Dŵr Cymru
Welsh Water

Enhanced Investment Case: WSH65-PE09 - Increasing Storage and Treatment Capacity and Disposal Options for Biosolids to Deliver Legal Drivers

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Executive Summary

We have structured this document using the enhancement assessment criteria set out in section A1 of Appendix 9 (Setting Expenditure Allowances) in the PR24 final methodology. The enhancement assessment criteria are divided into four criteria groupings:

- Need for enhancement investment (5 sections).
- Best option for customers (3 sections).
- Cost efficiency (2 sections).
- Customer protection.

Need: Effective treatment of biosolids enables processes at Wastewater Treatment Works (WwTW's) to operate in accordance with permits and to protect the environment. Additional biosolids will be created during the AMP8 period as a direct consequence of the National Environment Programme (NEP) and Water Industry National Environment Programme (WINEP). The need considered here is specifically for remote treatment centres receiving additional biosolids for further processing, as such it is not linked to specific WINEP/NEP driver codes for specific sites.

In addition to increasing volumes of sludge, legislative requirements in relation to sludge use in agriculture regulations (SUiAR) are evolving and are impacting how biosolids can be stored and ultimately disposed of.

Underpinning the need for this investment is the forecast across Welsh Water's operational area for biosolids volumes to increase from 2022 by 6% in 2025, by 10% in 2030 & by 13% in 2035 at Welsh Water's existing dewatering facilities.

Options: We have assessed different scenarios using cost benefit analysis (CBA) within Welsh Water's biosolids model. The model takes account of the biosolids loads created by differing WwTW processes (filter versus activated sludge etc.), in comparison to existing available biosolids storage and treatment capacity. The model also forecasts future biosolids volumes that will be created by considering the Phosphorus removal technique to be implemented and the impact of this on specific sites.

Our chosen option is centred around investing in new enhanced dewatering facilities. Enhancing dewatering capability will provide a basis from which increased capacity can be delivered.

What We Will Deliver:

1) Increased capacity at 5 regional biosolids processing centres (biosolids receiving, storage, transfer, thickening, dewatering).
2) Process upgrades and a new digester at Five Ford WwTW with associated work at Queensferry.
3) Conversion of Queensferry WwTW to a raw biosolids dewatering site (including liquid imports).
4) Significant increases in regional storage capacity.
5) Pilot low temperature biosolids drying technology, nutrient recovery techniques, emerging chemicals and micropollutants in sludge.

Investment Objectives	Regulatory Programme	Number of Sites	CapEx	OpEx	TotEx
Additional Digester at Five Fords WwTW & Dewatering at Queensferry WwTW	SUiAR	2	£20.413M	£1.316M	£21.729M
Upgrades to regional dewatering centres for additional P and CSO solids loads.	NEP	5	£54.434M	£9.429M	£63.863M
Low temperature drying and temperature treatment assessment	NEP	1	£6.768M	£7.967M	£14.735M
Nutrient recovery technology assessment	NEP	1	£5.264M	£-0.041M	£5.223M
Enclosed biosolids storage	NEP	10	£15.674M	£0.731M	£16.405M
Investigations for emerging chemical and microplastics	NEP	N/A	£0.748M	N/A	£0.748M
Grand Total					**£122.703M**

Efficient Costing: This investment case will deliver of £123M of investment (TotEx, post efficiency 2022/23 price base). We have used a range of approaches in line with our costing methodology, including working with supply chain and developing costs from previous work delivered.

Customer Protection: Over 80% of the investment will be directly overseen by the Environment Agency (EA) and Natural Resources Wales (NRW) as part of the WINEP and NEP. These agencies will also provide oversight of SUiAR. As such we a proposing no further customer protection.

Benefits: The removal, treatment and disposal of bioresources is a key element of the WwTW process. Investment within AMP8 will allow Welsh Water to maintain an effective and resilient sewage biosolids operation, deliver statutory environmental improvements, and develop our long-term strategy for biosolids handling.

Our approach has been independently assessed by Jacobs (Engineering and Costs) and Economic Insight (CBA).

1. Introduction

Biosolids (also referred to as bioresources or sewage sludge), is the term for the denser solid material that is separated from wastewater as part of the sewage treatment process.

Effective treatment of biosolids is a fundamental requirement in enabling processes at Wastewater Treatment Works (WwTW's) to operate in accordance with permits and to protect the environment. As additional flows and loads are received at or created in the WwTW's process the volume of biosolids increases. Where there is inadequate capacity, this increase in biosolids volume being removed from the process creates a requirement to change operational practices and ultimately requires the construction of additional assets to maintain treatment.

Additional biosolids will be created during the AMP8 period as a direct consequence of the National Environment Programme (NEP) and Water Industry National Environment Programme (WINEP) investment in additional Phosphorus removal and in reducing harm from Combined Sewer Overflows (CSO's).

The Enhancement Case for tightening phosphorus permit limits (included in WSH68-PE05) includes additional biosolids handling and storage on individual sites, but they do not include for additional cumulative biosolids at the remote sludge treatment centres receiving the exports for further processing and treatment. Similarly, with storm overflows, the reduction in discharges to the environment result in more flow containing a proportion of solids remains in the wastewater network and conveyed to the receiving wastewater treatment works.

We are putting forward a separate case to specifically cover the impacts on regional biosolids processing, beyond what has been set out in WSH68-PE05 for individual sites.

The graphic below, Figure 1, shows our full WINEP/NEP program and how investment, by driver, has been split between our cases for enhanced investment. Boxes are scaled to reflect the relative size of investment.

This Enhanced Investment case (WSH65-PE09) responds to emerging requirements for the treatment, storage and disposal of biosolids.

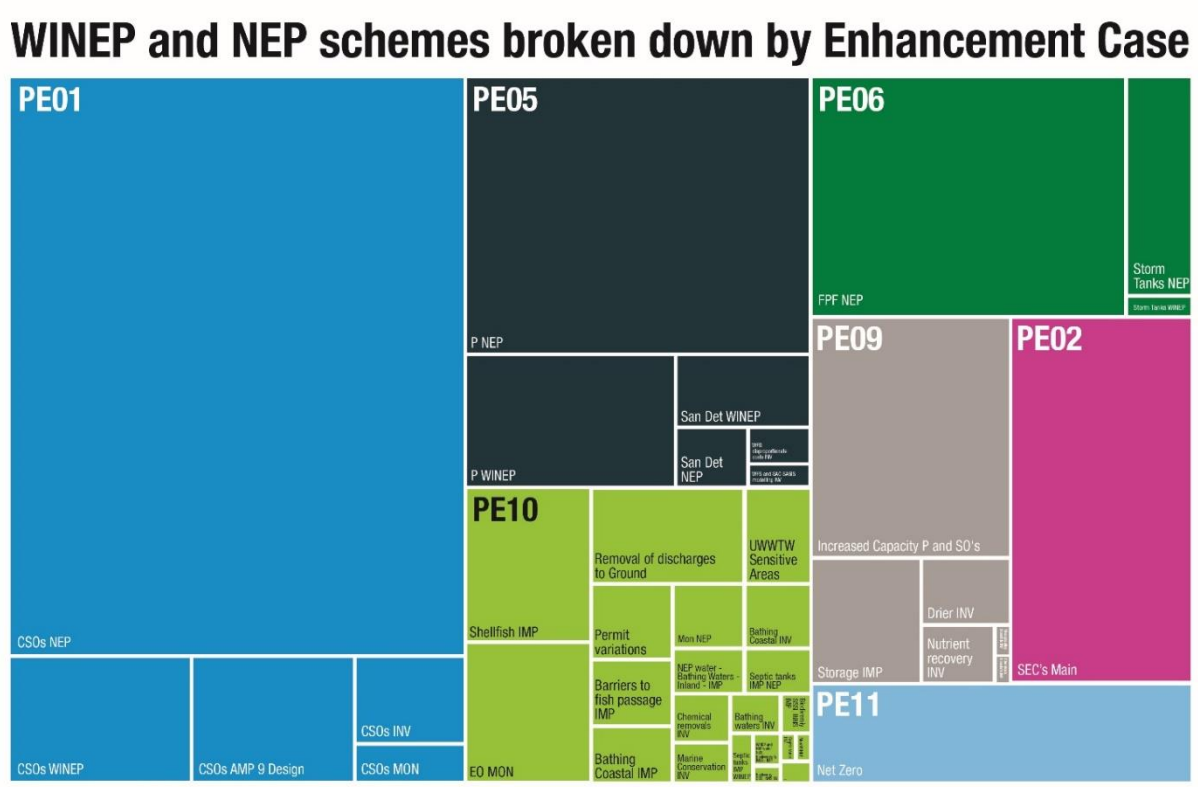

Figure 1: WINEP and NEP schemes broken down by Enhancement Case

In addition to increasing volumes of biosolids being consequentially created under the NEP and WINEP drivers, legislative requirements in relation to biosolids use in agriculture regulations (SUiAR) are evolving and are impacting how biosolids can be stored and ultimately disposed of. These changes require funding in AMP8 to address the immediate changes required by the regulations and determine the most effective and sustainable future treatment and disposal options.

This investment case covers the biosolids enhancement investment for the AMP8 period of £123M (ToTex, post-efficiency, 2022/23 price base). This biosolids investment is split into three key areas that require investment to enable us to deliver our NEP and WINEP drivers, and to remain compliant with new legislation.

The areas requiring enhancement funding in AMP8 are set out in Figure 2 below.

- Increased capacity in biosolids treatment processes to meet increased biosolids production linked to Phosphorus removal schemes, CSO improvements and population growth.
- Additional storage for biosolids resulting from legislative changes that restrict the periods in which biosolids can be spread to land.
- Investigation of alternative biosolids treatment and disposal routes to ensure long term resilience in biosolids handling.

These three areas are interrelated as set out in Figure 2 below.

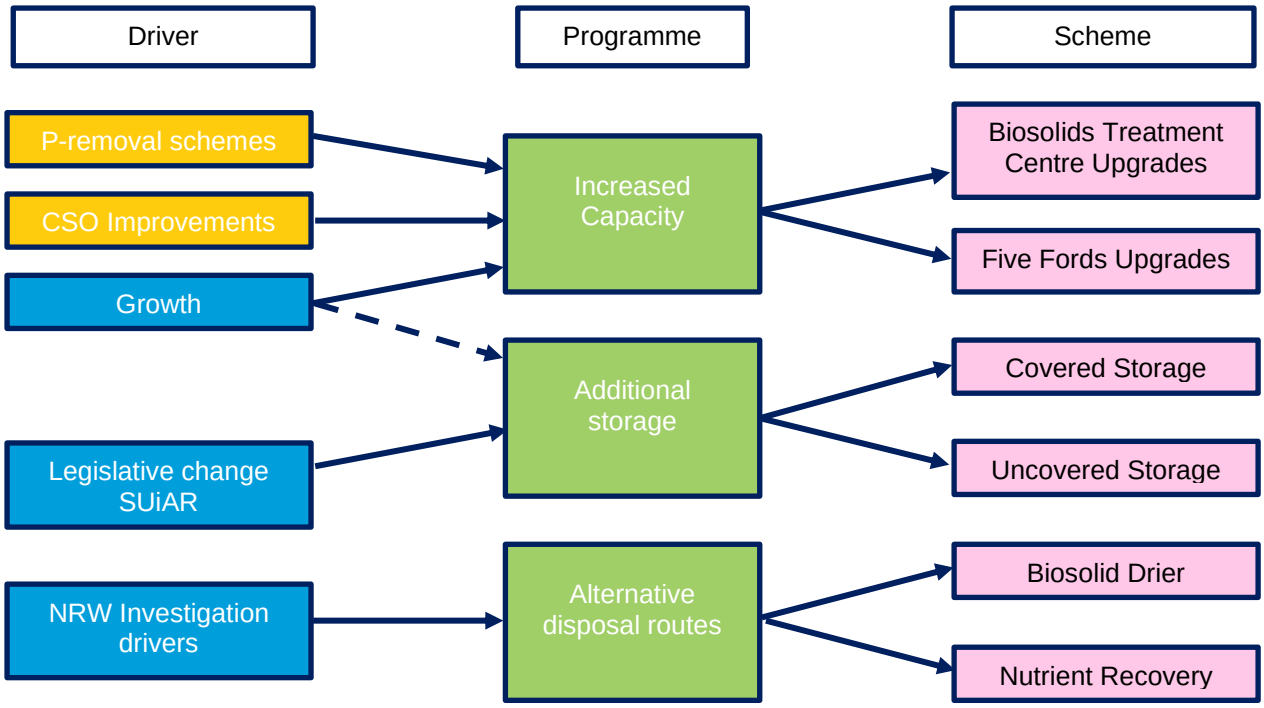

Figure 2: Driver scope for biosolids

This Enhanced Investment case is primarily driven by environmental improvements required to meet new statutory obligations delivered as part of the National Environmental Programme (NEP). It has been built up collaboratively with Natural Resources Wales (NRW).

Underpinning the need for this investment is the forecast across Welsh Water's operational area for biosolids volumes to increase from 2022, by 6% in 2025, by 10% in 2030 & by 13% in 2035 at Welsh Water's existing dewatering facilities.

1.1 Structure of this Document

We have structured this document using the enhancement assessment criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1:

ID from Appendix 9		Abbreviated Assessment Criterion	Addressed
A1.1.1 Need for enhancement investment	a	Is there evidence that the proposed investment is required?	Section 2.1
	b	Is the scale and timing of the investment fully justified?	Section 2.1
	c	Does the proposed investment overlap with base activities?	Section 2.2
	d	Does the need and/or proposed investment overlap/duplicate with previously funded activities or service levels?	Section 2.3
	e	Does the need clearly align to a robust long term delivery strategy within a defined core adaptive pathway?	Section 2.4
	f	Do customers support the need for investment?	Section 2.1
	g	Have steps been taken to control costs, including potential cost savings?	Section 2.5
A1.1.2 Best option for customers	a	Have a variety of options with a range of intervention types been explored?	Section 3.1
	b	Has a robust cost-benefit appraisal been undertaken to select the proposed option?	Section 3.1
	c	Has the carbon impact, natural capital and other benefits that the options can deliver been assessed?	Section 3.2
	d	Has the impact of the proposed option on the identified need been quantified?	Section 3.2
	e	Have the uncertainties relating to costs and benefit delivery been explored and mitigated?	Section 3.3
	f	Where required, has any forecast third party funding been shown to be reliable and appropriate?	Not applicable for this case
	g	Has Direct Procurement for Customers (DPC) delivery been considered?	Please refer to WSH50-IP00 Our Approach to Investment Planning (Section 3.4.1)
	h	Have customer views informed the selection of the proposed solution?	Please refer to Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2)
A1.1.3 Cost efficiency	a	Is it clear how the company has arrived at its option costs?	Section 4.1
	b	Is there evidence that the cost estimates are efficient?	Section 4.2
	c	Does the company provide third party assurance for the robustness of the cost estimates?	Section 4.1
A1.1.4 Customer protection	a	Are customers protected if the investment is cancelled, delayed or reduced in scope?	Section 5.1
	b	Does the protection cover all the benefits proposed to be delivered and funded?	Section 5.1
	c	Does the company provide an explanation for how third-party funding or delivery arrangements will work for relevant investments?	Not applicable for this case

2. Need for Enhancement Investment

This section will set out the drivers behind the Enhancement Case and describes the context within which it has arisen. As set out in Figure 2 there are several interrelated drivers for change. The proposed investment and the underpinning needs are introduced in **Error! Reference source not found.** below.

We shall examine these drivers, describe actions taken to mitigate their impact and how we have ensured no overlap of investment with base maintenance or previously funded investments.

Table 1: Enhancement Case Needs

Investment Area	Enhancement Need	Description
Increased capacity in biosolids treatment centres linked to P-removal and SO harm redcution	Regulatory Change	AMP8 schemes to improve water quality will decrease the amount of pollutants discharged from WwTW's. In most cases these pollutants will be removed as solid particles which form a biosolids. These biosolids then needs to be removed from sites and further treated prior to recycling. There is significant regulatory and public pressure to reduce spills to watercourses from CSOs. Reducing spills means that more solids will be transferred to WwTW's, where they will have to be removed in the form of biosolids. We have not allocated this investment to individual sites requiring investment in the NEP and WINEP but instead developed an integrated companywide response.
Biosolids treatment capacity at Five Fords	Capacity for growth and regulatory change.	Increasing population in the areas served by WwTW's means greater volumes of sewage will require treatment. This also increases the volume of biosolids produced at WwTW's.
Increasing options for biosolids disposal	Regulatory Change	Most sewage biosolids are currently treated and then spread to land. NRW have asked Welsh Water to investigate alternative reuse options.
Increased biosolids storage	Regulatory Change	NRW have introduced new requirements under the biosolids use in agriculture regulations (SUiAR) driver, which restrict the times of year when biosolids can be spread to land. This means that additional storage is required to hold biosolids during periods when it cannot be immediately recycled.

2.1 Evidence that Enhancement is Needed

Is there evidence that the proposed enhancement investment is required?
Where appropriate, is there evidence that customers support the need for investment?
Is the scale and timing of the investment justified?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.1a, A1.1.1b and A1.1.1f

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2). This section focuses on the regulatory changes which are impacting our approach to management of bio-resources.

Whilst the needs within this enhanced investment case are linked, it remains useful to draw out the different drivers individually.

2.1.1 Increased Bioresource Volumes

We have observed and forecast additional bioresource produced due to P-removal requirements, growth, and sewer overflow (SOs) schemes.

- P-removal schemes are a significant investment area within AMP8. Although different P-removal technologies are available, in many cases chemical dosing is used to precipitate dissolved phosphorous from wastewater. The precipitate is a solid which is captured by downstream solids removal processes e.g., settlement tanks. This results in an increase in biosolids production at the site compared to solids settlement without chemical precipitation.
- Welsh Water are also expecting an overall population increase within their operating area, a natural result of this is an increase in the amount of sewage generated and requiring treatment. In turn this will lead to an increase in the amount of sewage biosolids that has to be removed during the WwTW processes.
- As a result of the programme of SO improvements, more flow is being retained in the sewer network, resulting in more solids being transferred to WwTW's where they are removed as a normal part of the treatment process. In turn, this leads to increased load throughout the bioresources treatment operation.

As a result of these factors, using the baseline year of 2022, biosolids volumes are forecast to increase by 6% in 2025, by 10% in 2030 & by 13% in 2035 at Welsh Water's existing dewatering facilities.

As the works are required due to the consequence of addressing other WINEP/NEP drivers there is no direct WINEP/NEP driver related to these works. Additional biosolids are being generated because of other WINEP/NEP schemes being delivered and the resulting biosolids needs to be processed.

The capacity to treat the additional biosolids is not currently available on our sites. The increase in throughput being driven by other WINEP/NEP projects will impact on several assets in our bioresource processes. Examples are shown in Table .

Table 2: Investment areas

Asset type	Impact from increased volumes of biosolids
On-site biosolids storage	Increased biosolids production will require additional on-site biosolids storage at some sites. A lack of storage could impact the quality of the treatment process as biosolids cannot be removed from settlement tanks or require excessive tanker visits to remove biosolids from site.
Tankering	Biosolids are transferred between production and treatment sites. Additional biosolids production will increase additional tanker movements, with an associated cost increase.
Storage at regional biosolids centres	Increased storage will be required at some of our regional biosolids centres where additional biosolids processing is undertaken. This will improve the resilience of treatment operations.
Thickening process (belt thickener)	Belt thickeners are used to carry out basic removal of water from sludge. This decreases the volume and increases further treatment options. Additional assets will be required at certain sites. Where existing headroom is available, operational costs including chemical and electricity will increase.

Asset type	Impact from increased volumes of biosolids
Dewatering process (centrifuge)	Dewatering removes sufficient water from biosolids so that it can be handled as a solid rather than a liquid. This increases efficiency of transport and storage. Additional assets will be required at certain sites. Where existing headroom is available, operational costs including chemical and electricity will increase.
Dried solids storage in skips.	Dewatered cake is often stored in skips prior to recycling to land. Increased biosolids volumes mean that additional skips will be required at certain sites.
Digestion processes	Digestion allows biosolids to be heat treated so that they can be safely applied to land as fertilizer. We require additional digester capacity in order to deal with the increased biosolids produced as a consequence of the NEP and WINEP schemes and allow a viable output to landbank.
Associated transfer pumps, electrical installations, and interconnecting pipe work.	Existing assets will need to be upgraded to handle increased biosolids production volumes at certain sites.

One of the key challenges in treating additional biosolids loads, is that biosolids increases are dispersed throughout the Welsh Water operating area, often at small WwTW's. This means that Welsh Water must monitor the increase in biosolids delivered to our biosolids treatment centres to assess where the greatest impacts are on our assets as NEP and WINEP work is delivered, to efficiently target our investment.

As outlined in section 2.1.1 there is no specific line in the WINEP/NEP for works required as a consequence of additional sludge that is generated as a byproduct of achieving other WINEP/NEP requirements. Costs for processing the additional generated sludge are not included within the individual projects which are driving the generation of additional volumes e.g., Phosphorus removal or storm overflows. The sites where additional sludge treatment is required are not always the same sites that are driving the generation of the additional sludge, and as such costs could not be accurately apportioned at the scheme level for those sites.

2.1.2 Alternative recycling routes for biosolids

Ongoing investigations into the impact of spreading biosolids to land, including the impact of nutrients, chemicals and microplastics have the potential to restrict disposal to land. Environmental regulators have also made it clear that they expect to see greater resilience in biosolids disposal to allow for unforeseen events that restrict spreading to land e.g., weather or disease.

Welsh Water are currently working to understand the most appropriate business strategy to address these changes. Drying of biosolids is seen as likely to be beneficial for multiple potential future scenarios because of volume reduction and improved thermal destructibility of dried cake. Recognising this, Welsh Water propose investment in biosolids drying under an investigation driver agreed with NRW.

Sewage biosolids has significant value as a low-carbon fertiliser and when identifying alternative disposal routes, it is important to also investigate methods that will allow nutrients within the biosolids to be captured prior to drying them to ensure all valuable nutrients can be recovered. Existing technologies are available to extract nutrients from sludge, but it is currently unclear how easily they could be incorporated into Welsh Water's broader operations. An NRW improvement driver on nutrient recovery directs Welsh Water to complete study work into the effectiveness of this technology, informing a potential wider implementation in AMP9.

Table 3: Key NEP drivers for alternative disposal routes and investigations

Item	Key Driver
Nutrient recovery technology assessment	W_SUiAR_IMP1
Low temperature drying and temperature treatment.	W_SUiAR_INV1
Chemicals and micropollutants assessment in biosolids	W_SUiAR_INV1
Biosolids – Microplastics thermal treatment of biosolids	W_SUiAR_INV1
Biosolids resilience land bank	W_SUiAR_IMP1
Dewatering efficiency improvements	W_SUiAR_IMP1

2.1.3 Additional cake storage

Regulatory changes, including the Sludge Use in Agriculture Regulations (SUiAR) and 'The Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations 2018' – also known as the 'Farming rules for water' have already had a major impact on Welsh Water's biosolids disposal operations, including:

1. Restricting biosolids spreading during winter months.
2. Changes to the requirements for storage of biosolids prior to spreading.

Under current legislation open air storage is allowed, but the implementation of the Industrial Emissions Directive (IED) and other updates to environmental legislation have the potential to require all storage to be covered. Storage pads constructed in AMP8 will be designed so that they are structurally suitable for a roof to be added later.

In AMP8 Welsh Water need to install assets that will enable them to comply with the new legislation. Based on current understanding this means construction of impermeable storage pads with provision for collection and treatment of surface water/leachate. Note that the total storage volume required is also impacted by the increases in total biosolids volumes detailed above.

Table 4: SUiAR Biosolids storage and dewatering efficiency schemes in the NEP

Item	Key Driver
Enclosed biosolids storage	W_SUiAR_IMP1

2.1.4 Scale and Timing of Investment

These aspects are unique to our PR24 submission due to significant increases in Phosphorus schemes being required by NRW and the EA (149 total) and the volume of SOs being improved to reduce harm to the environment (109 total). Coupled with the increase in solids from growth, there is a requirement in AMP8 to increase biosolids treatment capacity, whilst maintaining quality and disposal compliance achieved with AMP7 funding.

Increased capacity

We plan on investing at 5 regional biosolids treatment centres and upgrading Five Fords WwTW's to enable larger capacity of treatment to produce a suitable and safe product for spreading to land.

With respect to regulatory compliance for P schemes and SO's, the WINEP/NEP standards were updated in August 2023 and have various implementation dates from 31st March 2027 to 31st March 2030.

Dates for compliance have been confirmed in the latest published versions of the NEP and WINEP.

These compliance dates for the NEP and WINEP schemes means that Welsh Water is required to identify appropriate solutions (including operational changes), create detailed designs, and construct or adapt assets to meet these obligations within the stipulated timeframes.

Increasing treatment capacity for growth at treatment works is not part of the WINEP and NEP but work to increase WwTW capacity will be delivered throughout AMP8 as per the programme in the OFWAT data tables.

This increase in treatment capacity will by nature result in an increase in the volume of biosolids produced, in addition to growth creep at other treatment works, and the assets necessary to process increased volumes must be available as WwTW capacity increases are implemented. We have predicted the increase in biosolids (see Section 2.1.1) based on a combination of increased P and SO sites along with predicted growth.

Drying and nutrient recovery

The timing of investigations into alternative disposal routes for biosolids is justified by two factors. Firstly, there are immediate concerns about the impact of spreading sewage biosolids to land e.g., the impact of microplastics on soil quality. Ongoing research into this, with unknown conclusions, means there is a real risk of rapid changes in the regulatory position and public attitudes to disposal of biosolids to land. Secondly, and recognising the first risk, the investigation drivers agreed with NRW that underpin this investment must be addressed within AMP8.

The scale of proposed investment is necessary for Welsh Water to assess the real-world operability of drying and nutrient recovery equipment at an existing biosolids treatment centre. This includes working with potential end-users to demonstrate that the dried cake is appropriate for their needs e.g., as a fuel to generate heat. Although a smaller scale trial could prove the fundamental capability of the process, it would leave significant doubt for both Welsh Water and the end-users of the dried biosolids about the practicality of using it at operational scale from AMP9 onwards.

Additional storage

Legal and regulatory requirements restricting spreading of treated sewage biosolids to land will be in place from the beginning of AMP8 and increased biosolids production linked to P-removal growth and SO improvements will further increase biosolids storage requirements throughout AMP8.

The scale of investment is justified by analysis of biosolids volumes produced at Welsh Water WwTW's, understanding of realistic best estimated storage periods and a gap analysis of existing storage capacity against required future capacity.

We plan to create 10 no. additional cake storage areas at various sites throughout Welsh Water.

2.2 Overlap with Activities to be Delivered through Base

> ***Does the proposed enhancement investment overlap with activities to be delivered through base?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1c*

For all Enhancement Cases we have undertaken an exercise to ensure that base and enhancement spend is clearly segregated. This is covered in Our Approach to Investment Planning (Section 3.4.2).

The cost estimates produced for PR24 are for new assets only rather than refurbishing existing assets.

The operational expenses (OpEx) component of the costs estimates is only for the delta i.e., the step up from base maintenance already present on site.

Therefore, the costs for new assets, separation from maintenance drivers and step up in OpEx ensures that the proposed enhancement investment does not overlap with any activities to be delivered through base allowances.

2.3 Overlap with Funding from Previous Price Reviews

> ***Does the need and/or proposed enhancement investment overlap with activities or service levels already funded at previous price reviews?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1d*

Increased Capacity

In AMP7, funding was requested to improve the biosolids product quality and biosolids disposal compliance. No funding was allowed for additional biosolids due to P schemes, increased growth and SOs.

Drying and nutrient recovery

The projects proposed for PR24 are new technology to Welsh Water and have not been funded in any previous AMPs.

Additional Storage

Increases in biosolids volumes have been requested in previous AMP's and are a long-term trend linked to improved WwTW processes, population growth and previously agreed performance commitments. The funding requested for additional storage in PR24 does not overlap with previous projects and is linked to a step change in regulatory requirements within the NEP.

2.4 Alignment with the Long-Term Delivery Strategy

> ***Is the need clearly identified in the context of a robust long term delivery strategy within a defined core adaptive pathway?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1e*

Welsh Water have several long-term ambitions which are associated with the environment and biodiversity.

These include outputs related to river and coastal water quality and pollution incidents. The NEP and WINEP programmes of work are central to achieving Welsh Water's long-term outputs and have formed the basis for the core pathway in the WSH01 Long Term Delivery Strategy.

Further details can be seen in Welsh Water's WSH01 Long Term Delivery Strategy report. We need to ensure that our biosolids treatment centres can process biosolids in an efficient manner to maintain effective and efficient treatment of wastewater, to allow biosolids to be effectively disposed of to land and to comply with all the relevant standards. These plans ensure we have a robust long-term strategy related to biosolids until 2050.

A practical example of Welsh Water delivering long term strategy is the proposed investment at Five Fords and Queensferry. This is the second phase of an initial investment made in AMP6 and was identified as a likely future development within the PR14 submission. The thermal hydrolysis process introduces at Five Fords WwTW in late AMP6 was sized with the process capacity for this second phase.

2.5 Management Control of Costs

> ***Is the investment driven by factors outside of management control? Is it clear that steps been taken to control costs and have potential cost savings been accounted for?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1g*

The factor that is driving this Enhanced Investment Case that is outside of management control is the environmental improvements required to meet new statutory obligations and population growth.

Welsh Water will need to manage the additional biosolids generated from P-removal consents, growth and SO harm reduction. This will ensure that the resilience of the biosolids disposal chain will be maintained, given the changes to phosphorus final effluent permits, growth and new CSOs. Welsh Water will also need to meet new regulatory obligations in relation to the storage and management of biosolids.

We maintain our existing assets using Base Maintenance expenditure to mitigate the need for larger scale investments wherever possible.

An example of base expenditure to avoid major capital expense on our Biosolids assets would include the optimisation of digesters. The expenditure in this investment case is going beyond what is practicable to manage using base expenditure as the magnitude of biosolids volume increases is so significant.

3. Best Option for Customer

All schemes proposed within this document were taken through a structured process to ensure that:

- The identified need was genuine and had been correctly assessed.
- A diverse range of options to address the need were considered.
- Costs for implementation of each option were robust and generated using a consistent process based on verified cost models.
- The preferred final option was selected through a repeatable, robust process based on quantitative analysis.
- Documents evidencing this process were created and that they captured all key information.

This methodology is set out in WSH50-IP00 Our Approach to Investment Planning.

3.1 Identification of Solution Options

> ***Has the company considered an appropriate number of options over a range of intervention types to meet the identified need?***
> ***Is there evidence that the proposed solution represents best value for customers, communities, and the environment over the long term?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2a and A1.1.2b*

Whilst small scale changes in the volume of biosolids created at a WwTW can be managed through base maintenance, the modelled step change in volumes driven by the WINEP and NEP requires us to consider our approach to biosolids more strategically. The centralisation of dewatering processes provides significant opportunities for improved management and the generation of wider benefits have been considered alongside more local solutions.

Modelling Biosolids Volume for Costing

We have assessed different biosolids scenarios within Welsh Water's biosolids model. The model takes account of the variance between theoretical and actual biosolids loads created by differing WwTW processes (filter versus activated sludge process etc), in comparison to existing available biosolids storage and treatment capacity. The model then forecasts future biosolids volumes that will be created by considering the Phosphorus removal technique to be implemented and the impact of this on specific sites. This model is the primary tool used in enabling Welsh Water to consider how best to scale and target our biosolids investment across our operational area.

The forecast volume of additional biosolids to be passed to our WwTW's following interventions in our SOs is less certain than that used to determine the additional biosolids volume created by P removal. A set of assumptions have been used to estimate the volume of flows, and associated sludge, which will now be retained within the sewer network and conveyed onward for treatment at WwTW's. These assumptions will be tested and refined as our CSO enhancement programme progresses and the associated biosolids becomes apparent as the investment takes place. This will be used to inform future AMP periods.

Structured development of long list options

For the improvement options (e.g., Five Fords, new dewatering facilities and the SUiAR IMP1 schemes) the options were long listed with all options considered.

Options were then ranked at long listing stage using the structured approach set out in figure 3.

Criteria	Sub Criteria	Description	Score			Weighting
			1	3	5	
Ability to meet S or NS obligations	**Regulatory Complexity**	How complex will this option be to regulate as a solution? (e.g., will there be a complex licence/permit).	Low	Medium	High	35%
	Problem Resolution	Will the option address the obligation identified? How much certainty is there that the option will deliver the benefits required?	Very Certain	Certain	Not Certain	
	Failure Risk	Is the option resilient to a range of future external factors/pressures, such as climate change and political and legislative changes?	Very Resilient	Resilient	Not Resilient	
Contribute to the WINEP wider environmental outcomes	**Natural Environment**	Will the option impact on biodiversity, shellfish cultivation and air quality?	Positive Impact	No Impact	Negative Impact	15%
	Net Zero	Will the option impact on GHG emissions during construction and/or operation, i.e., change in land-use, restoration, or enhancement of ecosystems.	Positive Impact	No Impact	Negative Impact	
	Catchment resilience	Will the option impact on flood risk (fluvial, groundwater or surface run-off), area of wetland or riparian habitants and river water quality? Will the option provide a more resilient and flexible water supply for the environment and public and private abstractions?	Positive Impact	No Impact	Negative Impact	
	Access, amenity and engagement	Will the option impact on recreational value of local green spaces, and provide educational opportunities to the local community? Will the option provide environmental volunteering opportunities to the local community?	Positive Impact	No Impact	Negative Impact	
Technical feasibility	**Technology Development Status**	What is the maturity of the technology	Well Proven	Some Installations	Trial Stage	15%
	Construction/Buildability	What level of confidence is there that the scheme can feasibly be constructed?	High Confidence	Moderate Confidence	Low Confidence	
	Operability	Would the option require an on-going level of management and maintenance?	Low Level	Moderate Level	High Level	
Deliverability	**Client Acceptability**	Operational Experience of technology within Welsh Water	Positive Experience	Moderate Experience	Negative Experience	15%
	Resourcing	Is the labour/resource available to manage and maintain this option?	Highly Likely	Possible	Unlikely	
	Complexity	Could the option be delivered without the need for extensive feasibility studies, trials, investigations or infrastructure modifications?	Low Complexity	Moderate Complexity	High Complexity	
Cost	**Cost band**	What is the relative scale of expenditure (CapEx and OpEx) anticipated with the option?	Low TotEx	Moderate TotEx	High TotEx	20%
	Co-funding	Can the option be co-funded?	Highly Likely	Possible	Unlikely	

Figure 3: Long listing approach

Table 5: Long listing options for additional dewatering sites due to P, SO's and growth.

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
1	Manage demand	**Not Viable**. Demand is from an increase in sludge due to the NEP and WINEP P and SO which increase sludge production. This is outside of Welsh Water management control.	✗
2	Manage operation or use of the existing asset or service	**Not viable.** Cannot manage the increased volume of sludge produced on site due to the reduction in P consent, increased flow from SO's and growth. Most sites affected by the drivers do not have any existing dewatering assets.	✗
3	Maintain the existing asset or service	**Not viable.** The individual sites either have no dewatering facilities or are undersized for the increased sludge load.	✗
4	Replace the existing asset like-for-like	**Not viable**. There are no existing dewatering facilities at the individual sites.	✗
5	Enhance/upgrade the existing asset or service	**Not viable**. There are no existing dewatering facilities at the individual sites.	✗
6	Mothball/dispose of the existing asset or service	**Not viable**. There are no existing dewatering facilities at the individual sites.	✗
7	Create/acquire a new asset or service	**Potentially viable.** Export sludge to private contractors for dewatering at private facilities. Not viable due to potential unreliability of the service and high Opex. Also, excessive use of tankers transporting liquid sludge.	✓
8	Create/acquire a new asset or service	**Viable.** Create five regional (NW, NE, SW, SE and central) sludge dewatering (centrifuge to 20-25% dry solids) sites to manage the increased sludge production.	✓
9	Create/acquire a new asset or service	**Not viable.** Create new dewatering (centrifuge) facilities on each individual site connected to a new P consent or an SO with reduced spills. CAPEX too high as there are >200 sites this affects. Also, land availability on sites is limited and suitable infrastructure is not available on many of the small sites (<200PE) the new P and SO drivers affect.	✗

Short listed options were costed using our Carbon and Costing Estimating Tool (C&CET) described below. The costs were subsequently input into our CBA process where the Cost Benefit Ratio (CBR) was obtained. This then identified our most cost-effective options when taking into consideration costs and other benefits.

Our chosen option for managing the additional biosolids generated due to phosphorus final effluent permits, growth and new CSOs is centred around investing in new enhanced dewatering facilities. Enhancing dewatering capability will provide a basis from which increased capacity can be delivered.

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.10 – 4.3). This includes a cost benefit analysis (CBA) tool, which comprises of a detailed analysis of benefit to costs for all proposed options. The proposed solutions include quantification of risk and benefit over the long term via service measure framework (SMF) values, including valuation of the following criteria: natural capital; social capital; human and intellectual properties.

Table 6 and 7 below have been completed using data from our cost benefit spreadsheets to illustrate the value generated by the proposed investment. These figures are pre-efficiency 2022/23 price base.

Increasing our dewatering facilities capacity will allow main de-watering centres to receive and process additional sludges at key locations before moving on to our digestion processes. Increases of biosolids from a 1.5-3.5 % TDS to a >22% TDS cake provides a logistical and carbon reduction, by reducing the amount of water being transported, which is both bulky and heavy.

This will be delivered via regional centres with the following template units:

- New tanker receiving bays.
- Biosolids holding tanks.
- Thickening process (belt thickener).
- Dewatering process (centrifuge).
- Dried solids storage in skips.
- Associated transfer pumps, electrical installations, and interconnecting pipe work.

The CBA below demonstrates that the new de-watering facilities option produces a significantly higher benefit to cost ratio and delivers major carbon savings compared to transporting liquid sludge off site via a third-party contractor (Table 6).

Table 6: CBA for 1 no. Dewatering Site

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	Additional Dewatering Sites	£11.964M	£18.432M	£77.408M	4.200	£58.976M
Option S2	Disposal Off Site	-	£183.547M	£77.408M	0.422	-£106.138M

Table 7 below for the Five Fords WwTW additional advanced digestion investment also shows a favourable CBR for the preferred option.

Table 7: Benefit to cost ratio analysis for Five Fords & Queensferry

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	Do Nothing	-	£0.624M	£0.000M	0.000	-£0.624M
Option S2	Installation of an additional digester at Five Fords. Conversion of Queensferry to a raw biosolids dewatering site	£22.611M	£27.738M	£34.349M	1.238	£6.611M
Option S3	Queensferry advanced digestion upgrade and reconfiguration of Five Fords.	£21.779M	£26.313M	£12.533M	0.476	-£13.780M

Third-party technical assurance of cost–benefit appraisal has been completed by Economic Insight who have confirmed that our approach is robust and in line with Ofwat expectations. Full details are given in WSH50-IP00 Our Approach to Investment Planning (Section 6).

What We Will Deliver:

- Increased capacity at 5 regional biosolids processing centres (biosolids receiving, storage, transfer, thickening, dewatering).
- Process upgrades and a new digester at Five Ford WwTW with associated work at Queensferry.
- Conversion of Queensferry WwTW to a raw biosolids dewatering site (including liquid imports).
- Significant increases in regional storage capacity.
- Pilot low temperature biosolids drying technology, nutrient recovery techniques, investigating emerging chemicals and micropollutants in sludge.

3.2 Quantification of Benefits

Has the company fully considered the carbon impact, natural capital and other benefits that the options can deliver?
Has the impact (incremental improvement) of the proposed option on the identified need been quantified, including the impact on performance commitments where applicable?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.2c and A1.1.2d

We have completed a standardised assessment of carbon; this approach is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). Carbon impact is calculated over the life of an asset and includes both the operational impact and embedded impact of Carbon. Whole Life Carbon (WLC) estimation is an important input to inform decision making and programme development by Welsh Water. In our development of programme options, we have developed appraisals of the carbon impact of shortlisted options using Carbon Unit Cost Database Models. Carbon referred to as Green House Gas Emissions (GGE) have been used as a direct input to calculate the benefit or disbenefit of scheme options to inform Cost Benefit Assessment (CBA). The monetised natural capital impact of carbon forming an overall 'benefit' or 'disbenefit' position alongside other service measure impacts.

Other qualitative benefits we have considered include:

- Customers may be against additional heavy goods vehicles moving liquid sludges through rural communities and carbon from burning fuel.
- Dewatering the biosolids allows for an easily movable product at around 20-25% dry solids in a skip, rather than a tanker and it will stay in a pile, rather than slumping as a slurry, meaning it can be stored on a biosolids pad if necessary. This storability and mobility mean a greater flexibility and resilience in the biosolids disposal chain. This also reduces the volume of liquid sludge, which takes up a large storage volume and many tanker loads to transport, reducing carbon outputs.

Using our Service Measure Framework (SMF) we have shown below how each of the benefit categories are apportioned across the case. For this case the consequences of poor management of biosolids are evident in the assessment, increased costs for transportation and potentially going to landfill, risk of prosecution and the potential for uncontrolled biosolids to enter the environment leading to damage and pollution.

Table 8: Benefits from AMP 8

Scenario	Benefits from AMP8 Spend relative to baseline				
	Legal Compliance	Avoidable Costs	Nuisance - Odour	Pollution Incidents	Total
Preferred	10.1%	24.7%	0.0%	65.2%	100%

3.3 Uncertainties relating to cost and benefit delivery.

Have the uncertainties relating to costs and benefit delivery been explored and mitigated? Have flexible, lower risk and modular solutions been assessed – including where forecast option utilisation will be low?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.2e

Our methodology is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.10). This includes commentary on our approach to optioneering, costing and cost benefit analysis.

For this Enhancement Case we have evaluated a wide range of options in line with our TotEx hierarchy approach, an example is shown in Table 10.

We have highlighted areas in which the calculation of costs or benefits are unusual or uncertain and how we have mitigated for this in our evaluation.

Innovation and new approaches are inherently more uncertain than tried and tested engineering approaches.

As an example, our identified three options have been included in table below for the P and CSO's biosolids increase scheme (5 new dewatering sites).

Table 9: Options considered for Biosolids Increased Capacity for P & CSOs.

Option	Description	Risks associated with costing this option or valuing its benefits	Mitigation [of the Risk associated with costing]
New dewatering facilities at 5 regional centres	New thickening/dewatering facilities at regional centres to process additional sludge.	Construction activities on operational sites. Potential land purchase requirements. There is a risk that the land bank will not be available to dispose of the cake.	Construction and land purchase risk well understood. Our investigations are mitigations to this risk (e.g., drying technologies).
Disposal off site	Disposal of raw biosolids to third party contractors for processing.	Assurance of available capacity within third party facilities. Increased tanker traffic Treatment cost fluctuations of facilities could be imposed by disposal company. High OpEx.	Removed as non-viable.
New dewatering facilities at individual sites	New thickening/dewatering facilities at individual sites to process additional sludge.	Construction activities on operational sites. Potential land purchase requirements. There is a risk that the land bank will not be available to dispose of the cake. Lack of infrastructure on individual sites. High CapEx as over 200 centrifuges and associated tanks required.	Removed as non-viable.

4. Costing Efficiency

In this section we provide details on our approach to costing and benchmarking.

Our overarching approach to developing efficient costs is set out in WSH50-IP00 Our Approach to Investment Planning (Section 7).

The two sub sections below correspond to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.3.

4.1 Developing a cost for NEP / WINEP

> ***Is it clear how the company has arrived at its option costs? Is there supporting evidence on the calculations and key assumptions used and why these are appropriate? Does the company provide third party assurance for the robustness of the cost estimates?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.3a and A1.1.3c*

As described in Section 5 Costing Methodology 'Overview: How we have developed our investment plan' we have three approaches to costing which we have adopted in this business case.

Where we can develop a scope for a project, such as the Five Fords Scheme or where we are able to set a band of standardised scope, for the cake storage pads, we have adopted a like-for-like top-down approach using our UCD C&CET to cost the schemes.

An individual specific scope was developed for each of the schemes, as part of the engineering optioneering process which identified the assets for construction, modification and upgrade along with any site specifics, which formed the basis of our estimates.

The scope is for items of work which have been constructed throughout previous AMPs, and therefore we have a rich source of historical cost data. For these items of work, we have developed cost models based on the most important cost drivers, e.g., the most influential driver to cost for a biosolids tank is volume. This costing approach forms the direct works and site-specific costs. We apply construction indirect costs and project oncosts based on the work stream, in this instance this is Wastewater Non-Infrastructure, which applies modelled percentages to the cost of the direct works and site specifics.

The scope is aligned to our Work Breakdown Structure (WBS), which was developed to support our data capture process of historical project cost against delivered assets, into a scope input sheet. Within this, sizing of the assets based on the relevant yardstick, which is dictated by the WBS, is provided following calculation in the previous engineering stages. Our costs models are developed in line with our WBS and this allows us to input this information into the C&CET and generate a project estimate. WBS details the inclusions and exclusions of works under each cost model and the limitations of the model, so we can ensure all project costs are captured and there is also no over costing.

The estimate for Five Fords lists out the scope items such as tanks with their volume, pumps with power in kW, digesters with the throughput in Total Tonnes of Dry Solids per year (TTDS/yr) and motor control centres in kW etc. With the relevant quantities against these, the C&CET calculates the costs for each item using the cost models. With the workstream selected the C&CET applies the correct models to the direct works and site-specific costs, the indirect costs to the contractor and indirect and project on costs associated with delivering the project.

The estimate for the 5 regional biosolids centres was based on a total solids load across all of Welsh Waters assets that must be processed (that is additional to the current biosolids load). This load is then divided into 5 centres for geographical convenience and to optimise transport. The appropriate equipment was sized at each site based on this load. As these sites remain unspecified geographically, but will be the most convenient sites, this approach to costing is the most appropriate for the level of information available and the stage of this programme of works.

Where there is insufficient information to provide a specific scope of works for interventions, we have used a historic trend analysis and extrapolation based on historical spend profiles to inform our AMP8 plan. This is appropriate as this is drawing on the experience, we do have to inform future costing.

We have used a bottom-up approach for costing new works where we do not have sufficient cost information to form cost models in our unit cost database. Here we build up costs on first principles supported by supplier quotations and framework or historical rates up lifted to reflect current prices.

A key assumption is around the forecast volume of additional biosolids to be passed to our WwTW's. This has been calculated from estimated volumes of flow and increases in sludge, from P removal and interventions in our SOs, which is detailed in our plan. It is an appropriate approach as it links directly to our AMP8 plan. In the calculation of the additional biosolids volumes addressed in this case, we also consider growth, and this forms the basis to size the assets required.

Other assumptions are that we will have maintained routes for biosolids storage which influences the sizing, such as biosolids cake pads, and that land will be available for the construction of new assets. We believe that these assumptions align with the long-term sustainable environment plans for Wales.

Along with our overall costing strategy being reviewed and assured by Jacobs, we have also employed third party consultants to review single Enhancement Cases to provide confidence that the estimates within them are robust, efficient, and deliverable. Please refer to WSH50-IP00 Our Approach to Investment Planning (Section 6) for more information regarding the review and assurance undertaken.

4.2 Benchmarking our approach

> ***Is there evidence that the cost estimates are efficient (for example using similar scheme outturn data, industry and/or external cost benchmarking)?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.3b*

We have engaged independent consultants to undertake a project level benchmark of the preferred solution for the scheme at Five Fords WwTW.

This industry benchmark was a review of our cost efficiency for delivering this project based on a like for like scope using 2021/22 base, pre-efficiency.

The benchmark findings report shows that our costs are in line with the industry and suggests that our pre-efficiency costing is already in an efficient position and achieving upper quartile.

Table 10: Benchmark costs

Scheme	Welsh Water Costing	Upper Quartile	Average	Lower Quartile
Queensferry & Five Fords Biosolids Strategy	£20.787M	£21.142M	£22.103M	£22.958M

5. Providing Customer Protection

The section below corresponds to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.4. There is no third-party funding associated with this Enhancement Case.

5.1 Proposed Protection

> ***Are customers protected (via a price control deliverable or performance commitment) if the investment is cancelled, delayed or reduced in scope?***
> ***Does the protection cover all the benefits proposed to be delivered and funded (e.g., primary, and wider benefits)?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.4a and A1.1.4b*

Over 25% of the proposed investment is directly contained in the NEP/WINEP, and as such has oversight from the EA and NRW. These mechanisms have well established and well-defined methodologies for annual reporting and control.

There are clearly defined timeline and output requirements for each element of the work program contained within this case.

Failure to deliver will result in enforcement, and potentially prosecution.

The remaining funding provides a centralised response to work driven by the NEP and WINEP. Whilst an action line has not yet been assigned by NRW the work will be required to deal with the consequences of the agreed work program. We are continuing to work with NRW to identify how this can best be represented in the forward program.

The benefits from this work are focused on delivery of the required NEP and WINEP deliverables. No wider benefits have been identified for the chosen solutions.

6. Appendix A

Table below shows the total CapEx enhancement cost in Amp 8, the Ofwat drivers for this Enhancement Case are:

CWW3b.131 - Sludge storage -Tanks (pre-thickening, pre-dewatering or untreated) (WINEP/NEP) capex
CWW3b.132 - Sludge storage -Tanks (pre-thickening, pre-dewatering or untreated) (WINEP/NEP) opex
CWW3b.134 - Sludge storage -Tanks (thickened/dewatered or treated); (WINEP/NEP) capex
CWW3b.135 - Sludge storage -Tanks (thickened/dewatered or treated); (WINEP/NEP) opex
CWW3b.137 - Sludge storage - Cake pads / bays / other; (WINEP/NEP) bioresources capex
CWW3b.138 - Sludge storage - Cake pads / bays / other; (WINEP/NEP) bioresources opex
CWW3b.143 - Sludge treatment - Thickening and/or dewatering; (WINEP/NEP) capex
CWW3b.144 - Sludge treatment - Thickening and/or dewatering; (WINEP/NEP) opex
CWW3b.149 - Sludge investigations and monitoring (NEP only) bioresources capex
CWW3b.150 - Sludge investigations and monitoring (NEP only) bioresources opex
CWW3b.162 - Sludge enhancement (growth); enhancement capex
CWW3b.163 - Sludge enhancement (growth); enhancement opex

ToTex in AMP8 Plan in 2022/23 prices

	Year in AMP8					
	1	2	3	4	5	Grand Total
CWW3b.131- CapEx	£2.100M	£4.106M	£6.055M	£5.099M	£3.180M	£20.540M
CWW3b.132- OpEx	£0.237M	£0.474M	£0.712M	£0.949M	£1.186M	£3.558M
CWW3b.134- CapEx	£1.763M	£3.447M	£5.082M	£4.280M	£2.669M	£17.241M
CWW3b.135- OpEx	£0.199M	£0.398M	£0.597M	£0.796M	£0.996M	£2.986M
CWW3b.137- CapEx	£3.187M	£3.115M	£3.062M	£3.094M	£3.216M	£15.674M
CWW3b.138- OpEx	£0.049M	£0.097M	£0.146M	£0.195M	£0.244M	£0.731M
CWW3b.143- CapEx	£1.703M	£3.329M	£4.909M	£4.134M	£2.578M	£16.653M
CWW3b.144- OpEx	£0.192M	£0.385M	£0.577M	£0.769M	£0.962M	£2.885M
CWW3b.149- CapEx	£0.378M	£2.199M	£7.557M	£2.646M	£0.000M	£12.780M
CWW3b.150- OpEx	£0.000M	£0.000M	£1.464M	£3.251M	£3.211M	£7.926M
CWW3b.162- CapEx	£2.066M	£5.344M	£8.650M	£4.353M	£0.000M	£20.413M
CWW3b.163- OpEx	£0.000M	£0.188M	£0.376M	£0.376M	£0.376M	£1.316M
Total	**£11.874M**	**£23.082M**	**£39.187M**	**£29.942M**	**£18.618M**	**£122.703M**

What We Will Deliver:

- Increased capacity at 5 regional biosolids processing centres (biosolids receiving, storage, transfer, thickening, dewatering).
- Process upgrades and a new digester at Five Ford WwTW with associated work at Queensferry.
- Conversion of Queensferry WwTW to a raw biosolids dewatering site (including liquid imports).
- Significant increases in regional storage capacity.
- Pilot low temperature biosolids drying technology, nutrient recovery techniques, emerging chemicals and micropollutants in sludge.