Dŵr Cymru
Welsh Water

Enhancement Investment Case : WSH61-RS05 - Increasing Resilience of Tap Water Supply - Treatment Works

Contents

Executive Summary

This investment will improve the resilience of our water treatment works against low probability high impact risks. As part of the process of identifying the priority interventions that will deliver this process we have consulted with the DWI and considered their views on Wales. For example, in his presentation of the "Chief Inspector's Report for Wales 2022", Marcus Rink highlighted low probability, high impact events that he linked to climate change. This builds upon the DWI's focus on bacteriological performance in 2021, where our SRV and Final Water tank estate was reviewed, highlighting the need for further enhancement. There are two other areas of Climate change that we have focused on, Flooding and Water Resources in AMP8.

The enhancements detailed within this case address these key areas:

1. **Critical Tanks – Single Points of Failure:** Some process tanks/reservoirs within treatment works have no facility to by-pass and take them offline for extended maintenance periods. Through this investment we aim to implement changes to these identified tanks to ensure we can maintain supply if they require extended maintenance period in future.
2. **Climate Change - Flooding** is resulting in more frequent and severe rain/flood events. Through this investment we aim to protect our treatment facilities against the 1:30 year flood events.
3. **Climate Change - Water Resources:** is worsening the already strained summer supply of smaller raw water sources. Through this investment we aim to improve the surety of supply within one of our water supply zones by removing the reliance on temporary measures.
4. **Sludge Management:** This investment will improve sludge management operations at two water treatment works (WTW) to meet new statutory guidelines on the spreading of WTW sludges to land and increase opportunities for the beneficial use of WTW sludge.

The programme of work that has been developed in these Categories consists of 23 schemes at a total cost of £36M.

We have structured this document using the enhancement assessment criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A1. The enhancement assessment criteria are divided into four criteria groupings, see bullets below.

- need for enhancement investment (5 sections);
- best option for customers (3 sections);
- cost efficiency (2 sections);
- customer protection

Need:

1. **Critical Tanks – Single Points of Failure:** There is a need to increase the resilience of supply at eleven water treatment works (WTW) sites to enable long term outages to facilitate tank inspections and maintenance. An assessment of water storage tanks at our WTW identified critical tanks built at a time when adequate redundancy or bypass facilities were not part of standard design. Currently, if during regular inspection and/or maintenance of these tanks, a problem is identified that requires significant down time, the entire WTW would need to shut down whilst the issue is rectified. As single points of failure, these tanks represent a risk at our WTW and an outage will impact both volumes of supply and water quality.

2. **Flooding:** Flood damage at our treatment facilities has resulted in significant downtime and cost, the proposed investment in this case will reduce the risk of this in future.

3. **Water Resources:** The current position in one of our water supply zones is reaching a point where during even failure short dry periods there is insufficient resource available and temporary

pumping using rented pumps is required to provide raw water resource. With the increased frequency of hot weather this operational solution is not a sustainable long term option and a permanent solution is required. This will enable reliable transfer of our raw water between the Carno impounding reservoirs and Nantybwch WTW.

4. **WTW Sludge:** The driver for this Enhancement Case are the changes to statutory guidance within the following documents: 'Environmental Permitting (England and Wales) Regulations (2016) and 'Code of Good Agricultural Practice for the Protection of Water, Soil and Air for Wales (2011 No.20)'. The guidance specifically limits the spreading of WTW sludge to land during excessively wet and frozen conditions. Consequently, we will need to change our sludge management techniques, particularly at key WTW sites to factor in the impact of this which will limit the available landbank for agricultural spreading particularly in winter months.

By undertaking the proposed programme of investment, we will significantly reduce the risk associated with critical tank bypass/redundancy, flood protection and supply resilience in AMP8 we will be a significant risk of long term interruptions to supply and water quality impacts for our customers.

Options: The process of solution development and selection has followed our standard approach where we have assessed and prioritised a range of scenarios and options to meet the enhancement needs outlined above. For each of our three intervention categories we have assessed over multiple solution options within our long listing process.

The output was a short list of solution options which have been taken forward for further assessment including costing and cost benefit analysis. This has enabled the highest priority locations and the most cost beneficial solution options to be selected for delivery in AMP8.

Our chosen options include:

1. **Critical Tanks:** Provision of a resilient supply for 15 critical tanks
2. **Flood Protection:** Schemes to protect from flooding for 2 x 1:30 year and 3 x priority 1:100 flood and 1:1,000 events.
3. **Water Resource:** A permanent raw water transfer to increase capacity of raw water from Carno impounding reservoirs to Nantybwch WTW.
4. **WTW Sludge:** additional sludge treatment at two key WTW sites to dewater sludge.

What We Will Deliver:

Critical Tanks – Re-engineering of by-passes and additional tanks/cells around 15 critical tanks within our water treatment facilities.

Flood Mitigation – Flood mitigation barrier infrastructure to our highest risk above ground water treatment assets against a 1:30 year flood scenario.

Nantybwch additional raw water resource – a duty/stand-by permanent pumps to augment the raw water supply with 16-21 ML/day of the Nantybwch water treatment works.

Sludge at water treatment works – the enhancement will deliver 1 traditional dewatering asset at Felindre and 1 innovative dewatering facility at Alaw.

Efficient Costing: We will invest in the following interventions:

1.	Critical tanks	£14M
2.	Flood protection	£5M
3.	Raw water augmentation:	£3M
4.	Sludge dewatering solutions at two key WTWs	£14M
Total		**£36M**

We have developed costs in line with our standard costing approach see WSH50-IP00 Our Approach to Investment Planning (Section 4.10).

Customer Protection: This work will be in addition to that delivered in our Base Maintenance programme and the programme budget of £36M (post efficiency, 2022/23 price Base) and will be ringfenced through a price control deliverable (PCD).

Benefits: This investment will improve our resilience of supply to our customers through multiple key investments. For example, the sludge programme will increase the sludge storage capacities at two WTW to enable high volumes to be stored on site. This will allow us to meet the new regulatory standards and helping to mitigate pollution to the environment. This will safeguard water supply by the avoidance of capacity limitations due to limitations with sludge disposal.

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

1. Introduction

This investment is driven by the need to improve our resilience to low probability high consequence events at our water treatment works. These events include extended maintenance on critical (single point of failure) tanks, flooding, and assurance of supply, which can negatively impact on water quality and supply impacting our service to customers.

To improve our position, we plan to invest £36M in four intervention programmes which are summarise in the bullets below, protecting our water supply at a Nantybwch WTW which can be supply constrained by low reservoir levels in warmer periods and securing sludge disposal through dewatering at two sites.

An overview of the four interventions programme can be seen in the bullets and Table 1 below.

a) Critical Tanks: adding assets to facilitate extended maintenance periods for critical tanks
b) Flood - Flood mitigation to critical Water assets at five WTW sites
c) Additional Resource - protecting our water supply at a Nantybwch WTW which can be supply constrained by low reservoir levels in warmer periods
d) Sludge Dewatering - securing sludge disposal through dewatering at Felindre and Alaw WTWs

A summary of the evidence of need, cost, and benefits for each of the four programmes can be seen in Table 1.

Table 1: Summary of the evidence of need, cost and objective for each scheme

Scheme name	Evidence of need	Cost (2022/23 Prices)	Benefits
Critical Tanks	17no. of the originally identified 49no. tanks within our water treatment facilities (final water holding-, and/or intermediate process tanks) have been identified as potential risks to water quality and supply. The risk centres around the lack of tank redundancy and resilience should conventional “same day clean and maintain” services be inadequate to bring a reservoir back into commission.	£14M	Security of supply Water quality: bacteriological parameters Compliance with tank cleaning standards
Flood mitigation to critical Water assets - FCERM	Recent flood events (within the last 10 years) have exposed the vulnerability of some WTW and water pumping station (WPS) sites and has resulted in costly damage to assets and interruptions to supply, significant clean-up costs and impacts upon service and the environment, along with significant impacts upon the business’ insurance premium.	£5M	Protect WTW and WPS at risk of flooding (fluvial or tidal) to a minimum standard of protection to >=1:30 flood event, where cost beneficial in alignment with our overarching Long Term Delivery Strategy

Scheme name	Evidence of need	Cost (2022/23 Prices)	Benefits
Nantybwch WTW Additional Resource	Shortfall of supply at Nantybwch WTW due to abstraction restrictions. Nantybwch WTW abstracts raw water from a combination of three reservoirs and springs. The maximum abstraction during normal operation from the sources is 30 ML/d, however during dry conditions the available abstraction rate can be reduced to as low as 9ML/d -this is below the minimum flow rate of the treatment works. Nantybwch has an average WTW demand of 19 ML/d with a maximum treatment capacity of 25 ML/d.	£3M	Security of supply
Sludge Dewatering	Legislation has been introduced in both England and Wales to manage agricultural pollution and reduce its impact on aquatic receptors. The legislation puts restrictions on the quantity and timing of spreading to land of various materials such as slurry, manufactured fertiliser, and sludges. This means that existing disposal routes are less available and secure, and it is likely that it will be necessary to transport the product further for disposal. The sludge product at these sites has no dewatering applied, meaning the resulting shipped product has a high volume. This means higher disposal costs and as part of our carbon zero strategy we need to reduce tanker movements and therefore dewatering sludges assists with this aim.	£14M	Security of supply Compliance with standards new environmental standards

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 A1.1:

ID from Appendix 9		Abbreviated Assessment Criterion	Investment Package 1: Critical Tanks	Investment Package 2: Flood Mitigation to Critical Water Assets	Investment Package 3: Nantybwch WTW Additional Resource	Investment Package 4: Sludge at Water Treatment Works
A1.1.1 Need for enhancement investment	a	Is there evidence that the proposed investment is required?	Section 2.1.1	Section 3.1.1	Section 4.1.1	Section 5.1.1
	b	Is the scale and timing of the investment fully justified?	Section 2.1.1	Section 3.1.1	Section 4.1.1	Section 5.1.1
	c	Does the proposed investment overlap with Base activities?	Section 2.1.2	Section 3.1.2	Section 4.1.2	Section 5.1.2
	d	Does the need and/or proposed investment overlap/duplicate with previously funded activities or service levels?	Section 2.1.3	Section 3.1.3	Section 4.1.3	Section 5.1.3
	e	Does the need clearly align to a robust long term delivery strategy within a defined core adaptive pathway?	Section 2.1.4	Section 3.1.4	Section 4.1.4	Section 5.1.4
	f	Do customers support the need for investment?	Section 2.1.1	Section 3.1.1	Section 4.1.1	Section 5.1.1
	g	Have steps been taken to control costs, including potential cost savings?	Section 2.1.5	Section 3.1.5	Section 4.1.5	Section 5.1.5
A1.1.2 Best option for customers	a	Have a variety of options with a range of intervention types been explored?	Section 2.2.1	Section 3.2.1	Section 4.2.1	Section 5.2.1
	b	Has a robust cost-benefit appraisal been undertaken to select the proposed option?	Section 2.2.1	Section 3.2.1	Section 4.2.1	Section 5.2.1
	c	Has the carbon impact, natural capital and other benefits that the options can deliver been assessed?	Section 2.2.2	Section 3.2.2	Section 4.2.2	Section 5.2.2
	d	Has the impact of the proposed option on the identified need been quantified?	Section 2.2.2	Section 3.2.2	Section 4.2.2	Section 5.2.2
	e	Have the uncertainties relating to costs and	Section 2.2.3	Section 3.2.3	Section 4.2.3	Section 5.2.3

ID from Appendix 9		Abbreviated Assessment Criterion	Investment Package 1: Critical Tanks	Investment Package 2: Flood Mitigation to Critical Water Assets	Investment Package 3: Nantybwch WTW Additional Resource	Investment Package 4: Sludge at Water Treatment Works
		benefit delivery been explored and mitigated?				
	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 2.3.1	Section 3.3.1	Section 4.3.1	Section 5.3.1
	b	Is there evidence that the cost estimates are efficient?	Section 2.3.2	Section 3.3.2	Section 4.3.2	Section 5.3.2
	c	Does the company provide third party assurance for the robustness of the cost estimates?	Section 2.3.1	Section 3.3.1	Section 4.3.1	Section 5.3.1
A1.1.4 Customer protection	a	Are customers protected if the investment is cancelled, delayed or reduced in scope?	Section 2.4.1	Section 3.4.1	Section 4.4.1	Section 5.4.1
	b	Does the protection cover all the benefits proposed to be delivered and funded?	Section 2.4.1	Section 3.4.1	Section 4.4.1	Section 5.4.1
	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. Investment Package 1: Critical Tanks

2.1 Need for Enhancement Investment

This section will set out the drivers behind the Critical Tanks programme of this Enhancement Case and describe the context within which it has arisen.

We describe, in detail, the low probability high-risk scenarios, the factors (outside of managements control) which are driving this, and the implication for performance. The need to invest in AMP8 is quantified by presenting the reduction in service and the increase in some operational costs which would emerge without action. We set out overlaps with our Base Maintenance programme, which we have examined and removed from the Enhancement Case and give confidence that past allowances have been effectively invested.

The proposed investment aligns with our long term delivery strategy – responding to the need for long term stewardship and improvement in service.

2.1.1 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*

There is a need to improve the resilience of clean water tanks across 11 of our water treatment works. This is to proactively allow us to address this UK water industry issue. Industry information has indicated several water companies have received enforcement action from the regulator for disinfection contact tanks, treated water and final tanks that cannot be removed from service for extended periods of time to carry out maintenance due to supply constraints. These represent a "single point of failure" for a treatment works.
To address this, Companies have received improvement notices to remove these deficiencies by providing an alternative arrangement. This needs to allow the identified tanks to be removed from service for an extended period of time, which can range from several days to several months, to complete any necessary maintenance activities.

Tanks we have identified as single points of failure at WTWs within Welsh Water we are designating "Critical Tanks. These are operated with a heightened regulatory risk to water quality but has yet to be realised to date. This is largely due to no sample failures for bacteriological or other parameters associated with expedited maintenance activities of these tanks using this current approach. The exception to this is Felindre WTW where we have had to construct a bypass around our Contact Tank to allow it to be removed from service following recent bacteriological sample failures, that had a significant impact on CRI.

The Critical Tanks identified as part of this study were designed or constructed during a time (some of which were pre privatisation of the water industry in 1989), where water storage was the priority rather than the precise disinfection requirements that govern water quality today standards today. Consideration of tank maintenance and redundancy (particularly where tanks consist of a single compartment) was not considered during the time of construction either due to financial, less stringent standards or other constraints.

In recent years there has been a significant practice shift and enhanced scrutiny on tanks to allow extended maintenance to allow the preservation of water quality and security of supply. Increased scrutiny on tank operation in Welsh Water follows the initiative of the whole industry including water companies, regulators and research organisations to improve WTW and tank design to introduce redundancy thus allowing tanks to be removed from operational service for extended periods.

This change in approach has highlighted the risk, particularly for single compartment tanks which are integral to the WTW process, which cannot be removed from service when an extended maintenance

period is required. While there is little evidence of significant deterioration of these assets, not being able to remove these tanks from service is not a satisfactory long term approach to water quality, water supply and overall asset health.

A review across production sites has identified 49 “Critical Tanks” across 31 sites that are limited in their capacity for extended maintenance. Solutions have been considered in each case that fully mitigate the risk, however, the outstanding risk beyond a change of practice, operation or immediate investment is not able to be fully mitigated in every case without further significant investment.

Within our water treatment works We have numerous tanks some of which are single compartment with no bypass facility, representing single points of failure.

Although there is a heightened risk to water quality by continuing to maintain “Critical Tanks” to an expedited timescale, there is no indication from the findings of inspections, surveys or normal operation that there is a trend of deteriorating performance.

However, continuing to operate and maintain tanks using this approach is not satisfactory to maintain long term water quality or a resilient water supply. Being unable to remove “Critical Tanks” from service for extended periods of time will inherently increase the risk to water quality further. When significant defects are discovered using the existing inspection and maintenance regime it will present a complex and costly situation of balancing the water quality risk with a loss of supply event for customers.

These are typically separated into two categories.

1. Process tanks: these tanks provide buffer capacity for certain processes or interstage pumpstations or are a specific process such as chlorine contact tanks.
2. Final water storage tanks: these tanks hold the final product awaiting distribution within our networks.

Currently all tanks are subject to a typical clean, inspect and maintain task on a risk based programme of 3 to 5 years (as per our internal standard). For those sites with single points of failure and with limited additional downstream storage in the system, the clean, inspect, and maintain task has to be completed within 12 hours so as to not compromise our supply to consumers. Normally during a clean, inspect and maintain task, if a significant defect is detected that does not allow the tank to be recommissioned (structural, water quality compromising potential, health, and safety etc) there are typically means to take that tank offline and maintain supply. This is often achieved through by-passes, dual-cell tanks, tanks in parallel, or other engineered solutions, these options are not available for these critical tanks.

We have conducted a study (during-AMP7) on all tanks at our Water Treatment Works that would require cleaning or maintenance activities undertaken that could impact supply, to identify any single points of failure. This identified 49 no. tanks that do not have a means to be taken offline for extended maintenance periods whilst continuing to supply the network e.g. a single point of failure. Work is being implemented in AMP7 alongside a risk assessed review of our tank cleaning strategy to resolve issues with 31 of these tanks, leaving 18 no. tanks across 12 water treatment facilities that will require risk mitigation. 15 of these tanks will be completed in AMP8 and a further 3 will be completed in AMP9. This programme has been agreed with the DWI as an appropriate timescale for resolution. This work is supported by the DWI, through support letter DWR3, as this represents a risk to long term water supply and quality.

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2).

Scale and Timing of Investment

The proposed AMP8 critical tanks programme builds on the programme of work started in AMP7. A summary of which for the 31 no. tanks that have already been completed or are in the process of completion is given below.

- **AMP 7 Enhancements (4 no. tanks)**

    - We are currently delivering schemes in AMP7 to resolve the risk around extended maintenance for 4 tanks across 3 WTW sites. The level of investment being delivered in AMP7 is £10M to deliver bypass facilities including at our largest WTW which supplies over 400,000 customers in South Wales.
- **Operational Management (13 no. tanks)**
    - Tanks that can be addressed under operational mitigation are anticipated to require minor enabling works including mains conditioning, new instrumentation, and automation adjustments. It is anticipated that there will be costs associated to the need to minimise WTWs outages and treated water tankering costs also. These have been estimated at £0.8M across the sites highlighted for delivery by the end of AMP7.
- **Policy Review (14 no. tanks)**
    - As part of this review a number of ancillary structures were identified by the Production operational teams including channels, surge vessels and intermediary chambers. It is considered that in comparison to contact and final water tanks they present a low risk and being able to provide the requirement for extended maintenance on all of these structures would incur very significant investment. As such they have been eliminated from the scope at this time.

AMPs 8 & 9 Programme

We are proposing a two-phase programme across the next 2 AMPs, 20225/26 to 2034/35, to deliver solutions for the remaining 18 “Critical Tanks”. A prioritisation exercise using a risk-based approach has been undertaken using information including Compliance Risk Index (CRI) impact, history of failure and most recent condition assessments.

By prioritising the tanks and phasing the delivery across the next 10 years it not only addresses risk in terms of prioritisation, affordability and solution deliverability. We propose to address 15 of the 18 tanks in AMP8, see summary in Table 2 below. The three remaining tanks located at Bretton WTW will require detailed feasibility in AMP8 to identify the best solution for delivery in AMP9.

Table 2: Location and Type of Critical Tanks and Proposed Solutions for the AMP8 Programme

WTW	Tank	No of Tanks	Possible Solution
Llwynon	Contact Tank, Final Water Tank 1 and 2	3	Network solution required to facilitate removal from service.
Bolton Hill	Contact Tank and Pump Sump	2	New bypass and a new bypass or tank
Builth	Contact Tank	1	New bypass manifold utilising Llanelwedd SRV as contact tank.
Whitbourne	Final Water tank. (used as Contact tank)	1	New tank
Glascoed	Contact Tank	1	Network solution to reduce demand on Glascoed WTW. [POSSIBLE NETWORK SOLN.]
Cwellyn	Contact Tank	1	New bypass
Elan	Contact Tank	1	New bypass, reutilising one half of treated water tank for contact tank.
Preseli	Contact Tank	1	New bypass (also to include bypass of the onsite backwash tank)

WTW	Tank	No of Tanks	Possible Solution
Mayhill	Final Water Tank 1 and High lift sump	2	New tank
Gwastadgoed	Interstage tank (post membrane)	1	New pre-membrane booster pumping station. Abandon tank.
Pen y Bont	Treated water pump tank	1	Construct second tank (10m3)
Total Number		**15**	

Whilst these tanks, based on the latest assessments, do not show signs of imminent failure or requirements for extended maintenance they pose a higher risk to supply. If an engineered solution to facilitate extended maintenance of these tanks is not implemented a low probability event will pose a significant risk to supply of water to our customers

Table 3: Critical Tank Programme Summary Cost

Interventions	AMP8 Budget (2022/23 prices)
PR24 15 x identified single point of failure mitigation projects at WTW tanks	£14M
Total Programme	**£14m**

2.1.2 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

We have an ongoing programme of maintaining our WTW assets, this work is routine, and risk based, it will ensure compliance with previous legislation and effective operation. In summary for Critical Tanks: New assets (bypasses, parallel tanks etc.) are required to facilitate significant periods of maintenance on tanks that cannot currently be removed from service for more than 12 hours. The cleaning and maintenance activities themselves, of these and all our other tanks, will continue to by covered under Base Maintenance in the future.
The investment set out in this case is entirely separate from Base Maintenance and has no overlap. It involves the construction of new assets which will sit alongside our existing ones.
Base activities will continue to maintain any existing assets only.

2.1.3 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

There is no overlap or duplicate activities from previous price reviews. The risks associated with the 15no. critical tanks identified for AMP8 have not been funded in previous price reviews.

2.1.4 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 a dedicated long term output focused on resilience for water assets covering both water treatment works and network assets. The long term target focuses on minimising customers who are supplied by single sources of supply. This Enhancement Case directly aligns to Welsh Water's core pathway and addressing single points of failure on WTW. Further details can be seen in WSH50-IP00 Our Approach to Investment Planning

2.1.5 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*

This business case is driven by external factors, such as climate change (water shortage, floods) and changes in design standards, requiring redundancy in operational and storage tanks, since the existing WTWs were designed.

2.2 Best Option for Customer

In this section we will describe how we have developed options to address the high consequences risk regarding critical tanks as single points of failure within our system. Currently the critical tanks require the water treatment works site to be removed from service for prolonged periods of time to facilitate extended maintenance periods without compromising supply to customers. In order to select the optimal solution we have followed our standard TotEx hierarchy approach which is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.10).

The sections 2.2.1 to 2.2.6 below set out examples of how we have optioneered and quantified benefits for each of the options against our objectives. This has been assessed using our cost benefit analysis method which is linked to the Service Measure Framework to achieve the objective.

2.2.1 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*

Our approach to options development is set out in which is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.10).

For this Enhancement Case we have considered a range of options for each scheme at the long listing stage which are summarised in Table 4 below. The three options that were viable or partially viable were then taken forward to the shortlisting stage which is detailed in Section 2.2.2 below.

Table 4: Long list of options considered for the Critical Tanks scheme

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
1	**Eliminate, reduce or delay the need for change.** Manage demand	**Partially Viable -** The demand at some of the affected WTW sites could be met by another asset during maintenance activities. However, although a viable solution at some sites, this would not be sustainable for long periods due to other demands at the majority of identified assets. This makes this option partially viable for the duration of the maintenance activities.	✓
2	**Maintain the effective risk controls already in place.** Manage operation or use of the existing asset or service	**Not Viable -** This is not deemed a viable solution due to the critical tank assets being single points of failure and the potential duration that they will need to be taken offline during maintenance activities.	×
3	**Maintain the effective risk controls already in place.** Maintain the existing asset or service	**Not Viable -** This is not a viable solution because the problem only occurs when the asset is taken out of service for maintenance.	×
4	**Maintain the effective risk controls already in place.** Replace the existing asset like-for-like	**Not Viable -** This is not a viable option because the new tank would have the same issue associated with long duration outages for maintenance as the current critical tanks.	×
5	**Enhance existing resources or add new resources.** Enhance/upgrade the existing asset or service	**Viable -** This option has been deemed a potential solution and viable via the construction of a bypass arrangement for particular assets. A bypass of the existing contact tank or final storage tank would allow for disinfection contact time and supply to be maintained while also taking the existing asset offline for sufficient time for maintenance activities.	✓
6	**Maintain the effective risk controls already in place.** Mothball/dispose of the existing asset or service	**Not Viable -** This is not a viable option because the WTW in question are required in the medium to long term and their associated critical tank storage resilience need to be improved.	×

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
7	**Enhance existing resources or add new resources.** Create/acquire a new asset or service	**Viable -** This option has been deemed a potential solution for several sites where existing tanks cannot be taken out of service for maintenance for extended period of time. It is also a potential solution where a bypass would not be suitable as it would not provide sufficient disinfection contact time or maintaining of supply.	✓
8	Innovation	No viable innovations identified.	×

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). 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.

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).

2.2.2 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*

In its analysis of option cost benefit Welsh Water has considered the impact of Carbon and Natural and other Capital benefits. 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.

Natural capitals and wider societal capitals have also been considered through application of Welsh Water's Multi Capital Approach (MCA) valuation of service measure impacts. Like GGE impacts these are considered as part of the CBA. The benefits of a scheme have been calculated by our asset planning and engineering teams based on the best available information available and have been used forecast the impact a scheme will have on service measures in comparison to the pre investment position/do nothing position. Benefits are quantified against the Welsh Water service measure framework, see Table 5 below, meaning they are well understood and trackable through regular business activity.

For more detail on this approach see WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

We present the programme-level benefits disaggregated by relevant category in the table below. NB: this is for the entire Increasing Resilience of Tap Water Supply - Treatment Works enhancement programme not solely the critical tanks.

Table 5: Benefits Table for Water Supply Resilience

Scenario	Benefits from AMP8 Spend relative to baseline							
	Unplanned network interruptions	Loss of production	Greenhouse Gas Emissions Reduction	Traffic and Transport Disruption	Legal Compliance	Sludge Treatment and Disposal	Avoidable Costs	Total
Preferred –	98.97%	0.00%	-0.04%	0.06%	0.06%	0.09%	0.84%	100%

2.2.2.1 Quantifying the Impact on Need and Performance Commitments

Within our cost benefit process the impacts of each option on the need have been quantified our methodology is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). As part of this process our Service Measure Framework quantifies as a financial value a wide range of consequences including Carbon and impacts on performance which are then used within our cost benefit analysis.

2.2.3 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 4.1 – 4.3). This includes commentary on our approach to optioneering, costing and cost benefit analysis.
For this Enhancement Case we have evaluated a range of options in line with our TotEx hierarchy approach, these are set out in Section 2.3 below.

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 such as nature-based work is inherently more uncertain than tried and tested engineering approaches.

2.3 Costing Efficiency

In this section we give specific 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 4.1).

2.3.1 Developing a cost for Water Treatment Works

> ***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

With the Critical Tanks element of this Enhancement Case, to allow us to use our preferred like-for-like (top down) costing approach, we generated a scope so that we could use our Unit Cost Database (UCD) Cost & Carbon Estimating Tool (C&CET). This was the preferred method as it is based on the historical project costs we experience within our operating area.

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. Further detail can be found in WSH50-IP00 Our Approach to Investment Planning (Section 4.1).

UCD has been used the develop the costs for this programme. Selective benchmarking of UCD outputs has been undertaken but not for this area of work.

2.4 Providing Customer Protection

This section has been combined with the other three Investment Packages in Section 6 below.

3. Investment Package 2: Flood mitigation to critical Water assets

3.1 Need for Enhancement Investment

This section will set out the drivers behind the Enhancement Case and describe the context within which it has arisen.

We describe, in detail, the low probability high-risk scenarios, the factors (outside of managements control) which are driving this, and the implication for performance. The need to invest in AMP8 is quantified by presenting the reduction in service and the increase in some operational costs which would emerge without action. We set out overlaps with our Base Maintenance programme, which we have examined and removed from the Enhancement Case and give confidence that past allowances have been effectively invested.

The proposed investment aligns with our long term delivery strategy – responding to the need for long term stewardship and improvement in service.

3.1.1 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*

The programme of work has been developed to meet the ambition to ensure all critical above ground water assets have at least a 1 in 30 year flood event protection, informing the core pathway of the overarching Long Term Delivery Strategy.

Our Water Treatment Works (WTW) and Water Pumping Stations (WPS) provide a key function in the provision of drinking water across the Welsh Water operational area. Recent flood events (within last 10 years) have exposed the vulnerability of some WTW and WPS sites and has resulted in costly damage to assets (an event at unprotected Mayhill WTW resulted in damages of £5M, including addition of flood defences) and interruptions to supply, significant clean-up costs and impacts upon service and the environment, along with significant impacts upon the business' insurance premium. Furthermore, climate change has, and will continue, to result in more severe weather events that will exacerbate the risk.

The primary aim of this investment programme is to protect critical WTW and WPS at risk of flooding (fluvial or tidal) to a minimum standard of protection to >=1:30 flood event, where cost beneficial. In addition, further sites that have been identified as vulnerable to >=1:30, assets that are not categorised as critical but still represent a significant risk due to their size should they fail have been included within our investment plan. This forms part of our WSH01 Long Term Delivery Strategy.

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2).

Scale and Timing of Investment

The programme of work has been developed to meet the ambition to ensure all critical above ground water assets have at least a 1 in 30 year flood event protection, informing the core pathway of the overarching Long Term Delivery Strategy.

This iterative programme of flood risk assessment has highlighted the vulnerability of specific water above ground assets to >=1:30 flood risk.

The sites identified as the highest priority have been selected for further detailed assessment and ultimately costs and tested for whole life value added.

The proposed investment is summarised in Table 6 below.

Table 6: Summary of Flood Mitigation to Critical Water Assets

Interventions	AMP 8
PR24 5 x identified flood mitigation projects at WTW	£5M
Total	**£5M**

This programme would enable 100% of critical above ground WTW water assets to be protected against 1 in 30 year (or greater) flood events once Pontsticill and Llwyn-on WTWs are decommissioned as part of the new Cwm Taff WTW (AMP9).

3.1.2 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

We have an ongoing programme of maintaining our WTW assets, this work is routine, and risk based, it will ensure compliance with previous legislation and effective operation.

The investment proposed in bullet 1. below does not overlap with our Base programme and focuses on the enhancement of flood protection, to new levels driven by climate change, by installing new assets to protected critical water treatment and pumping stations.

1. Flood mitigation: New assets (for example flood berms) are required to ensure critical above ground water assets have at least a 1 in 30 year flood event protection.

The Base activities will continue to maintain any existing flood protection assets.

3.1.3 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

None of the flood mitigation schemes included in this proposed investment overlap or duplicate activities from previous price reviews, as the requirements are based on the impacts of climate change.

3.1.4 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 a dedicated long-term output focused on resilience for water assets covering both water treatment works and network assets. The long term target focuses on minimising customers who are supplied by single sources of supply. This Enhancement Case directly aligns to Welsh Water's core pathway and addressing single points of failure on WTW. Further details can be seen in WSH50-IP00 Our Approach to Investment Planning.

3.1.5 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

This business case is driven by external factors, such as climate change including floods, cold and dry weather period. This programme of work focuses on the protection of the high risk water assets from flooding the severity and frequency of which have increased since the existing asset were designed.

3.2 Best Option for Customer

In this section we will describe how we have developed options to address the high consequences risk regarding flooding of our critical water treatment and water pumping station sites. During the development of this Enhancement Case number of our facilities were assessed to provide sufficient flood protection to mitigate more frequent flood occurrences. Should these assets fail, it would result in costly repairs and significant periods of downtime to water supply within our water supply network. We have followed our standard TotEx hierarchy approach which is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.1).

The following sections set out examples of how we have optioneered and quantified benefits for different options using our Service Measure Framework to achieve our flood prevention objectives.

3.2.1 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

Our approach to options development is set out in WSH50-IP00 Our Approach to Investment Planning.

For this Enhancement Case we have considered a range of options for each scheme at the long listing stage which are summarised in Table 7 below. The two options that were viable or partially viable were then taken forward to the shortlisting stage which is detailed in Section 3.2.2 below.

Table 7: Long list of options considered for the Flooding Programme

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
1	**Eliminate, reduce or delay the need for change.** Manage demand	**Not Viable -** The demand at some of the affected WTW sites could be met by another asset should the site be flooded and out of service. However, although a viable solution at some sites, this would not be sustainable for long periods. It would not protect our assets from high cost repairs following a significant flooding event.	×

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
2	**Maintain the effective risk controls already in place.** Manage operation or use of the existing asset or service	**Not Viable:** This is not deemed a viable solution due to the nature of flooding being outside of operational control.	×
3	**Maintain the effective risk controls already in place.** Maintain the existing asset or service	**Not Viable:** This is not a viable solution because the problem only occurs when the asset is flooded because the existing flood protection is insufficient to protect the asset.	×
4	**Maintain the effective risk controls already in place.** Replace the existing asset like-for-like	**Not Viable:** This is not a viable option because the new asset would be at equally high risk of flooding and long term outages.	×
5	**Enhance existing resources or add new resources.** Enhance/upgrade the existing asset or service	**Viable:** This option has been deemed a potential solution and partially viable via the construction of improvements to any existing flood protection measures for example raising embankments and adding flood protection assets to existing buildings.	✓
6	**Maintain the effective risk controls already in place.** Mothball/dispose of the existing asset or service	**Not Viable:** The sites in questions are key to maintaining a clean water supply and so cannot be shut down or disposed of.	×
7	**Enhance existing resources or add new resources.** Create/acquire a new asset or service	**Viable:** This option has been deemed a potential solution to mitigate flooding for a number of sites where new assets are required to provide flood protection.	✓
8	Innovation	**Not Viable:** No viable innovations identified.	×

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). 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.

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).

The outcome for the CBA undertaken for the Critical Water Asset (WTW and Water Pumping Stations) Flood mitigation schemes can be seen below.

Option S1 – Install new assets to provide an improved flood resilience at for the two critical water sites that are at risk of a 1 in 30 year or greater return period for flooding. Although this would address the highest return period flood risk there are still critical assets for which the risk of failure is too great.

Option S2 – As option 1 above but to mitigate the risk of flooding for an additional three highest critical sites for flood risk

Option S3 – As option 2 above but to mitigate the two remaining sites at risk of flooding.

The options assessment identified that undertaking Option 2 would provide the greatest risk reduction and provide the opportunity to monitor flood risk in AMP8 to define the scope of work and future risk at the remaining two sites. The output of the CBA for the Flood risk sites can be seen in Table 8 below.

Table 8: Cost benefit analysis of the for Flood Mitigation Programme for Critical Water Assets

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)
Conventional Solution	Do Nothing - Reactive Maintenance	£0.588M	£0.528M	-£2.827M	**-5.355**	-£3.354M
Option S1	1:30 flood wall defence 2 x Schemes Crai and Bryncrug WTWs	£4.066M	£3.787M	£6.952M	**1.836**	£3.164M
Option S2 Preferred Scheme	Option 1 + 3 x Schemes Talybont and Llyswen WTWs and Nantgaredig Low Level	£5.804M	£5.355M	£34.604M	**6.462**	£29.249M
Option S3	Option 2 + 2 x schemes Elan Valley WTW and Llantrisant on Usk Water Pumping Station	£6.149M	£5.692M	£37.177M	**6.532**	£31.486M

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. For more detail on this approach see WSH50-IP00 Our Approach to Investment Planning (Section 6).

3.2.2 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

In its analysis of option cost benefit Welsh Water has considered the impact of Carbon and Natural and other Capital benefits. 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.

Natural capitals and wider societal capitals have also been considered through application of Welsh Water's Multi Capital Approach (MCA) valuation of service measure impacts. Like GGE impacts these are considered as part of the CBA. The benefits of a scheme have been calculated by our asset planning and engineering teams based on the best available information available and have been used forecast the impact a scheme will have on service measures in comparison to the pre investment position/do nothing position. Benefits are quantified against the Welsh Water service measure framework meaning they are well understood and trackable through regular business activity. Table 5 in section 2.2.2 presents the benefits for the entire Increasing Resilience of Tap Water Supply - Treatment Works enhancement programme.

For more detail on this approach see WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

3.2.2.1 Quantifying the Impact on Need and Performance Commitments

Within our cost benefit process the impacts of each option on the need have been quantified. Our methodology is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.10). As part of this process our Service Measure Framework quantifies, as a financial value, a wide range of consequences including Carbon and impacts on performance which are then used within our cost benefit analysis.

3.2.3 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. This includes commentary on our approach to optioneering, costing and cost benefit analysis.

For this Enhancement Case we have evaluated a range of options in line with our TotEx hierarchy approach, these are set out in Section 3.3 below.

We have highlighted areas in which the calculation of costs or benefits are unusual or uncertain and how we have mitigated for this through our evaluation. Innovation and new approaches such as nature-based work is inherently more uncertain than tried and tested engineering approaches.

Throughout the optioneering process we have selected the most appropriate schemes for the specific characteristics of the location, that provides the highest confidence of mitigating the risk at the most efficient long run cost. The most cost-beneficial schemes are the outcome of this process.

3.3 Costing Efficiency

In this section we give specific 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 4.10).

3.3.1 Developing a cost for Water Treatment Works and Water Pumping Station Flooding

> ***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*

With the flooding element of this Enhancement Case, to allow us to use our preferred like-for-like (top down) costing approach. We generated a scope of work for each of the sites so that we could use our Unit Cost Database (UCD) Cost & Carbon Estimating Tool (C&CET). This was the preferred method as it is based on the historical project costs we experience within our operating area and applies a consistent level of overheads and risk.

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.

3.4 Providing Customer Protection

This section has been combined with the three other programmes of work to provide a single customer protection in section 6 below.

4. Investment Package 3: Nantybwch WTW Additional Resource

4.1 Need for Enhancement Investment

This section sets out the drivers behind the Enhancement Case and describe the context within which it has arisen.

We describe the Additional Water Resource scheme and the low probability high-risk scenarios, the factors (outside of management control) which are driving this investment and the impact on performance. The need to invest in AMP8 is quantified by presenting the current risk to clean water supply interruptions and the associated avoidable costs which would result. We set out review overlaps with our Base Maintenance programme, which we have examined and removed from the Enhancement Case and give confidence that past allowances have been effectively invested.

The proposed investment aligns with our WSH01 Long Term Delivery Strategy (LTDS) responding to the need for long term stewardship and improvement in service.

4.1.1 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*

This scheme is required to improve the resilience of the raw water supply to our Nantybwch WTW. The proposed approach is to improve the reliability of the raw water transfer from our Carno impounding reservoirs to Shon Sheffrey from which Nantybwch abstracts its raw water. Without this investment, the current temporary pumping arrangements used regularly during the summer and autumn periods do not provide a sustainable long term solution for this need. A low probability high consequence risk to resilience of the raw water supply currently exists.

The water supply zone fed by the Carno and Nantybwch WTWs has an average demand of 19 Ml/day and 25Ml/day during peak demand. The rated capacity of Carno WTW is 9Ml/day and Nantybwch WTW is 25 Ml/day. Consequently both WTWs are required to meet peak demand. While Carno WTW has a maximum potential output of 9Ml/d, due to issues with quality at higher volumes, the WTW is limited to 4.5Ml/d unless further capital investment is undertaken.

Nantybwch WTW abstracts raw water from a combination of two reservoirs and springs (Shon Sheffrey and Rhymney). The maximum abstraction during normal operation from these sources is 30 Ml/d. During periods of dry weather, levels drop rapidly and the available abstraction rate can be reduced to as low as 9Ml/d. The impact of this is that there is insufficient water available to run the WTW as it is lower than the minimum design flow of the treatment works. This would also mean that demand could not be met for the water supply zone during this period. Due to the limited storage in the Shon Sheffrey and Rhymney reservoirs, the resource position can move from spilling in all three reservoirs to reduced output in a matter of a few weeks of warm weather.

There is more water available in the Carno reservoir system and there is a pipeline that can facilitate transfer water from Lower/Upper Carno reservoir to Nantybwch WTW. We currently transfer water through this pipeline using hired pumps to supplement the Nantybwch WTW raw water supply. The transfer is done by diesel pumps, which is not a sustainable, economic or secure option.

The annual costs for diesel pump hire is approximately £100k which includes additional site security (to mitigate diesel theft from the temporary installation) and it is forecast that running costs of the pumps are between £20k-£50k depending upon demand requirements. However, the greater risk to security of supply is the availability of hire pumps when needed and the time taken from need identification to commissioning. To mitigate this the pumps are now being hired every year.

This is not a long term cost-effective solution, a permanent pump installation would provide the security of full availability, in a secure building, with significantly cheaper running costs, if electrically powered rather than through diesel.

Scale and Timing of Investment

Every year we hire diesel pumps, secure them, and operate them at significant cost. Upon our extensive review of the system, a permanent augmentation solution is preferred, see cost in Table 9 below. The solution will achieve the need for the installation of permanent pumps is to remove risk of hire pump availability, the security risk, and the cost of operation.

Table 9: Cost of the Resource Resilience Scheme

Interventions	AMP 8
PR24 1 x Resource resilience scheme	£3M
Total	£3M

4.1.2 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

We have an ongoing programme of maintaining our WTW assets, this work is routine, and risk based, it will ensure compliance with previous legislation and effective operation. In summary, new assets (permanent pumps) are required to mitigate the risk of hire pump supply and installation time on a system that requires them every year. The operation and maintenance of the pumps will be a Base activity in the future.

The investment set out in this case is entirely separate from Base Maintenance and has no overlap. It involves the construction of new assets which will sit alongside our existing ones.

Base activities will only continue to maintain any existing assets.

4.1.3 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

The scheme included in this proposed investment does not overlap or duplicate activities from previous price reviews. The installation of permanent pumps has not been addressed in previous price reviews.

4.1.4 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 a dedicated long term output focused on resilience for water assets covering both water treatment works and network assets. The long term target focuses on minimising customers

who are supplied by single sources of supply. This Enhancement Case directly aligns to Welsh Water's core pathway and addressing single points of failure on WTW. Further details can be seen in WSH50-IP00 Our Approach to Investment Planning.

4.1.5 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

This business case is driven by external factors, including climate change and the impact of this on raw water resources and the current temporary position where pumps are hired each year to transfer raw water.

4.2 Best Option for Customer

In this section we will describe how we have developed options to address the high consequences risk at Nantybwch WTW. We have followed our standard TotEx hierarchy approach which is set out in WSH50-IP00 Our Approach to Investment Planning

The following sections set out examples of how we have optioneered and quantified benefits for different options using our Service Measure Framework to achieve the objective.

4.2.1 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

Our approach to options development is set out in which is set out in Section 6 of the document WSH50-IP00 Our Approach to Investment Planning.

For this Enhancement Case we have considered a range of options for each scheme at the long listing stage which are summarised in Table 10 below. There is one option that was viable which was then taken forward to the shortlisting stage which is detailed in Section 4.2.2 below.

Table 10: Long List Options considered for the Critical Tanks

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
1	**Eliminate, reduce or delay the need for change.** Manage demand	Although there is a certain element of conjunctive use in the network system, during periods of higher and peak demand the strategic location of Nantybwch WTW is critical. To ensure future demand is met, an additional and sustainable resource is required.	×

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
2	**Maintain the effective risk controls already in place.** Manage operation or use of the existing asset or service	Even though the system been optimised during higher periods of demand, we have identified an additional resource is still required for Nantybwch WTW during these periods. Reliance on the availability of hire pumps for a critical asset is not a resilient option.	×
3	**Maintain the effective risk controls already in place.** Maintain the existing asset or service	This is not a viable solution because the risk has identified an enhanced asset is required.	×
4	**Maintain the effective risk controls already in place.** Replace the existing asset like-for-like	This is not a viable option because the capacity of the current pump arrangement is not sufficient to meet current or future demand.	×
5	**Enhance existing resources or add new resources.** Enhance/upgrade the existing asset or service	This option has been deemed the most appropriate solution owing to the need to provide an additional and sustainable additional resource for Nantybwch WTW due to limitations in providing demand from elsewhere in the system during higher demand.	✓
6	**Maintain the effective risk controls already in place.** Mothball/dispose of the existing asset or service	This is not a viable option as Nantybwch WTW is a critical asset to ensure demand is met during periods of higher and peak use of water in this system.	×
7	**Enhance existing resources or add new resources.** Create/acquire a new asset or service	This option has not been deemed viable due to location of the existing asset which can be upgraded. The cost of creating a new asset to provide the same function of upgrading the current asset would be inhibitive.	×
8	Innovation	No viable innovations identified.	×

Assessment and Selection of Solution Options

Our approach to cost benefit appraisal and its role in decision making is set out in Section 6 of our document WSH50-IP00 Our Approach to Investment Planning. 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.

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 Section 7 of our document WSH50-IP00 Our Approach to Investment Planning.

The outcome for the shortlisting process has assessed the solution options. These have been through our CBA undertaken for Nantybwch WTW Additional Resource scheme can be seen below.

Option 1 the 'permanent' diesel pump installation, would use the same pumps (or similar) to the temporary arrangement and for added reinforcement may include a third pump to offer duty/assist/standby functionality. This arrangement would still require the existing Low Lift Pumps at Carno WTW to run in tandem drawing the raw water from the reservoir to feed the diesel pumps to achieve the required 16 - 21 Ml/d output.

Option 2: The advantages of Option 2 'Provide permanent electrical pumps within secure building and upgrade power supply, compared with the others, is that once the power upgrade has been agreed with the DNO, operational flexibility would allow remote automatic control of the transfer system whilst optimising power consumption from Carno WTW.

The key advantage of Option 3 'Provide permanent electrical pumps within secure building, upgrade power supply and provide new low lift pumps over Option 2 is that the residual risk of low lift pump failure is mitigated whilst retaining the previous OpEx benefit.

The benefit to cost ratio for Option 2 outweighs Options 1 and 3 as its CapEx, OpEx and whole life costs are lower.

Table 11: Benefit to cost ratio analysis of the for Nantybwch WTW Additional Resource scheme. All monetary values are expressed in 2022/23 prices and are prior to portfolio adjustments for corporate overheads and efficiency challenge. Welsh Water ref: SMF version 5.

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)
Conventional Solution	Do Nothing		£0	-£65.891M	**0.000**	-£65.891M
Option S1	Provide Permanent Diesel Pumps within secure Building	£3.741M	£7.911M	£19.767M	**2.499**	£11.856M
Option S2	Provide Permanent Electrical Pumps within secure Building and upgrade Power Supply	£3.413M	£7.521M	£19.767M	**2.628**	£12.246M
Option S3	Provide Permanent Electrical Pumps within secure Building, upgrade Power Supply and provide new Low Lift Pumps	£3.820M	£9.131M	£19.767M	**2.165**	£10.636M

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. For more detail on this approach see Section 6 of our document WSH50-IP00 Our Approach to Investment Planning.

4.2.2 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*

In its analysis of option cost benefit Welsh Water has considered the impact of Carbon and Natural and other Capital benefits. 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.

Natural capitals and wider societal capitals have also been considered through application of Welsh Water's Multi Capital Approach (MCA) valuation of service measure impacts. Like GGE impacts these are considered as part of the CBA. The benefits of a scheme have been calculated by our asset planning and engineering teams based on the best available information available and have been used forecast the impact a scheme will have on service measures in comparison to the pre investment position/do nothing position. Benefits are quantified against the Welsh Water service measure framework meaning they are well understood and trackable through regular business activity. Table 5 in section 2.2.2 presents the benefits for the entire Increasing Resilience of Tap Water Supply - Treatment Works enhancement programme.

For more detail on this approach see Section 6 of our document WSH50-IP00 Our Approach to Investment Planning.

Quantifying the Impact on Need and Performance CommitmentsWithin our cost benefit process the impacts of each option on the need have been quantified our methodology is set out in Section 6 of the document WSH50-IP00 Our Approach to Investment Planning. As part of this process our Service Measure Framework quantifies as a financial value a wide range of consequences including Carbon and impacts on performance which are then used within our cost benefit analysis.

4.2.3 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 Section 5 of the document WSH50-IP00 Our Approach to Investment Planning. This includes commentary on our approach to optioneering, costing and cost benefit analysis.
For this Enhancement Case we have evaluated a range of options in line with our TotEx hierarchy approach, these are set out in Section 4.3 below.

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 such as nature-based work is inherently more uncertain than tried and tested engineering approaches.

The summary in the table below provides an example of the costing risks associated with the options considered in the Nantybwch WTW Additional Resource scheme.

Table 12: Options considered for Nantybwch WTW Additional Resource

Option	Description	Risks associated with costing this option or valuing its benefits	Mitigation
Conventional Solution	Do nothing, i.e. carry on with the reactive work	The risk is high as it could lead to interruption to supply.	Not applicable
Option 1	Provide Permanent Diesel Pumps within secure Building	The risk is significant as the existing Low Lift Pumps that draw water from the Lower Carno Reservoir to feed the transfer pumps are near their design life and failure would prevent the transfer of water to Nantybwch.	Not applicable
Option 2	Provide Permanent Electrical Pumps within secure Building and upgrade Power Supply	The risk is significant as the existing Low Lift Pumps that draw water from the Lower Carno Reservoir to feed the transfer pumps are near their design life and failure would prevent the transfer of water to Nantybwch. A further risk to both the cost and programme is from the electrical upgrade required, provided by Western Power Distribution to the existing Carno WTW. It is currently assumed that reinforcement of the supply cable will not be required and Western Power Distribution have based their cost estimate on this assumption	Should low lift pumps need replacement and/or electrical upgrade is required, we would finance them.
Option 3	Provide Permanent Electrical Pumps within secure Building, upgrade Power Supply and provide new Low Lift Pumps	As Solution 2 but with uprated low lift pumps to increase the volume of water that can be pumped from Carno WTW. This solution has the benefits of the above without the risk associated with re-using the existing Low Lift Pumps. Only the additional cost is for enhancement has been included.	Not applicable

4.3 Costing Efficiency

In this section we give specific 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 4.1).

4.3.1 Developing a cost for Water Treatment Works

> ***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*

With the resource element of this Enhancement Case, to allow us to use our preferred like-for-like (top down) costing approach, we generated a standardised scope so that we could use our Unit Cost Database (UCD) Cost & Carbon Estimating Tool (C&CET). This was the preferred method as it is based on the historical project costs we experience within our operating area.

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. Further detail can be found in WSH50-IP00 Our Approach to Investment Planning (Section 6).

4.4 Providing Customer Protection

This section has been combined with the other Investment Packages to provide a single customer protection in section 6 below.

5. Investment Package 4: Sludge at Water Treatment Works

5.1 Need for Enhancement Investment

This section will set out the drivers behind the Enhancement Case and describe the context within which it has arisen.

The five sub sections below correspond to the seven criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.1.

5.1.1 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*

There are two main aspects driving the need for the proposed investment.

- One is the trickle-down effect of new legislation and the resulting security of supply,
- The other is a reduction in transport and handling.

However, we also have a deterioration in raw water quality which means the sites are naturally producing more sludge over time. In addition, due to farming regulations limiting when wet sludges can be applied to land, a dryer product is more attractive to the end users.

Legislation has been introduced in both England and Wales to manage agricultural pollution and reduce its impact on aquatic receptors. The legislation, still in the period of roll out in Wales, puts restrictions on the quantity and timing of spreading to land of water treatment sludges. The legislation targets sludges produced at water treatment works and the conditions when they can be spread to land, i.e. the condition of the receiving land banks (particularly those that are steep and adjacent to a watercourse) following inclement weather conditions including rainfall, snow and freezing temperatures. It is now a less favourable product to land managers who have to consider the wetness of soils before applying a beneficial product.

This means that existing disposal routes are less available and secure, and it is likely that it will be necessary to transport the product further for disposal. The sludge product at these sites has no dewatering applied, meaning the resulting shipped product has a high volume, but with a significant portion as water. This means higher disposal costs and as part of our carbon zero strategy we need to reduce tanker movements and therefore dewatering sludges assists with this aim.

In summary investing in dewatering will allow sludge volumes to be reduced, which will in turn reduce the transport costs, energy, and carbon, and the risk generated by landbank availability.

5.1.2 Scale and Timing of Investment

As the legislation has come into force the risk that the landbank will not be available for our disposal route has increased.

At present to manage this issue, managing the output through our usual disposal routes, however this is not sustainable as if the routes to dispose are closed to us then storage capacities are not sufficient for long term holdings. Furthermore, inadequate storage effects the quality of WTW sludge for land application. It is proposed to develop solutions for the two largest sludge producing sites initially as this will have the greatest reduction in risk and in cost and carbon.

Table 13: Programme Summary of the Dewatering Schemes

Interventions	AMP8 Budget (2022/23 Prices)
PR24 provision of dewatering facilities at Alaw WTW	£5M
PR24 provision of dewatering facilities at Felindre WTW	£9M
Total	£14M

5.1.3 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

We have an ongoing programme of maintaining our WTW sludge assets. This work is routine, and risk based, and it will ensure compliance with previous legislation and effective site operation.

The investment set out in this case is entirely separate from Base Maintenance and has no overlap. It involves the construction of new assets which will sit alongside our existing ones.

Base activities will only continue to maintain any existing assets or equipment along with covering the cost of sludge disposal as part of OpEx.

5.1.4 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

This Enhancement Case is in response to developing statutory legislation and guidance the which was under review during the previous price review. Previous investments were made under the prior legislation where a suitable disposal route was readily available. Therefore, proposed investment does not overlap or duplicate activities from previous price reviews.

5.1.5 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

The storage and spreading of WTW sludge directly aligns to Welsh Water's long term strategy associated with river and coastal water quality. Any runoff from WTW sludge has a direct impact on river water quality. The schemes included in this Enhancement Case form part of Welsh Water's core pathway and directly contribute to achieving the long term ambitions. Following the assessment against a range of scenarios alternative pathways have been developed with respect to climate change impacts effecting WTW sludge spreading windows, and changing requirements associated with spreading sludge to land. Further details can be seen in WSH50-IP00 Our Approach to Investment Planning.

5.1.6 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

This work is driven by changes in legislation with regards to the spreading of WTW sludge.

Our existing approach has been permissible for many years but will no longer be appropriate because external guidance. As WTW sludges are of low nutritional value to farmers they are paid to take these sludges and dispose of them. As incoming NRW and EA legislation makes this more difficult, the disposal route cost will increase or not be possible. Changes in the legislation means that we have to be proactive is making these changes in order to ensure a suitable and cost-efficient disposal route for WTW sludges.

Welsh Water have optimised their water treatment processes to minimise the sludge produced, however this reduction of volume will not make a significant difference at the sites identified unless dewatering can be undertaken. Typically, our thickened sludges vary in concentration between 1 & 3% dry solids, adding a dewatering stage can increase this to between 15 & 18%ds. This represents a minimum 5-fold reduction in volumes of sludge to be removed from site.

Largely, operations at these sites have stayed business as usual, as there has been immediate pressure until now to change approach. Sludge is continuing to be disposed of via farmers, and no additional storage has been implemented. Although we currently comply with guidance from NRW, there has been increased scrutiny on water-based sludges in recent years where the guidance dictates they should be spread to land during wet or freezing conditions. This situation could quickly change, and we need to be ready to switch to a dryer product where current disposal routes may become unavailable, particularly during winter months.

Water sludges have no nutritional content. Therefore, these thickened sludges are not directly taken to wastewater sludge treatment centres (STCs) as it can reduce the quality of biosolids (certification of STW digested sludges due to high metal content). Therefore, these farmers make revenue taking low nutritional value sludges from Welsh Water WTWs. Once farmers decide that it is too risky to continue taking due to NRW enforcement, they will increase gate fees (when they are allowed to spread).

We have investigated alternative disposal of these sludges including at our WwTW regional centres to be thickened, however, these sludges would end up at our digester sites and WTW sludges are not suitable for digestion due to their very low calorific value. Therefore, we are proposing dewatering facilities at the WTW sites to reduce transport costs and encourage a more cost effective and efficient disposal route.

5.2 Best Option for Customer

In this section we will describe how we have developed options to address the high consequences risk regarding critical tanks as single points of failure within our system. Currently our sludge disposal route is spreading liquid sludge to land which due to legislation changes is going to be harder to undertake during wet weather periods. To reduce the risk of not meeting the new legislation and facing water treatment output limitations we have assessed the best solution options to achieve this. To select the optimal solution we have and followed our standard TotEx hierarchy approach which is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4).

The sections below set out examples of how we have optioneered and quantified benefits for each of the options against our objectives. This has been assessed using our cost benefit analysis method which is linked to the Service Measure Framework to achieve the objective.

5.2.1 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

Our approach to options development is set out in which is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4).

For this Enhancement Case we have considered a range of options for each scheme at the long listing stage which are summarised in the table below. There are three options that were viable or partially viable which were then taken forward to the shortlisting stage which is detailed in Section 5.2.2 below.

Table 14: Longlisting Options Considered for the WTW Sludge Programme

Option	Type of Option	Brief Description of Option and Comments	Option Viability	Potentially Viable, i.e., progress to shortlisting?
1	**Eliminate, reduce or delay the need for change.** Manage demand	Reducing demand for water and thereby the production of sludge at WTW.	Even through a reduction in demand these sites would still produce a large element of sludge as a byproduct of the treatment process. Only by abandoning the site would the issue of sludge not be present. NOT VIABLE	✗
2	**Maintain the effective risk controls already in place.** Manage operation or use of the existing asset or service	Further site optimisation to reduce sludge volumes.	Would not address the overall issue of large volumes of sludge being generated as a byproduct of the treatment process. Considered as the "do nothing" option for comparison but leaves legacy risk that is not acceptable. VIABLE	✓
3	**Maintain the effective risk controls already in place.** Replace the existing asset like-for-like	Existing assets would be replaced with new ones with the same performance.	The new level of performance expected is beyond the technical capability of the existing asset – even if that asset were in an as-new condition. NOT VIABLE	✗
4	**Enhance existing resources or add new resources.** Enhance/ upgrade the existing asset or service	Existing assets would be modified or upgraded for enhancement of performance.	The existing asset is not designed to provide any additional sludge treatment than what it is already providing and as such there is limited scope to address the business need through the existing asset performance even if it is upgraded.	✗

Option	Type of Option	Brief Description of Option and Comments	Option Viability	Potentially Viable, i.e., progress to shortlisting?
			NOT VIABLE	
5	**Maintain the effective risk controls already in place.** Mothball/ dispose of the existing asset or service	Existing assets would be removed from service and made redundant.	The function of the existing asset performance is essential to the water treatment process. Any downtime risks network stability and revenue. NOT VIABLE	✗
6	**Enhance existing resources or add new resources.** Dewatering facilities on site	Install specific dewatering technologies that can effectively increase the solids content of the sludge.	Installation of a dewatering asset would reduce the volumes of sludge generated on site and by association reduce the costs of storage and disposal (disposal is paid per tonne). VIABLE	✓
7	**Enhance existing resources or add new resources.** Send to landfill	Rather than spreading sludge to land it is possible to send it to landfill.	The cost of transportation and landfill would still be based on weight and therefore higher because of the high-water content, the risks around storage would be addressed as there would not be any restrictions on when it could be sent to landfill. VIABLE – BUT HIGH COST	✓
8	**Enhance existing resources or add new resources.** Send to sewage works	Rather than spreading the sludge to land the sludge by product could be transported to the nearest wastewater works for treatment.	The wastewater treatment works would need to be able to treat the additional volume and have enough headroom and would impact performance. NOT VIABLE	✗

Assessment and Selection of Solution Options

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). 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.

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).

The outcome for the shortlisting process has assessed the three options at shortlisting. The landfill option was discounted on further assessment due to the logistics to tanker liquid sludge to landfill,

cost and resilience of the disposal route. The other two options the conventional solution to manage using the existing Strategy and Option S1 Dewatering Facilities were taken through our CBA undertaken for the two sites Felindre and Alaw which can be seen in Tables 15 and 16.

Option S1 'dewatering facilities on site' was the only option that was progressed to CBA due to its viability.
The option of sending sludge to landfill was deemed not viable due to the higher costs involved with landfill gate fees, which are also subject to steep future increases.

The preferred technology for dewatering facilities are decanting centrifuge at both sites. The benefit to cost ratio for the dewatering facilities option significantly outweighs the 'do nothing' option of managing sludge via the existing strategy as it relieves risks of sludge management and benefits the environment over the long term.

This is true for both sites within this enhancement investment, we have presented the CBA for both sites below.

Table 15: Example of benefit to cost ratio analysis (Felindre).

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)
Conventional Solution	Manage sludge via existing strategy	£0	£0	£0	**0.000**	£0
Option S1	Dewatering facilities on site	£9.744M	£21.444M	£38.173M	**1.780**	£16.729M

All monetary values are expressed in 2022/23 prices and are prior to portfolio adjustments for corporate overheads and efficiency challenge. Welsh Water ref: SMF version 5

Table 16: Example of benefit to cost ratio analysis (Alaw).

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)
Conventional Solution	Manage sludge via existing strategy	£0	£0	£0	**0.000**	£0
Option S1	Dewatering facilities on site	£5.178M	£7.030M	£7.565M	**1.076**	£0.536M

All monetary values are expressed in 2022/23 prices and are prior to portfolio adjustments for corporate overheads and efficiency challenge. Welsh Water ref: SMF version 5

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. For more detail on this see WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

5.2.2 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

Our approach to best value analysis is set out in our investment approach chapter. Table 5 in section 2.2.2 presents the benefits for the entire Increasing Resilience of Tap Water Supply Treatment Works enhancement programme.

5.2.2.1 Quantifying the Impact on Need and Performance Commitments

This need is not related to a performance commitment, and as such we have not had to quantify impact.

5.2.3 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). This includes commentary on our approach to optioneering, costing and cost benefit analysis.

For this Enhancement Case we have evaluated a range of options in line with our TotEx hierarchy approach, these are set out in Section 5.3 below.

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 such as nature-based work is inherently more uncertain than tried and tested engineering approaches.

The summary in Table 17 below provides an example of the costing risks associated with the options considered in for the Sludge programme.

Table 17: Options considered for Alaw, Felindre.

Option	Description	Risks associated with costing this option or valuing its benefits	Mitigation [of the Risk associated with costing]
Dewatering facilities on site	Install specific dewatering technologies that can effectively increase the solids content of the sludge.	Low risk conventional approach	In assessing this option within our appraisal process the delivery risk has been taken into account as part of our qualitative assessment.

Uncertainties relating to cost were minimised by using our assured UCD where applicable and employing third parties to review and benchmark our estimates. This allowed us to go forward with an estimating tolerance of +/-20% for the estimates used within our business case, in comparison to the industry standard developed by AACE for projects at this design maturity of +/-30%.

Uncertainties relating to benefits were mitigated by through use of our SMF which has been assured and testing the application of the SMF to this investment case via independent audit by Economic Insight.

5.3 Costing Efficiency

In this section we give specific 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).

5.3.1 Developing a cost for WTW sludge management

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

With the resource element of this Enhancement Case, to allow us to use our preferred like-for-like (top down) costing approach, we generated a standardised scope so that we could use our Unit Cost Database (UCD) Cost & Carbon Estimating Tool (C&CET). This was the preferred method as it is based on the historical project costs we experience within our operating area.

Project scopes are developed that 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.

For both the Felindre and Alaw schemes a scope and costs has been developed within the C&CET to provide the costs for these schemes. This process assumed that the scope of the scheme at Alaw is similar to our previous sludge centrifuge schemes. For the Felindre scheme a historic scope of work from AMP6 was reviewed and updated to provide the scope and cost for the scheme.

The key assumptions are that processes are in an acceptable condition and operating within their design envelope and there is a risk that optimisation of the existing works may not provide the required resilience and robustness to ensure the required water quality long term without additional processes.

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. Further detail can be found in WSH50-IP00 Our Approach to Investment Planning (Section 6).

Any costs which were derived from the UCD have also been verified internally through our governance process described in the costing methodology in Section 5 which verifies its accuracy and relative efficiency.

5.4 Providing Customer Protection

This section has been combined with the three other programmes of work to provide a single customer protection in section 6 below.

6. Providing Customer Protection

In this section has been combined for all four Investment Packages from Sections 2 to 5 above. This is designed to provide strong controls in terms of work delivered against funding allowed to protect customers from non-delivery of the critical tanks programme of work.

6.1.1 Proposed Price Control Deliverable (PCD)

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

The proposed approach is set out below. The response to low likelihood high consequence events is diverse with multiple projects being undertake. We have reviewed the proposed activity and identified the most material elements for inclusion in the PCD. The PCD covers 74% of the value of this Enhancement Case. Two work packages are considered non material for PCD Flood Risk Mitigation and Nantybwch WTW Water Resources

Summary of deliverables	1) Removal of single point of failure tanks at water treatment works 2) Sludge dewatering solutions at two key WTWs

Customer Facing Description of Enhancement Case	**WSH61-RS05 - Increasing Resilience of Tap Water Supply - Treatment Works**
PCD Number	**PCD5**
Summary of deliverable	**Removal of single point of failure tanks at water treatment works & Delivering two Sludge Dewatering Solutions**
Description	**Removal of 15 single point of failure tanks at water treatment works:** Due to a historical lack of resilience at some sites, a non-operational tank will result in an interruption to supply for customers that cannot be fed from another source. The risk of being unable to bypass tanks or having customer supply interrupted must be addressed to eliminate single points of failure. Alternative means of ensuring customers are not impacted are needed to comply with DWI requirements and, more generally, ensure resilience of the single point of failure assets. In response we will invest to allow 15 tanks, in AMP8, to be isolated from supply by providing additional storage in the network, reconfiguring local pipework arrangements to create tank by-passes or by investing to 're-plumb' the network. **Delivery of two Sludge Dewatering Systems** Delivery of two sludge dewatering systems at Felindre and Alaw WTW to mitigate the risk of a restricted sludge disposal route due to changes in legislation.

Measurement and Reporting

Removal of 15 single point of failure tanks at water treatment works:
Measuring and reporting on these tanks to the DWI as part of the Notice covering these improvements, currently being drafted for the DWI, will ensure that the company no longer have single points of failures at those sites with respect to final and contact tanks and through the closure of the DWI notices.

All 15 named tanks will have interventions by the end of AMP8, see Table 18 below. Progress will be reported annually to the DWI as part of the terms of the Notice.

Compliance with the Notice will be deemed a successful outcome for each site.

Table 18: Summary of the Critical Tanks Programme Locations and Costs

WTW Site	Tank No.	Cost (£M) (2022/23 Prices)
Llwynon	3	1.1
Bolton Hill	2	1.4
Builth Wells	1	0.6
Whitbourne	1	3.3
Glascoed	1	2.2
Cwellyn	1	0.6
Elan	1	0.1
Preseli	1	0.6
Mayhill	2	3.3
Gwastadgoed	1	0.1
Penybont	1	0.2
	Total Cost	13.5

Delivery of two Sludge Dewatering Systems
For the sludge dewatering schemes a successful delivery of the two projects at Felindre WTW and Alaw WTW will be deemed a successful outcome.

Conditions on scheme

No additional conditions identified.

Assurance

The company will work with Ofwat to develop appropriate assurance as part of Final Determination.

Price control deliverable payment rate

Removal of 15 single point of failure tanks at water treatment works:
As these are covered by a DWI Notice no PCD is required as failure to deliver could result in prosecution.

	Delivery of the Sludge Dewatering Schemes the following repayments are proposed: If the two schemes are delivered no payment. If the Felindre scheme only scheme is delivered then £4.687M will be returned to customers If the Alaw Scheme only is delivered then £8.822M will be returned to customers If neither scheme is delivered the full £13.509M will be returned to customers
Impact performance in relation to performance commitments	This work will help reduce the consequence of low likelihood (high consequence) events which would impact on water quality or interruptions to supply. The work will improve resilience's but is not linked to a quantified improvement in annual interruptions performance.

7. Appendix A

The table below shows the total CapEx, OpEx and TotEx enhancement costs in AMP 8 for this Enhancement Case. This maps to Table CW3 lines CW3b.118 to CW3b.120.

Table 19: Total CapEx, OpEx and TotEx during AMP8 Plan in 2022/23 prices

Investment Category	Contribution to Table Line	Year in AMP8 Spend £M					
		1	2	3	4	5	Grand Total
	CapEx Spend £M						
Critical Tanks Extended Maintenance Programme	CW3b.118	£2.716	£2.677	£2.676	£2.693	£2.725	£13.487
WTW Sludge Dewatering	CW3b.118	£1.688	£3.362	£3.117	£3.374	£1.967	£13.508
Carno Abandonment - Nantybwch WTW Additional Resource	CW3b.118	£0.000	£1.536	£1.536	£0.000	£0.000	£3.072
FCERM - Flood mitigation to critical W assets	CW3b.118	£0.265	£2.090	£1.567	£1.051	£0.266	£5.239
Total CapEx Spend	CW3b.118	£4.669	£9.665	£8.896	£7.118	£4.958	£35.306
	OpEx Spend £M						
Carno Abandonment - Nantybwch WTW Additional Resource	CW3b.119	£0.000	£0.000	£0.408	£0.408	£0.408	£1.224
Total OpEx Spend	CW3b.119	£0.000	£0.000	£0.408	£0.408	£0.408	£1.224
	TotEx Spend £M						
TotEx Spend	CW3b.120	£4.669	£9.665	£9.304	£7.526	£5.366	£36.530

What We Will Deliver:

Critical Tanks – Re-engineering of by-passes and additional tanks/cells around 14 critical tanks within our water treatment facilities.

Flood Mitigation – Flood mitigation barrier infrastructure to our highest risk above ground water treatment assets against a 1:30 year flood scenario.

Nantybwch additional raw water resource – a duty/stand-by permanent pumps to augment the raw water supply with 16-21 ML/day of the Nantybwch water treatment works.

Sludge at water treatment works – the enhancement will deliver 1 traditional dewatering asset at Felindre and 1 innovative dewatering facility at Alaw.