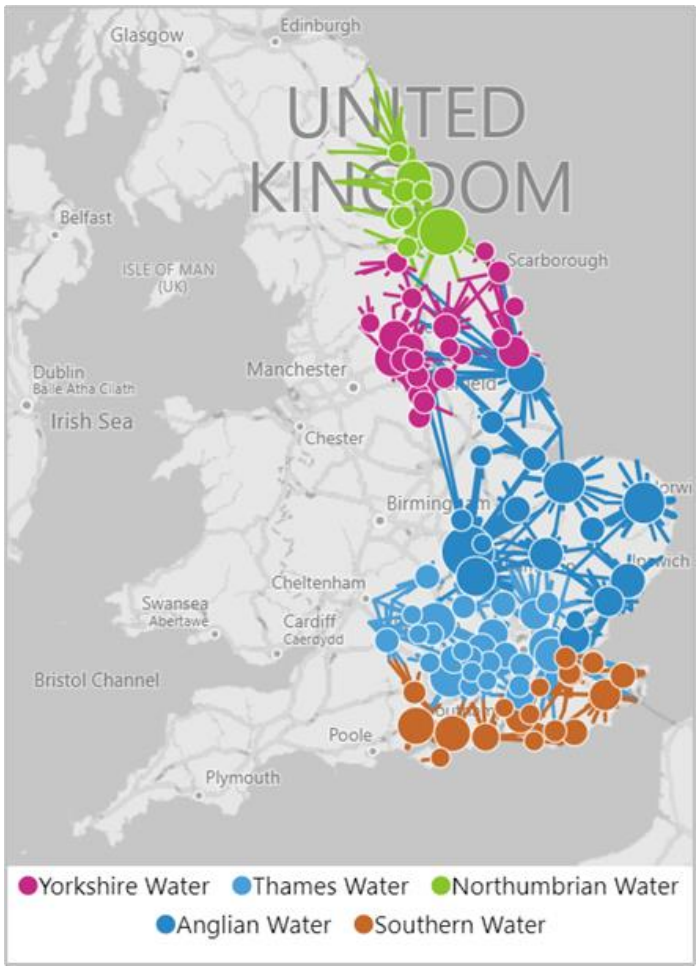

Figure12 – Network map showing potential trading opportunities across the traditional boarders of the participating WaSC's when the network is considered as a whole, rather than five individual company networks.

The model considered the existing asset base and explored potential future scenarios. Figure 13 shows the bioresources value chain pathways that were considered.

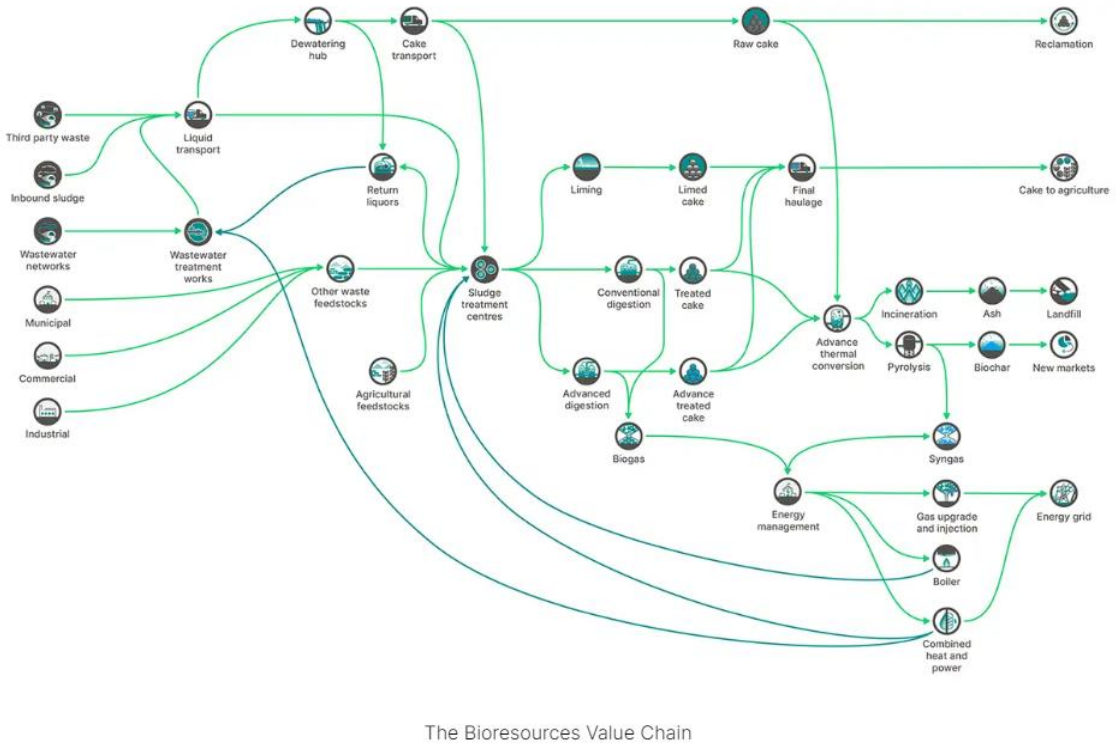

Figure 13 – Model configuration. Pathway options considered

Key finds from the project include;

1. Long-term collaboration - Establishing a foundation of long-term and fully shared collaboration creates a more resilient network to withstand potential future changes and offers significantly greater opportunities. When investments are allowed within the model, the distinction between open and closed networks becomes notably more pronounced, especially in the face of external challenges that impact the network. The effects of scenarios such as the closure of agriculture landbank for product recycling, decreased asset availability, or elevated capital costs all highlight significantly greater opportunities within an open network framework.
2. Short-Term trading - Trading between the current networks can help reduce capacity constraints. In a scenario devoid of new investments, opening the company borders brings an advantage. This advantage manifests as an increased throughput within digestion facilities and a consequential decrease in lime-treated cake production. Lime-treated cake was deployed as the default option when permanent capacity is lacking, becomes less preferable, especially when ample landbank resources are available.
3. Net Zero - There are multiple ways to stimulate the bioresources sector to achieve Net Zero. Three approaches were evaluated for driving the sector towards achieving Net Zero. These included testing the carbon penalty, full carbon accounting (costs and benefits) and the biomethane incentive strategies. While the carbon cost strategy did not completely reduce the carbon emissions down to zero, the full carbon scenario successfully attained a carbon-negative status ahead of schedule. The biomethane incentive scenario also achieved carbon-

negative state, while maintaining a more economical operational cost compared to the alternatives.

4. As-Is optimisation - Systemic thinking can improve both the existing network as well as company-centric investment futures. The advantage arises from optimisation within established constraints. The variance in costs stems from improved capacity utilisation, optimised logistics, and the elimination of redundant material handling. It is important to note that the values presented for the optimised scenario, which accounts for both planned and unplanned downtime events, depict an ideal scenario that is difficult to attain in real-world operations due to the constraints inherent in practical implementation.
5. Regulatory testbed - The network representation allows a testbed for potential regulatory changes. Closing the agricultural landbank results in a substantial impact. Emissions surge by over two-fold, while the demand for capital inflates by more than six-fold, accompanied by a corresponding escalation in operating costs.

For full details of this project and access to the outputs and final report visit the link.

In preparation for delivery of our plans for 2025- 2030 we have engaged with potential suppliers for both Sewage Sludge Management Services, this in relation to our 23TTDS additional capacity need and Biomethane Upgrading to support our transition in from CHP to biomethane to grid. Market notices were issued in Spring 2023. However, suppliers can express interest in providing services to support our bioresources ambitions at any time through our published bid assessment framework.

Through our Bid Assessment Framework (BBAF (Bioresources Bid Assessment Framework)) we have received a number of interesting proposals that align with our ambitions. These include potentially exciting opportunities that would deliver and alternative outlet for sludge derived products, such as production of biochar through Pyrolysis or production of biocrude oils using hydrothermal liquefaction processes, this with possible further refining has potential to produce a sustainable aviation fuel contributing the UK targets to reduce carbon emissions from the aviation sector.

Innovation

Innovation fund projects (AMP7)

Anglian Water are leading on Unlocking Bioresources Market Growth, and are partners on SENECA, Biopolymers in Circular Economy, Ammonia Recovery, and Catalysing a Net Zero Future.

Future use of fund (remainder of AMP7 & beyond)

There is a recognised need to transformational innovation in the Bioresources space, to: (i) enable the opening up of new markets, (ii) test the viability of new Advanced Thermal Conversion (ATC) processes, (iii) develop & test truly circular economy-focussed approaches, (iii) manage increasing concerns around emerging pollutants (PFAS, micro-plastics, AMR etc), and (iv) increase the quantity of renewable fuels being produced from biosolids.

Anglian Water are currently involved in the development of Ofwat bids in the areas of Hydrothermal Gasification, and Gasification of bioresources and Metagenomics of AD for improved efficiency.

Through our Research & Innovation team, we currently fund circular economy research at Cranfield University to investigate the use of membrane separation and crystallisation in the recovery of phosphorus and ammonia. This includes energy generation from ammonia fuels and offset of manufactured ammonia as an input product into other materials such as fertiliser.

Anglian Water are also a partner in a project investigating the use of hydrothermal liquefaction (HTL) to convert biosolids to Sustainable Aviation Fuel (SAF) at a national scale. This project also has international interest from Metro Vancouver in the US.

In terms of increasing quantities of renewable energy from AD, we are looking to develop the first full-scale installation of a technology using thermophilic bacteria to increase AD gas yields by 20%. We are also working closely with academia to better our understanding of the genetics of our biological sludge treatment processes and have recently conducted exciting work with the University of York. This work is aiming to develop ways to monitor digester health using on-site Minion genetic sequencing, as well as ways to improve the biology of digesters for renewable energy production.

Whilst Anglian Water are leading in many of these areas, we feel the urgency and scale of the current challenges requires a cross-industry approach and are seeking ways to collaborate more with other WaSCs to increase the cross-cultivation of ideas and speed the rate of new and reliable innovations entering the Bioresources space.

Adaptive pathway investment for ATC technologies

The recently published National Biosolids Strategy provides insight into the many potential options for ATC technologies. Conversion of municipal biosolids has specific treatment challenges, and the scale at which these technologies need to be developed is a further challenge. Anglian Water is currently involved in projects that will test Hydrothermal Liquefaction, and are preparing additional proposals for Hydrothermal Gasification, and conventional Gasification. To make the findings from these projects relevant at the scale required, and understand the relative benefits of these and other technologies, however, significant investment will be required. With our existing network of commercial, research and engineering partners involved in the bioresources sector, we believe we are well placed to utilise any investment most efficiently to progress the understanding of how ATC processes can provide the adaptive capacity to transform the bioresources space in the water sector in the coming years.

We are currently actively engaged with exploring alternative outlets for bioresources products. This includes an exciting opportunity to potentially use sewage sludge as a feedstock for production of sustainable aviation fuel to help the UK meet targets to decarbonise the aviation industry.

Looking forward we see potential in moving towards a full bio-refinery approach for the treatment, recovery and beneficial use of a range of products derived from sewage sludge. Whilst we recognise many of these options are still at research and development stage and work is required with regulators and end users to ensure there are sustainable pathways to market we are encouraged by the progress that is being made. We fully support the findings and recommendations identified in the national bioresources strategy development report and will continue to be at the forefront of further work in this area both with the supply chain, academic partners and our regulators. Figure 14 is an extract from the CIWEM national bioresources strategy report and illustrates a wide range of opportunity in the space.

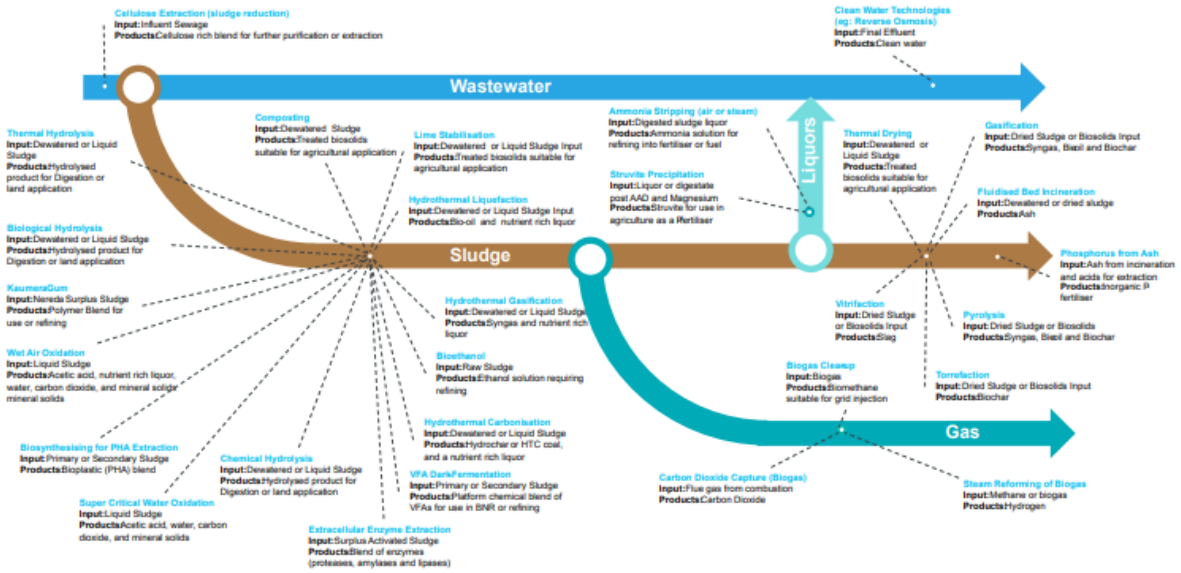

Figure 14 - CIWEM National Bioresources Long Term Strategy Report – July '23

We are active in many areas across bioresources across the solids (sludge), gas and liquid phase. Some of these are covered by work we are leading or supporting through the Ofwat Innovation fund but we are also actively working with academia and supply chain partners directly. Examples include;

Biological Hydrolysis – In April 2022 we announced and exciting partnership with RHDHV to explore and exploit our in-house developed hydrolysis process that we have deployed at four of our ten sites. RHDHV have re-branded the process as Helea and we see great opportunity in combining this technology with other AD technologies in their technology portfolio with the aim of improving organic conversion rates and as a result further reducing residual process emissions supporting Net Zero ambitions.

Carbon Dioxide Capture – We have had a number of enquiries and discussions in relation to carbon dioxide recovery and capture as a beneficial by-product of biomethane upgrading. Raw biogas is approximately 35% CO2 and this has led to discussions regards capture and use in a range of applications from concrete blocks to displacement of manufactured CO2 in fertiliser products.

Ammonia recovery – Typically the dewatering liquors from post digestion are in excess of 2,000mg/l, this is often returned to the head of the host WRC for treatment along with the incoming effluent flows or treated with a package plant. This is not only a high electrical energy and in many cases a high chemical input it also produced high N2O emissions as the effluent is aerated. We are therefore exploring opportunities to recover the ammonia through scrubbing or membrane technologies. Recovered ammonia has the potential to be used in a number of markets including energy generation from ammonia fuels and offset of manufactured ammonia as an input product into other materials such as fertiliser.

APPENDIX 4 – Bioresources Product Recycling

Our asset base & Production

The increase in raw (untreated) sludge production is as a result of a combination of population growth and quality drivers. The reduction in treated sludge (biosolids) production is as a result of investment in enhanced anaerobic digestion processes at our sludge treatment centres.

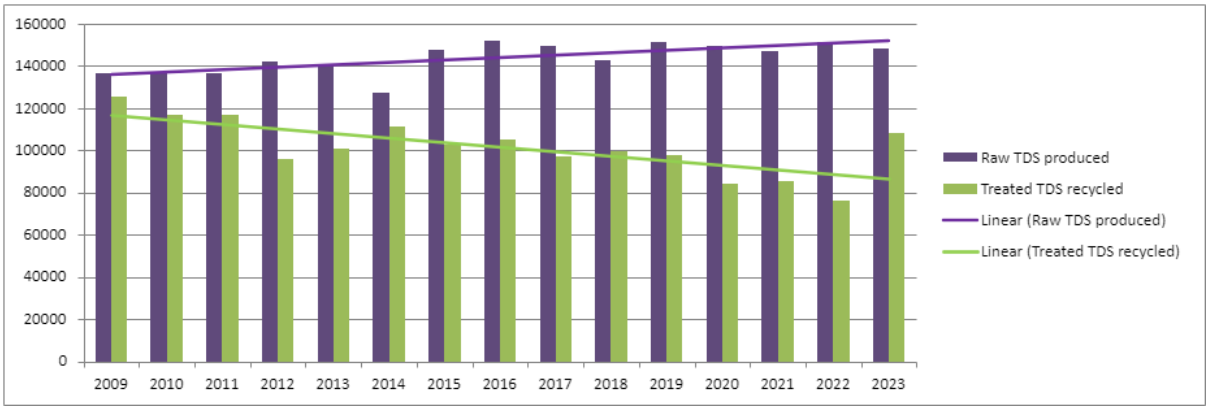

Figure 15 – Historic Raw sludge production vs Biosolids Product Recycled

The chart shows an increasing trend in raw sludge production over time as a result of population growth and tightening environmental consents through the WINEP programmes. Over the same period the tonnage of biosolids recycled shows a reducing trend, this is driven by our strategy to treat our sludge through our advanced anaerobic digestion facilities and reducing over time the quantity we treat through lime stabilisation. This has been achieved through substantial investment in our sludge treatment assets in the period from 2005 – 2015 upgrading and building new sludge treatment capacity.

Year on year variations as can be expected, for our biosolids product output, this can be because of maintenance at our STC's meaning more mobile lime treatment is required or impacts of weather resulting in more stock carrying from one year to another.

Future Strategic Direction

Key Risks

Changes in agricultural landbank availability

Access to the agricultural land bank is critical to Anglian Water's bioresources strategy, so we routinely undertake landbank availability assessments and risk analysis. Our most recent survey considered five different scenarios based on the PR24 WINEP drivers. These scenarios were developed and modelled to understand the effect of increasingly stringent environmental restrictions on our landbank. The models are based on an updated version of the ALOWANCE GIS

modelling tool, with our current Sludge Treatment Centre (STC) configuration.

The five different scenarios modelled are listed below. The assumptions relating to each can be found in Appendix 1 of the Anglian Water Biosolids Landbank Assessment Report (Grieve/ADAS)

1. Historical 2020 baseline
2. Forecast - End of AMP7
3. Forecast - 10 year minimal change
4. Forecast - 10 year most likely change
5. Forecast - 10 year max plausible change

For Scenarios 1–3 there is sufficient available agricultural land within at most 60 kilometres of our STCs. For Scenarios 4 and 5 there is likely insufficient available agricultural land for all biosolids in Great Britain. For Scenario 4 there is an almost 5-fold increase in landbank required and for Scenario 5 there is an over 10-fold increase (based on an increase over Scenario 3).

Summary of estimated maximum distances (km) to access suitable landbank from the scenario maps,

Data	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Figure	*1*	*2*	*3*	*4*	*5*
Amount to land (tds)	90,400	92,300	95,000	103,900	108,400
Landbank required (ha)	204,200	415,100	505,800	2,142,400	3,863,100
Frequency of application (years)	1.5	2.4	2.2	3.5	3.7
Maximum distance to access suitable landbank (km)	24	37	57	>500	>500
Average distance to access suitable landbank (km)	17	26	40	>350	>350

table 3 – Landbank scenario results

The key factors which result in the increase in landbank required (between Scenario 3 and Scenarios 4 and 5) are a ban on applications in the autumn to winter cereals, increased restrictions on phosphate management and increased quantity and P content of biosolids. Restrictions on biosolids use on grassland, rules in/around sensitive sites and a decrease in farmer acceptance also have a negative effect.

Producing an enhanced treated biosolids product at all STC sites would reduce the landbank required, leading to a reduction of almost 1 million hectares. However, the key determining factor is still the environmental restrictions and in particular if biosolids can be applied in the autumn before winter cereals. Changing the rules around phosphorus restrictions and the quantity and quality of biosolids produced also have a significant effect, but the effect is dwarfed by the impact of a possible ban on autumn applications.

The landbank availability maps represent the theoretical maximum distance (to the nearest km) to access both suitable and sufficient agricultural land for recycling biosolids from that site.

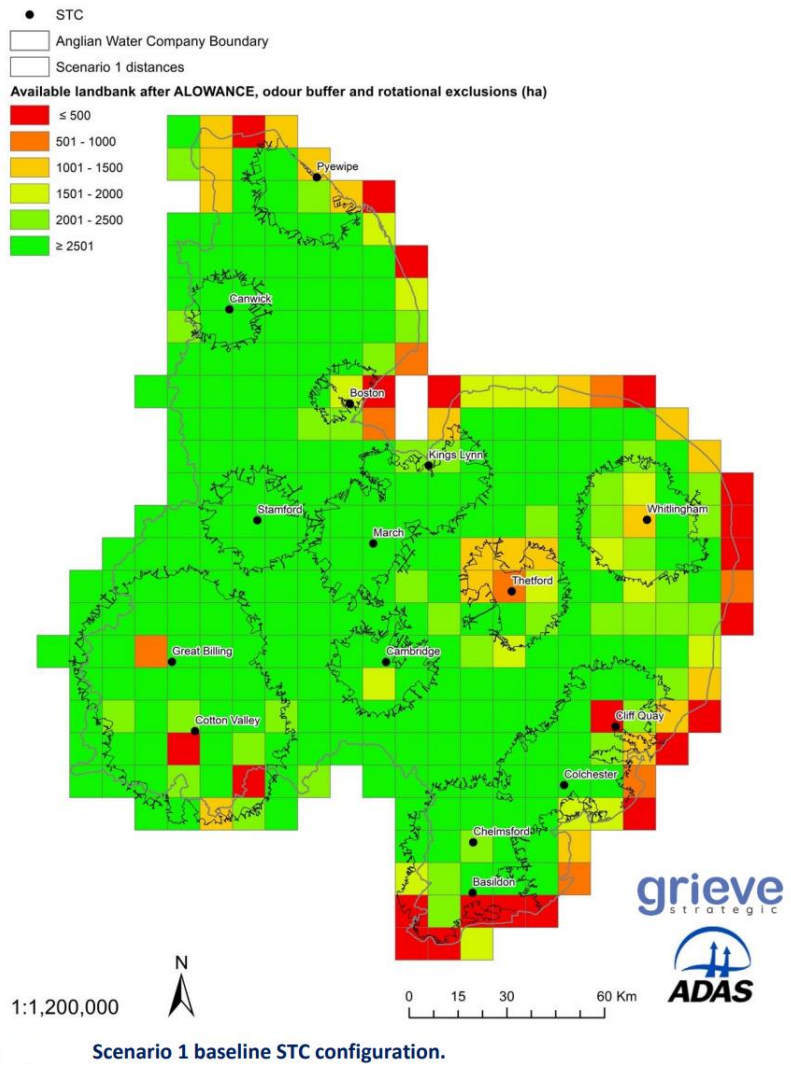

Figure 16 – Landbank Scenario 1

Figure 16 (Scenario 1) illustrates the position which existed at the start of AMP7, with a significant surplus of agricultural land available for recycling biosolids

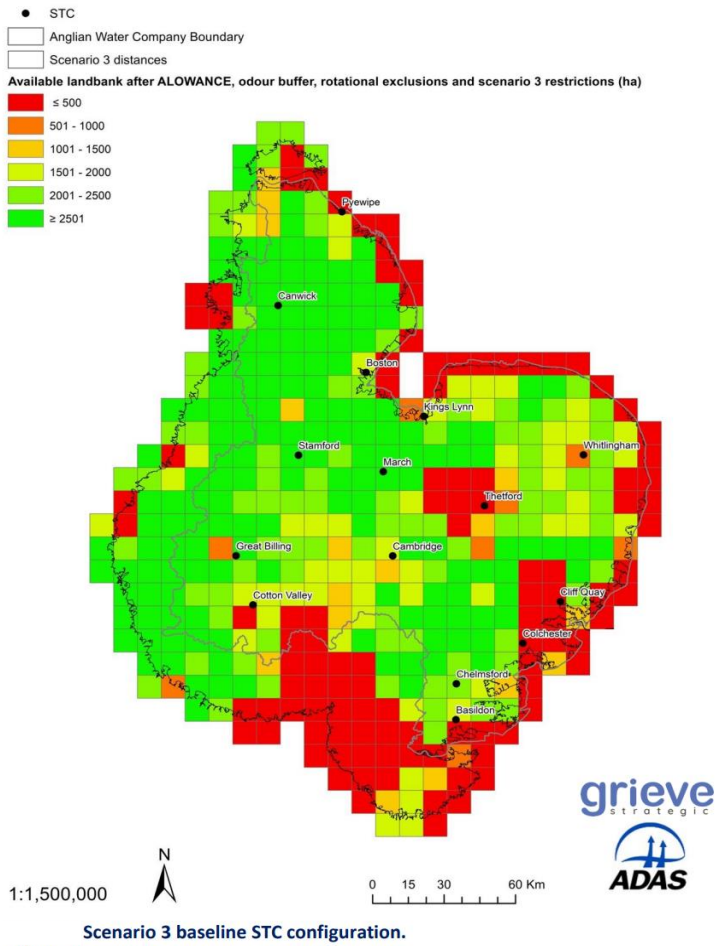

Figure 17 – Landbank Scenario 3

A comparison of scenario 1 (Figure 16) and scenario 3 (Figure 17) highlights the increase in haulage distance and reduction in available landbank, particularly in the south of our region. There is however sufficient agricultural land available for our full biosolids production, subject to the increase in haulage distance.

Our environmental and economic regulators (EA, Defra & Ofwat) have stated that in terms of the AMP8 period, we must plan on the basis of the current legislative & DEFRA (Department for Environment, Food and Rural Affairs) Farming Rules for Water Enforcement Position i.e. scenario 3 in terms of the Grieve/ADAS landbank modelling.

Figure 18 (Scenario 4) illustrates the position if all autumn applications were banned, with the exception of autumn applications ahead of winter oilseed rape, which has an immediate fertiliser nitrogen requirement. In this scenario there would be insufficient available landbank to recycle all our biosolids production.

Further restrictions on biosolids applications, particularly in the autumn ahead of winter cereals is still under consideration by our environmental regulators (EA & Defra). This is despite biosolids only containing a small proportion of freely available nutrient (c.10-15%), which poses a relatively small risk of diffuse pollution by comparison with other organic materials. Given the significant effect this one change would have on the agricultural landbank, which is used for the recycling of c.60million tonnes of organic wastes annually, providing significant soil nutrient and organic

matter benefits and the lead time for implementation of alternative options (typically c.8-10 years for thermal processes), we and other agricultural stakeholders continue to discuss the issue with regulators.

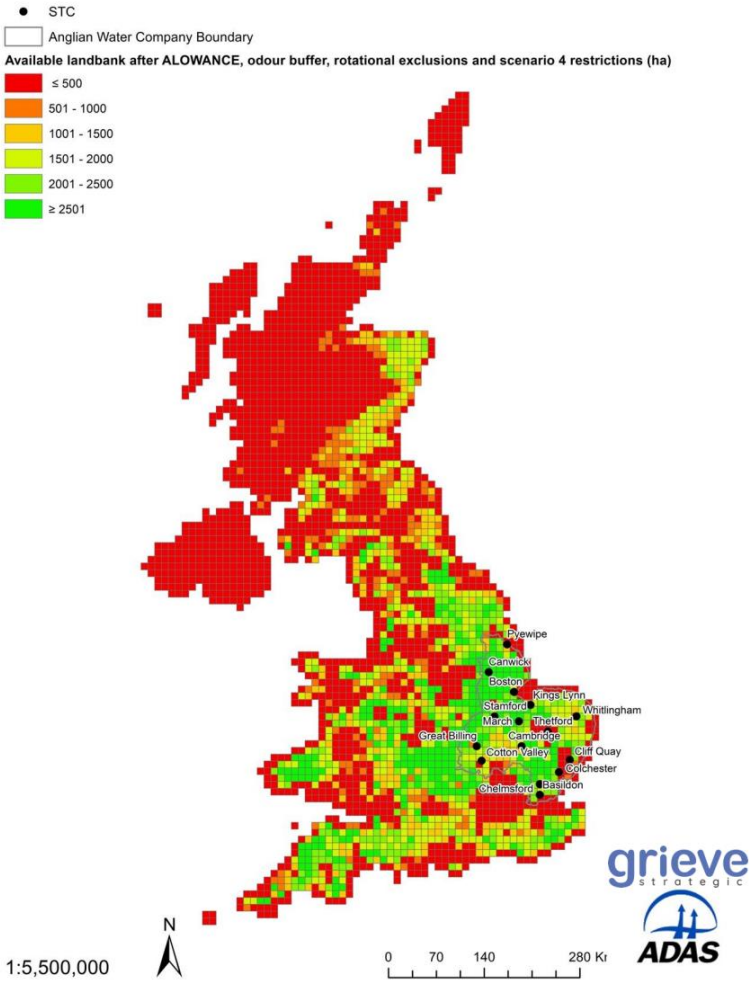

Figure 18 – Landbank Scenario 4

Key Opportunities

Our bioresources activities and the products we produce for onward recycling contribute significantly to our ambitions on NetZero, Carbon and wider circular economy principles. In the medium to long term we see our sludge treatment asset base will evolve to represent a biorefinery approach. As a result we expect the breadth and range of products for beneficial recycling to increase. This will likely include many of the outputs identified in the National Bioresources Strategy Development report and included within figure 14 in appendix 3 of this document.

Market Engagement

Biosolids Recycling (spreading operations to land) are also tendered at 5-7 year intervals, with all the workload now being completed by 3rd party subcontractors. We sell the biosolids product to farmers as a replacement for artificial fertiliser, recovering a significant annual revenue stream.

Retaining a sustainable landbank for our biosolids recycling operations is critical to the future of our business and the quality of service provided by our biosolids spreading contractors in particular forms a key aspect in securing that landbank. We conduct a number of farmer surveys to ensure that the service provided continues to support their needs.

The surveys illustrate that timeliness of spreading, minimising soil damage (compaction) and ensuring an even spread of material across the field are the key customer service requirements.

As a result of customer and stakeholder feedback, our strategy is to purchase and retain ownership of eleven high specification trailed biosolids spreaders and to subcontract the operation of these units to approved 3rd party operators.

The units have a high capital cost and a significant lead time to purchase, which restricts the number of potential operators able to provide the services consistently and poses a significant risk if any of our subcontractors were unable to provide the service at short notice. We believe the approach of owning the units and then subcontracting their operation minimises the overall risk and cost of the spreading operation, whilst ensuring that the agricultural landbank can be sustainably maintained for the future.

Innovation

Development of alternative bioresource products

We are adopting a Circular Economy approach to the challenges we face with bioresources, in particular concerns in relation to contaminants such as PFAS and microplastics. We're working with partner organisations to develop advanced thermal conversion (ATC) processes for the treatment of sewage sludge and biosolids. There are a range of ATC processes which have the potential to generate syngas, biochar and biocrude in differing proportions, dependent on the specific characteristics of the ATC process, whilst also removing contaminants such as microplastics and PFAS. One of these projects involves the development of a pilot and subsequent full-scale hydrothermal liquefaction plants, for the generation of sustainable aviation fuel (SAF) from biosolids, to contribute towards UK government targets for decarbonisation of the aviation industry.

The biochar produced as an output from these ATC processes could be recycled to agricultural land, in a similar manner to that of biosolids, providing long-term carbon and nutrient benefits over incineration. There is currently however no regulatory framework under which sewage derived biochar can be recycled to agricultural land, so we're commencing a project, to work with other stakeholders and the Environment Agency to develop a suitable framework, which already exists in other European countries. We're also working with others to investigate the potential of utilising this material in the manufacture of concrete. We're confident that alternative bioresources products will develop to meet the challenges currently faced and will play an active role to ensure this happens.

Improving treated sludge (biosolids) product quality

Maintaining the agricultural recycling route for biosolids and therefore building strong relationships with agricultural and food chain stakeholders is critical. Since the introduction of the safe sludge matrix in 1998 we have been successful in moving our traditional sludge disposal operations to a product and customer focused function. We were the first UK WASC to have our agricultural recycling operations accredited by LRQA for 9001 and 14001. We were also the first to market our products at prices linked to the market value of rock phosphate (typically we sell our products based on c.80% of the phosphate fertiliser equivalent value).

We have an established nationally recognised brand in Nutri-bio for the treated biosolids products we recycle. We actively engage with our farmer customers and key agricultural and food industry stakeholders using this brand. Further information on our products and the services we provide to our customers can be found at www.nutri-bio.co.uk

We believe that agricultural recycling of biosolids is currently the best practical environmental option in most cases and the ongoing implementation of the national Biosolids Assurance Scheme (BAS) is designed to help to protect the agricultural outlet. We promoted the initial concept of an assurance scheme to the industry and have led the development of BAS. We see its full adoption across the industry and continued evolution to meet stakeholders needs as critical to maintain the compliance and quality of biosolids products used for agricultural recycling, and the confidence of food chain and other stakeholders. Anglian Water is represented on the board of Assured Biosolids Limited which operates and administers the Biosolids Assurance Scheme. Further details of the scheme can be found at www.assuredbiosolids.co.uk

Whilst agricultural recycling is currently the best practical environmental option, there are growing concerns however over the long-term sustainability of this approach, particularly in relation to contaminants such as PFAS and microplastics, tightening of legislation associated with diffuse agricultural pollution (nitrogen & phosphate) and the impact of climate change. We are committed to protecting the agricultural recycling route for as long as possible, but it's likely that we will have insufficient agricultural landbank to recycle all our biosolids production within the next 10 years, hence the development of the alternative pathways outlined earlier.

We consider the following steps to be essential to protect the agricultural landbank in the short to medium term -

- **Enhanced treated biosolids** – with the increased landbank restrictions associated with nitrogen & phosphate, a transition to enhanced treated biosolids is now essential, reducing the overall rotational landbank requirement by c.1 million Hectares and the associated haulage distance. Our sludge treatment processes are capable of treating to the enhanced standard.
- **Dry solids** – increasing the dry solids of biosolids produced at any STC reduces the freely available nutrient content and thus the diffuse pollution risk when applied to agricultural land. The Industry committed to increasing the dry solids content of biosolids to a minimum of 25% at all sites when developing and agreeing the "Industry's 20 Measures" to ensure compliance with Farming Rules for Water.
- **PFAS** – with the increased focus on PFAS/PFOA (forever) chemicals, we will sample & analyse our biosolids products twice annually for a suite of these chemicals and conduct catchment investigations to trace and proactively manage down the levels of these

chemicals in biosolids.

- **Microplastics** – we will ensure all the wastewater entering our Water Recycling Centres is appropriately screened, to remove physical contaminants at the start of the treatment process. All sludge will be fine screened (<6mm) to protect biosolids quality and to ensure that abrasion of plastic particles within the sludge treatment process, which would add to the overall microplastic content, is minimised.

We fully support and are actively engaged in the UKWIR (United Kingdom Water Industry Research) Chemicals Investigation Programme (CIP4), which includes studies into the impact of PFAS and microplastics on groundwater.

The challenge associated with chemical and microplastic contamination of wastewater and bioresources is particularly difficult. We promoted the recent BITC (Business in the Community) project **Optimising Bioresources: Reducing Water Pollution** (Reducing plastic and chemical pollution of wastewater) and fully support its findings. The proposed hierarchy of actions identified as a result of this project is illustrated in figure 19.

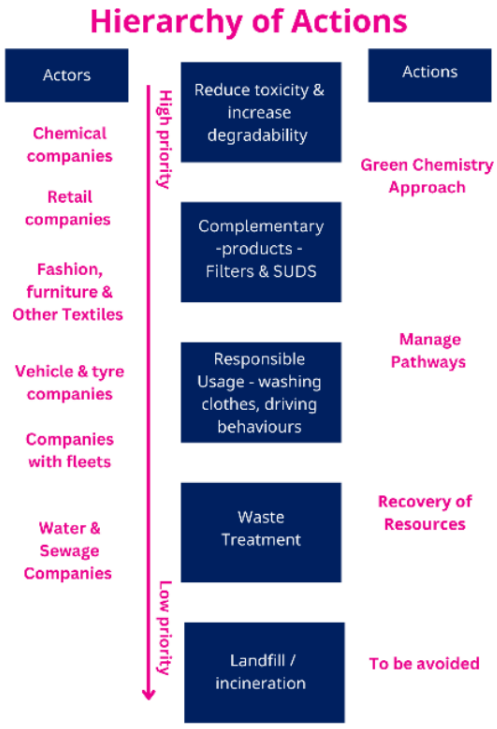

Figure 19 – hierarchy of actions

Our 25 year strategy continues to build on the investments and strategic changes to our bioresources asset base made since 2005 by delivering high quality products for agriculture in the short/medium term, with the addition of advanced thermal conversion processes for at least part of our production thereafter. Generating renewable energy will remain at the heart of what we do and contribute to our long term ambitions on NetZero, carbon and sustainable growth in our 25 year Strategic Direction Statement. Our PR24 plans for Bioresources represent a stepping stone towards those long term aims.