



Dŵr Cymru
Welsh Water

Enhanced Investment
Case:
WSH59-RS03 –
Increasing Safety of
Impounding Reservoirs

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Executive Summary

This investment will improve dam safety in line with legislation to ensure customers and communities can have confidence that dams in their area are safe. This investment is mandated by the Reservoirs Act (1975) and the Flood and Water Management Act (2010) to respond to newly emerging risks.

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: need for enhancement investment; best option for customers; costing efficiency; and customer protection.

Need: All dams in Wales holding back over 10MI must be inspected at least every 10 years and issues arising addressed. The investment is required to fulfil this legal need stipulated in the Reservoirs Act (1975) and the Flood and Waters Management Act (2010). This need has evolved, responding to lessons learnt from the Toddbrook incident (Balmforth review), and new guidance to respond to the changing climate which has put dams under more strain.

If we do not step up the level of funding of our dams, we can expect to see deteriorating safety standards which will ultimately put the public at greater risk.

We have worked with independent specialists, panel engineers and experts within Welsh Water to develop an approach to manage the risk in our portfolio of dams and ensure that improvements are made to safety in line with legislative requirements. The guidance provided by the Guide to Risk Assessment for Reservoir Safety Management (RARS), published by Defra and the Environment Agency (EA) is incorporated into our Portfolio Risk Assessment (PRA) tool. This tool focuses on the dam's response to internal and external 'threats' and loads and the release, direction, and consequences of flood water from the reservoir. The threats and loads influence the assessment of the probability of failure, informing the inherent risk of an asset and the need for investment to manage that risk.

Options: We have assessed each dam individually and only requested the minimum level of funding required to meet MITIOS S10 requirements. In the enhanced investment case, all work is related to tightening of regulations and best practice over recent years in relation to spillway capacity and draw down facilities. The options put forward are carefully analysed and considered to provide best value in terms of improving dam safety. Our decision making is informed by cost benefit analysis, but the option selected must also be approved by the independent inspecting engineer who will establish the required outputs from an intervention. All optioneering includes discontinuance, if possible, to ensure a whole life approach is taken.

What We Will Deliver: We will deliver investment at 29 dams, particularly on re-engineering spillways and overflow mechanisms.

Efficient Costing: We will invest £78.996M (post frontier shift and real price effects, and in 2022/23 price base) above the base allowance at 29 sites to ensure that our dams remain resilient to our changing climate and compliant with the latest legislative and safety requirements.

Customer Protection: This work will be in addition to that delivered in our base maintenance programme (£68.037M post frontier shift and real price effects, and in 2022/23 price base) and will be ring-fenced through a price control deliverable (PCD) linked specifically to the number of dams receiving investment.

If the volume of work is not delivered, funding will be returned to customers on a proportional basis.

Benefits: The investment will deliver dam safety investment and keep customers safe in line with legislation.

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

1. Introduction

Welsh Water is responsible for a portfolio of 140 reservoir sites. Of this estate, 85 are impounding reservoirs with dam structures, 10 are non-impounding reservoirs and 45 are service reservoirs. We have 88 “large reservoirs” above 25,000m³ and 52 “small reservoirs” of between 10,000 and 25,000m³.

This investment will deliver improved dam safety and legislative compliance, increased resilience for our assets allowing them to perform safely in the changing climate.

Welsh Water treat approximately 800 megalitres/day (Ml/d) of drinking water to supply 1.35 million households and businesses. The water stored within the impounding reservoir asset base accounts for 75% of this daily supply need.

Our dam structures are a highly regulated assets, in terms of security of supply, but critically in terms of protecting lives and downstream properties from dam failure. Risk assessment has identified that 81% of Welsh Water reservoirs are likely to cause significant loss of life if they failed, as they are located close to population centres.

Over recent years the failure of two spillways within the company and incidents elsewhere in the world, for example, in Oroville in California (2017) and the Toddbrook incident in Derbyshire (2019) have further heightened awareness of the level of risk carried by the company and driven a change in the approach to dam safety.

This enhanced investment case is for an investment of £78.996M (post frontier shift and real price effects, and in 2022/23 price base) above the base allowance to ensure that our dams remain resilient to our changing climate and the latest legislative and safety requirements. The funding is primarily to meet the guidance for passing the probable maximum flood via our spillways during intense rain and to meet the new draw down of levels in a reservoir during an emergency condition.

Two of our large service reservoirs, that fall under the legislation, are in England – these reservoirs do not have dam structures. All our impounding and non-impounding reservoirs are under Natural Resources Wales (NRW) regulation.

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	Addressed in...
A1.1.1 Need for enhancement investment	a Is there evidence that the proposed investment is required?	Section 2.1
	b Is the scale and timing of the investment fully justified?	Section 2.1
	c Does the proposed investment overlap with base activities?	Section 2.2
	d Does the need and/or proposed investment overlap/duplicate with previously funded activities or service levels?	Section 2.3
	e Does the need clearly align to a robust long term delivery strategy within a defined core adaptive pathway?	Section 2.4
	f Do customers support the need for investment?	Section 2.1.1
	g Have steps been taken to control costs, including potential cost savings?	Section 2.5
A1.1.2 Best option for customers	a Have a variety of options with a range of intervention types been explored?	Section 3.1
	b Has a robust cost-benefit appraisal been undertaken to select the proposed option?	Section 3.1
	c Has the carbon impact, natural capital and other benefits that the options can deliver been assessed?	Section 3.2
	d Has the impact of the proposed option on the identified need been quantified?	Section 3.2
	e Have the uncertainties relating to costs and benefit delivery been explored and mitigated?	Section 3.3
	f Where required, has any forecast third party funding been shown to be reliable and appropriate?	Section 3.4
	g Has Direct Procurement for Customers (DPC) delivery been considered?	WSH50-IP00 Our Approach to Investment Planning
	h Have customer views informed the selection of the proposed solution?	Stepping up to the Challenge: Business Plan 2025-30
A1.1.3 Cost efficiency	a Is it clear how the company has arrived at its option costs?	Section 4.1
	b Is there evidence that the cost estimates are efficient?	Section 4.2
	c Does the company provide third party assurance for the robustness of the cost estimates?	Section 4.1
A1.1.4 Customer protection	a Are customers protected if the investment is cancelled, delayed or reduced in scope?	Section 5.1
	b Does the protection cover all the benefits proposed to be delivered and funded?	Section 5.1
	c Does the company provide an explanation for how third-party funding or delivery arrangements will work for relevant investments?	Section 3.4

2. Need for Enhanced Investment

This section sets out the drivers behind the enhanced investment case and describe the context within which it has arisen.

We describe the increase in investment required to improve dam safety in line with changing legislation and the impacts caused by climate change. The need to invest in AMP8 is quantified by looking at our portfolio of dams and the MITIOS S10 dam improvement works which will be required over the AMP to ensure each dam is maintained to the minimum legal standard that the public expects. We also consider the change in risk position from our PRA, of which more is detailed below.

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

2.1 Evidence that Enhancement is Needed in AMP8

Is there evidence that the proposed enhancement investment is required?

Is the scale and timing of the investment justified?

Is there evidence that customers support the need for investment?

– Ofwat’s final methodology for PR24, Appendix 9, A1.1.1a, A1.1.1b and A1.1.1f

Managing the safety of our dams is one of the most critical roles we undertake as a water company and is subject to strong regulation by Natural Resources Wales (NRW) under the 1975 Reservoirs Act and the Flood and Water Management Act (2010).

Over recent years regulation and good practice guidance relating to reservoir safety have seen significant updates:

- Under the 2010 Act, Regulation in Wales changed in 2016, to bring all reservoirs of over 10MI capacity within the Act. This change, from 25MI is specific to Wales, and requires additional funding to bring the smaller reservoirs up to the required standard.
- The Balmforth review (2021) recommendations, which came out of the Toddbrook incident.
- Good practice guidance relating to the management of flood risk at reservoirs (Floods and Reservoir Safety 4th Edition, Institution of Civil Engineers, 2015ii) and relating to drawdown in an emergency (Guide to drawdown capacity for reservoir safety and emergency planning, EA, 2017iii) have been introduced.

These guidance documents create the need to upsize spillways, raise dam crests and upgrade pipes and valves at our reservoir sites, due to the increases in expected storm intensities driven by climate change.

On the dam’s next Regulatory 10-year inspection (S10), the independent inspecting engineer will mandate actions to comply with the latest guidelines. The recommended actions are called MITIOS (Measures In The Interest Of Safety) and will be enforced by NRW.

Typically, these actions need to be undertaken over a 2-to-3-year period. As such inspections undertaken within the AMP period may also need to be completed in the same period. In addition to work already identified for delivery in AMP8, we have anticipated the action required at the sites that are due a S10 inspection in AMP8 to ensure we have the funding available to complete the work in line with the legislation.

Not undertaking the work could lead to a failure of the asset. A failure of one of these assets would lead to the disruption of water supplies to tens of thousands of people and could potentially result in extensive damage to property and loss of life downstream.

These improvements to our estate began in AMP7 and were highlighted as a 10-year programme as part of the PR19 process. This mirrors the 10-year inspection frequency of our dams and manages

the volume of specialist work and the impact to our operational assets. Due to the evolving safety recommendations this investment is likely to continue into AMP9 and beyond.

The scale and timing of the investment is driven by the regulatory framework and as such is fully justified.

Welsh Water have a statutory duty to ensure our bulk storage of water complies with legislation on health and safety under the Reservoir Act (1975) and the Flood and Water Management Act 2010, with a requirement to carry out detailed inspections (Section 10 reports) every 10-years supported by annual statements (Section 12 reports).

The timing of these inspections is known and agreed with NRW. They will be the trigger for moving to compliance with the latest guidelines. Statutory deliverables identified by the inspecting engineer must be completed within set timescales as set out in Section 10 reports.

Without investment the residual level of risk posed by reservoir assets would increase and Welsh Water would expect to see increased enforcement actions from NRW. Any enforcement action would need to be completed over more challenging timescales than if we had acted proactively, leading to increased costs due to the loss of efficiency of pre-planning.

Table 1 lists the sites we will invest in during AMP8 as part of this enhanced investment case.

Table 1: List of Sites in Our AMP8 Enhanced Investment Plan

Site Name		Site Name	
1	Aled Isaf	16	Llyn Anafon
2	Beacons	17	Llyn Bran
3	Blaen-y-Cwm	18	Llyn Cefni
4	Brithdir Mawr	19	Llyn Celyn
5	Cantref	20	Llyn Cwellyn
6	Castell Nos	21	Llyn Gelli Gain
7	Cilcain No 3	22	Nant Hir
8	Cilcain No 4	23	Nant Moel
9	Clydach	24	Penderyn
10	Court Farm	25	Pond-y-Gwaith
11	Cwm Dulyn	26	Tynywaun
12	Cwm Wern Deri	27	Upper Lliw
13	Dolwyddelan	28	Usk
14	Llwyn-on	29	Wentwood
15	Llyn Aled		

Note: In AMP7 we are also investing in 29 sites.

2.1.1 Evidence of Customer Support

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30. This work is driven by statutory compliance to maintain customer safety, and as such has not been an area in which we have consulted customers.

2.2 Overlap with Activities to be Delivered through Base

Does the proposed enhancement investment overlap with activities to be delivered through base?

– Ofwat’s final methodology for PR24, Appendix 9, A1.1.1c

We have a systematic process in place for assessing and removing overlap with base, this is described in WSH50-IP00 Our Approach to Investment Planning.

We have developed a single investment case for Dams and then considered which elements should be assigned to Base and Enhancement.

The enhancement funding is specifically around structural changes to dams to cope with increased flows and draw down requirements – altering assets which were previously fit for purpose but do not now meet current guidelines.

Base allowance will cover the maintenance activities required to keep the assets fully operational. It should be noted the MITIOM (Measures in the Interests of Maintenance) are also now legally enforceable but are not included in our enhancement programme.

An assessment of the requirements of each asset in the next investment cycle (AMP8) have been made by the Dam Safety team. The required programme costs are shown below in Table 2.

Table 2: Programme Costs

Work Type	Base Costs* £M	Enhancement Costs* £M
Preventive Maintenance	65.269	
Reactive Maintenance	2.768	
Enhancement		78.996
Sub-Total:	68.037	78.996
Total Programme:	147.033	

* post frontier shift and real price effects, and in 2022/23 price base

2.3 Overlap with Funding from Previous Price Reviews

Does the need and/or proposed enhancement investment overlap with activities or service levels already funded at previous price reviews?

– Ofwat’s final methodology for PR24, Appendix 9, A1.1.1d

The activity proposed in this enhancement case is a continuation of a multi-AMP programme which began in AMP7.

In AMP7 we were funded through an enhancement case for interventions at 29 dams. This work is tracked through a performance commitment ‘Delivery of our reservoirs enhancement programme’ and will be delivered.

The work proposed for AMP8 is a continuation of this activity at an additional 29 locations (a response to the same underlying enhancement need). The programme of work will be completed in AMP9.

Note: At PR19 the investment requirement to address the business need at the time was submitted as a cost adjustment claim to recognise the step change in investment required to meet the requirements of the drivers discussed above. The Final Determination included the work as a bespoke performance commitment.

2.4 Alignment with the Long Term Delivery Strategy

Is the need clearly identified in the context of a robust long term delivery strategy within a defined core adaptive pathway?

– Ofwat’s final methodology for PR24, Appendix 9, A1.1.1e

Dam safety is an essential ingredient in securing long term reliability; it is the subject of legal obligations based around the system of periodic inspections, followed by remedial works, which will define the programme of works for AMP8 and beyond. Further details can be found in the WSH01 Long Term Delivery Strategy.

Welsh Water’s Long Term Delivery Strategy has a specific measure associated with the safety of impounding reservoirs. The long-term ambition is focused around the timely and ongoing addressing of essential works as identified by Section 10 reports. Following the identification of actions to be addressed, Welsh Water will undertake the necessary works, and report to NRW annually, ensuring that there is no work outstanding.

Enhancement works are associated with upgrades to address climate change related impacts which are reflected in the core pathway. As reservoirs are upgraded to adapt to climate change forecasts, enhancement related spend is forecast to reduce over the long-term strategy. Welsh Water have identified an alternative pathway focused on potential future remedial works in line with legislation changes from the Balmforth review into the Toddbrook incident. Further details related to the core and alternative pathway for impounding reservoirs are contained in Welsh Water’s Long Term Delivery Strategy.

The preferred approach for the Long Term Delivery Strategy is to include reservoir enhancements in the list of ‘known additions’ that have been included in the core pathway post-2030. Dam safety is an essential ingredient in securing long term reliability; it is the subject of legal obligations based around the system of periodic inspections followed by remedial works; we have the report which will define the programme of works for AMP8; thereafter we can be certain that there will be a substantial programme of works, however as the next ten yearly set of inspections has not taken place it is a risk based projection on anticipated funds required.

2.5 Management Control of Costs

Is the investment driven by factors outside of management control? Is it clear that steps been taken to control costs and have potential cost savings been accounted for?

– Ofwat’s final methodology for PR24, Appendix 9, A1.1.1g

Our response to dam safety is driven by our regulatory framework. There are two material areas of change which, through the direction of our inspecting engineers, we are now responding to:

- 1) Climate Change
 - a. More intense storm events are leading to the re-estimating of floods (in accordance with the Flood Estimation Handbook Volume 4) creating greater spill volume targets. This creates a requirement to re-engineer spillways to be able to cope with bigger flood events.
 - b. Greater Probable Maximum Floods (PMFs) requires more work such as dam crest refurbishment to increase resilience.
 - c. Under emergency condition, best practice guidelines mean that reservoir levels will need to be drawn down more quickly.
 - d. Drier, hotter summers have impacted dams such as exposing pier supports which has exacerbated corrosion leading to early cracking. Drought conditions have also impacted reservoirs operationally with water levels dropping to levels not seen for many years.

- 2) Increased understanding of dam safety risks – Recent dam failures across the world have increased global knowledge of dam safety issues. We also continue to refine the accuracy of modelling specifically for our own dams. As such there is a change in our understanding of consequences of dam failure and in regulators tolerances for risk. This is creating the need for additional response.

For the management of risk at a company level, and for reporting our risk position, for internal governance, we use our PRA Tool.

We have used guidance from the Guide to Risk Assessment for Reservoir Safety Management (RARS), published by Defra and the EA, as the basis for establishing the PRA. The methodology focuses on the Dam’s response to internal and external ‘threats and loads’ and the release, direction and consequences of flood water were we to see an uncontrolled release from the reservoir. The ‘threats and loads’ influence the assessment of the probability of failure and include factors such as structural integrity of spillways, the hydraulic capacity of chutes and spillways, slope stability and emergency draw down capacity.

It should be noted that as the PRA measures the consequence of a failure, some of our largest assets will remain in the High-risk designation despite any improvement work undertaken. In these cases, our responsibility is to reduce the risk of failure according to the As Low as Reasonably Practicable (ALARP) principle.

Figure 1 outlines the principle.

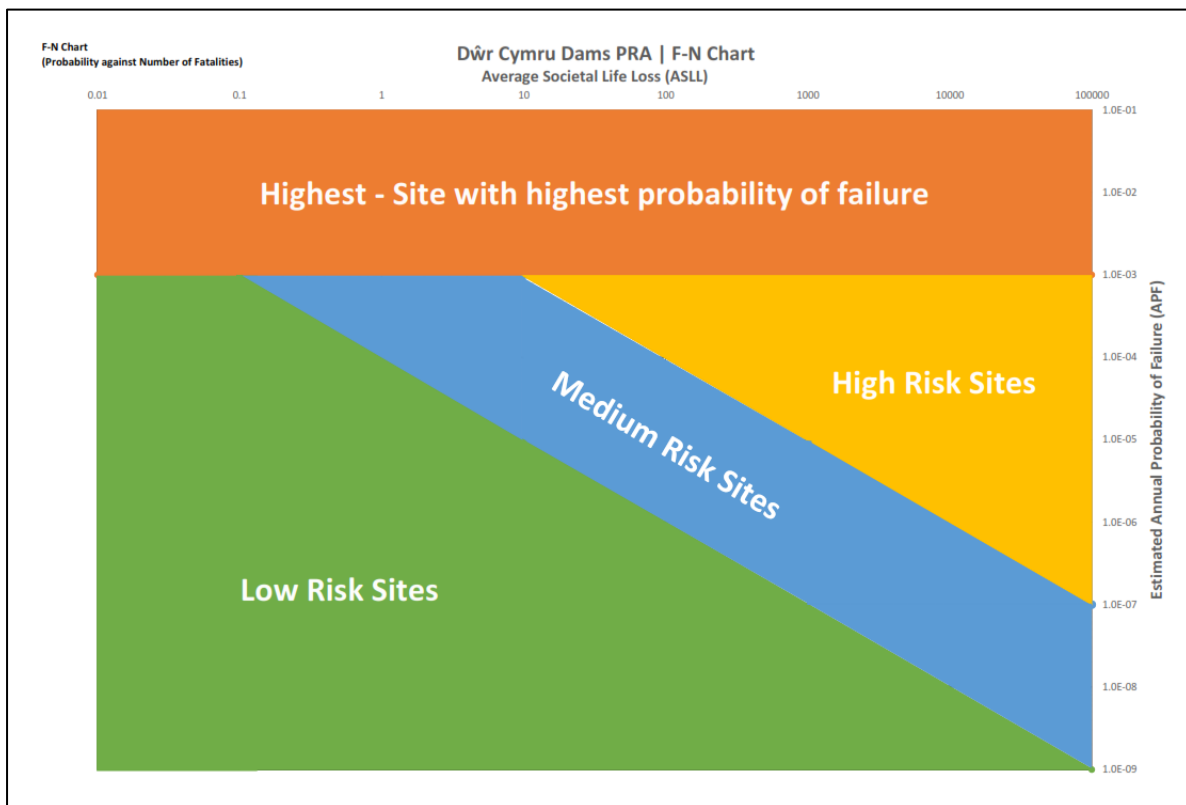


Figure 1: ALARP Principle

We have used the detailed chart produced by our PRA to manage and report on our risk position through AMP6 and into AMP7.

Over the past 12 months, to ensure the position we report has external validation, we have developed and implemented a structured review process for the site-specific assessments. This review includes the engagement and 'sign off' of an independent All Reservoirs Panel Engineer (ARPE). The review process's sign off is managed via a newly established 'PRA Calibration Group'. This Group includes all the Dam Safety Leadership Team, and an independent ARPE.

The review process also includes our Dam Safety Engineering Managers, as they can contribute the considerable knowledge and experience gained from their own assets, as well as apply their challenge and scrutiny as qualified Supervising Engineers under the Act. This review process and the establishment of the PRA Calibration Group has considerably improved our governance around our risk assessment process and change control.

As a result of this detailed and rigorous review, the site-specific risks may be reduced, may stay the same or may increase. The 'real risk' onsite has not been changed by our review process. What has changed is our understanding and confidence in the assessed risk and this facilitates better decision making.

We now routinely use our site-specific risk assessments and our PRA to:

- Inform our risk-based decision making at the portfolio level, both in the short term and in terms of our forward planning for PR24 (AMP8).
- Inform and understand the benefits of capital investment in terms of risk position movement and risk reductions gained.
- Inform periodical inspections under Section 10 of the Act and to question and challenge, where appropriate, any MITIOS recommendations.

Consequently, our confidence in our risks has improved and this has led to better informed risk-based decision making. This process is one of continuous improvement and development, we will maintain this approach into the future as we review and update our risk assessments.

2.5.1 Assessing and Maintaining Our Portfolio Risk Position

Figure 2 shows our progress on reducing risks based on both our Enhancement and Base programmes of work. We show the total number of assets (which would change following discontinuance of a reservoir) and then the number of assets in each of the 4 categories defined within the PRA methodology.

Progress can be seen in a simple format, where each concentric ring represents a period. In this case the inner rings represent future positions as we move from the baseline position of AMP7 in the outer ring.

The changes leading to the end of AMP7 are covered by our AMP7 investment programme.

The changes in AMP8 are as follows:

- 1 site to move from Highest risk to medium (Base Maintenance scheme)
- 6 sites move from High risk to medium (3 Base Maintenance and 3 Enhancement schemes)
- 3 sites removed from the medium category and, as they are discontinued, they are removed from the total (Enhancement schemes). There are also plans to discontinue a further two depending on the option selected at final design stage. This is not shown in the graphic.
- Investment at other sites (Base and Enhancement schemes; will not alter the risk category within which the dam operates)

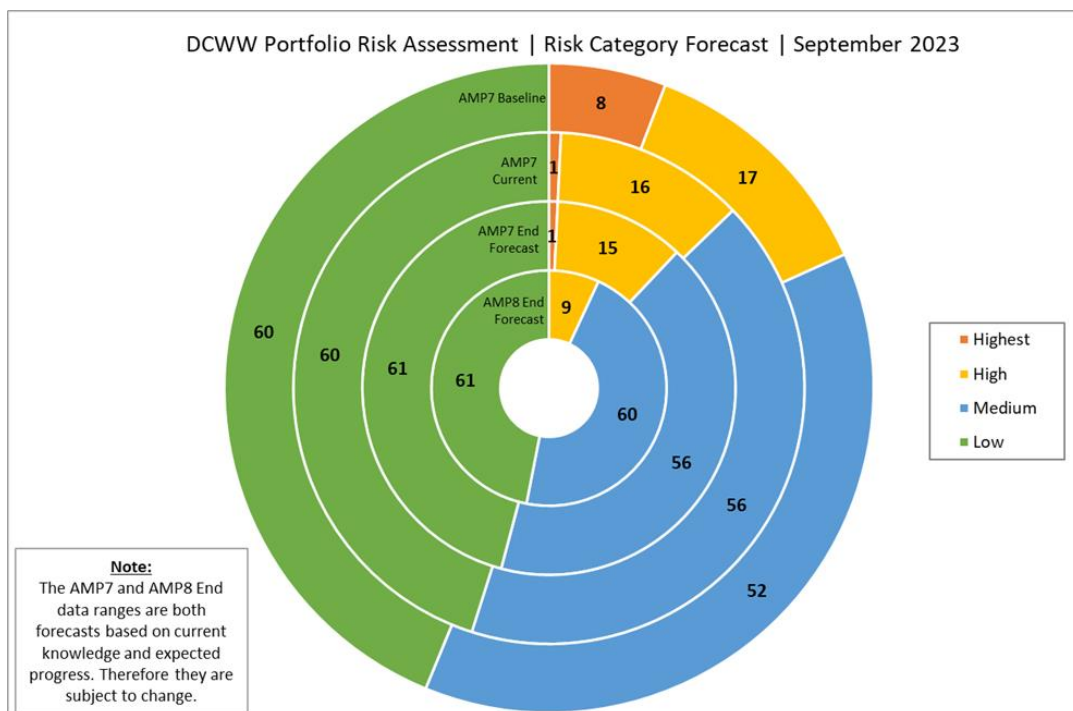


Figure 2: Portfolio Risk Assessment / Risk Category Forecast (September 2023)

3. Best Option for Customer

In this section, we describe how we have developed options for intervention within the framework set by legislation and the instruction of our inspecting engineers.

We identify investment required to ensure our portfolio of dams is maintained to the minimum legal standards. The chosen options are those which deliver the best value dam safety improvements to ensure customers can enjoy safe dams at the minimum level of investment.

We use case studies to illustrate our approach to option development within the overall programme of work. The principles we illustrate in these examples play out across the programme.

3.1 Identification of Solution Options

Has the company considered an appropriate number of options over a range of intervention types to meet the identified need?

Is there evidence that the proposed solution represents best value for customers, communities, and the environment over the long term?

– Ofwat’s final methodology for PR24, Appendix 9, A1.1.2a and A1.1.2b

The programme of works has been designed to meet the minimum legislative requirements of the S10 safety inspection regime and therefore maximise affordability of the overall programme.

Our approach to optioneering is set out in WSH50-IP00 Our Approach to Investment Planning. However, for dam safety, the process is delivered within the strict confines of the legislative requirements and the requirements of independent ARPE overseen by NRW as the Regulator. Prior to the commencement of any scheme, longlisting and more detailed shortlisting is undertaken as part of optioneering in the investment planning process.

Our inspecting engineer will make specific recommendations for the interventions required. There is some opportunity at the margin to propose different solutions or to refine the detail or timing of the work proposed but any such changes must be agreed with the independent ARPE.

In considering how best to respond to requirements following inspection, we will consider all available options within the limits set by the ARPE – this includes the option to decommission the reservoir.

3.1.1 Case Study Discontinuance: Clydach Reservoir

We have an S10 MITIOS to refurbish pipework which we estimated would cost £3M, we considered this carefully and decided, instead, to spend £3M to discontinue the reservoir. This was the best long-term decision as this asset was likely to need a new spillway at the next S10 inspection, estimated to cost at least £8M. As we could manage water resource without this asset, we took a decision, which was more expensive now, but delivered value for money in the long term. This scheme will be delivered in AMP8.

The Dam Safety manager has considered the likely range of intervention types and these costs have been reviewed by dam safety experts.

3.1.2 Case Study Project Optimisation Process: Beacons, Cantref and Llwyn-Onn Reservoirs

The Taf Fawr cascade comprises of three large reservoirs – Beacons, Cantref and Llwyn-Onn – located 4 miles northwest of Merthyr Tydfil in the Brecon Beacons National Park (see Figure 3). They are fed by various watercourses draining the southern slopes of the central Brecon Beacons and are one of the principal raw water supplies for South Wales.

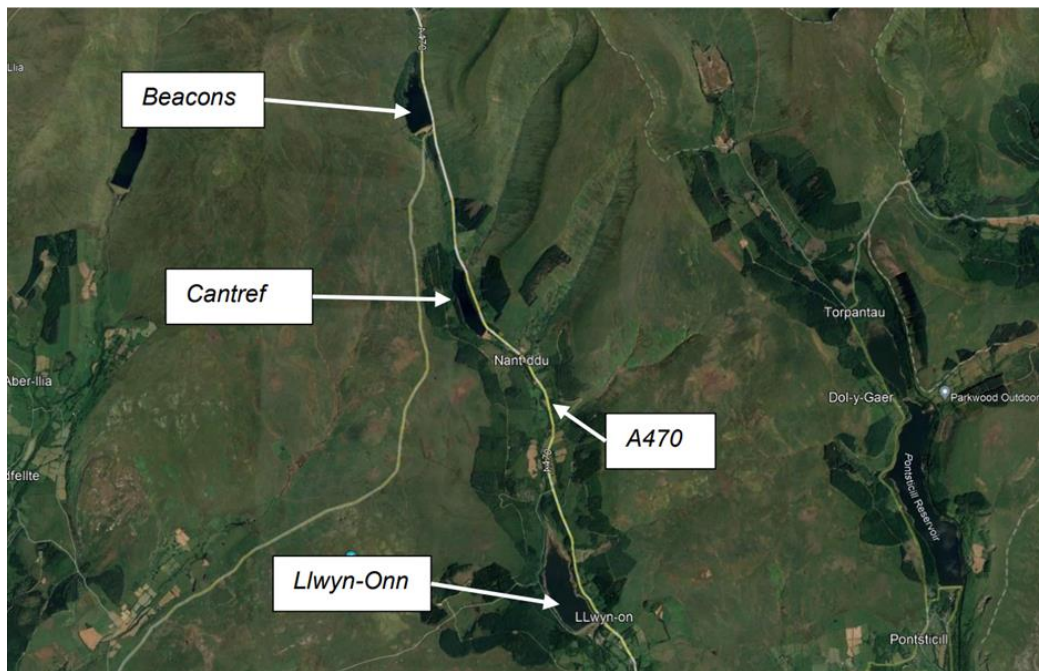


Figure 3: Taf Fawr Cascade

Section 10 inspections were undertaken at the sites in 2014 and 2016 by two different Inspecting Engineers. The reports for Cantref and Llwyn-Onn raised concerns over the ability of the spillways to safely convey design and safety check flood events. MITIOS were recommended to undertake physical or CFD (computational fluid dynamics) modelling of the spillways and update the flood study. Due to the interdependency of the three sites, the initial 2019 hydraulic studies project also included Beacons reservoir. The work comprised of:

- Using existing Beacons reservoir rating curves from previous studies and calculations.
- Topographical survey and development of CFD models for Cantref and Llwyn-Onn. The models were run for three different flows at each site to develop and refine rating curves for outflows at those two reservoirs.
- A flood model was also developed and run to assess reservoir levels and outflows under design (10,000 year) and safety check (Probable Maximum Flood - PMF) flood events.

The studies identified several potential issues, including water levels exceeding core and/or crest levels and spillway capacity being exceeded. There were also several uncertainties in the studies due to the slightly different approaches to rating curve development at each site, and the complexity in outflows, primarily around how the siphons at Cantref and Llwyn-Onn prime and operate.

To address this a second phase of modelling was completed in 2020. This comprised of:

- Development of a CFD model for Beacons reservoir and then three runs to refine the rating curve for that site.
- Additional CFD runs for Cantref and Llwyn-Onn reservoirs to better understand priming of the siphons and performance under PMF flows.
- An update of the cascade flood modelling, including initial considerations of possible remedial works options.

With conclusion of the 2020 studies, there was a clear picture as to the key hydraulic issues at the three reservoirs and some concept options for remedial works were developed. The current stage of

work is to procure the necessary on-site investigations and refine the scope of future remedial works to enable detailed design and construction through the remainder of AMP7 and into AMP8/9.

A range of options were considered including those shown in Table 3.

Table 3: Range of Options Considered

Options considered based on TotEx hierarchy	
Eliminate, reduce or delay the need for change	Do nothing/minimum
Maintain the effective risk controls already in place	Lowering of reservoir top water level (TWL) and/or active management
Enhance existing resources or add new resources.	Improvements to siphons
	Adaptation of existing spillways and additional spillways
	Replacement of siphons with open channel spillways
	Bypass channels
	Crest raising and wave walls
	Upstream flood storage reservoir(s)

The current phase of work for the sites are:

- Procurement of ground and structural investigation to provide further information on the form of construction of the embankments and spillway structures.
- Scoping and specifying of geophysical, geotechnical, and structural investigations were undertaken in mid/late 2022.
- Geophysical investigations of the spillways at all three sites were undertaken in late 2022. The purpose of this was to look for potential voiding or other issues in the existing spillways which are proposed to be retained and adapted in any future remedial works options. These have identified several anomalies which will be investigated further during the intrusive investigation planned for mid-2023.
- Procurement of the ground investigation and structural investigation contractors is nearing completion.

This case study demonstrates our approach at a sample of dams within our programme of work. We have built robust models to understand risks, considered multiple options for intervention and aligned with regulatory requirements in our response.

3.1.3 Case Study: Use of CBA at Castell Nos

Our dam safety work is driven by options directed by the independent ARPE undertaking the Section 10 inspection. As such cost benefit assessments are not undertaken for this activity until after the S10 inspections have occurred. Before construction of schemes, all costs will be considered as part of a longlisting, shortlisting and cost-benefit process which gives a cost benefit ratio for the preferred solutions. The cost is reviewed by our cost intelligence team and an external consultant. The option for delivery must be agreed with the APRE based on safety.

The start of the longlisting, shortlisting and cost benefit process begins when the scheme specifics such as S10 dates and scale of engineering are known.

Castell Nos underwent an extensive and comprehensive optioneering process which included undertaking a series of site studies and investigations to ensure the best option was taken forward. Third parties with a track record in this field produced several reports and cost analysis to support the

optioneering. This includes a comprehensive 395-page MITIOS findings report which goes through the data gathering process, optioneering including numerical comparisons of options, culminating in a preferred solution for the site.

Table 4 sets out options considered with their relative costs and benefits for Castell Nos. The preferred option is S1 as this solution delivers the most superior net benefit across a range of measures: a cost-benefit ratio of 3.7 and a payback of under 15 years. While Option S2 is close and delivers higher absolute benefits, it requires nearly double whole-life cost to achieve proportionally less overall benefit.

Table 4: Assessment of Options for Castell Nos

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)
S1	Replace stack in tower, refurbish tunnel, replace footbridge, repair siphon	£5.310M	£4.766M	£17.861M	3.748	£13,095M
S2	New valve tower, new tunnel, replace footbridge, abandon siphon	£9.011M	£8.088M	£28.903M	3.574	£20.815M
S3	New Dam	£45.685M	£41.007M	£28.946M	0.706	- £12.061M
S4	New shafts and tunnels and draw-off pipes to required diameters	£13.946M	£12.518M	£28.906M	2.309	£16.388M
S5	Do nothing	£0	£0	-£56.666M	0.000	- £56.666M

** all monetary values are prior to portfolio-level efficiency challenge, and are in 2022/23 price base*

3.2 Quantification of Benefits

Has the company fully considered the carbon impact, natural capital and other benefits that the options can deliver?

Has the impact 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

Table 5 shows the benefits which have been assigned to our programme of dam safety work within the submitted data tables. As expected, the benefits flow from secure water for supply (avoidances of water use restrictions) and more significantly health and safety (avoidances of dam failures). Whilst dams are primarily seen as a benefit in terms of the resources they provide, their risk to downstream safety must not be forgotten.

Table 5: Profile of Benefits from our Preferred Option

Scenario	Benefits from AMP8 Investment relative to Baseline		
	Health & Safety	Water Use Restrictions	Total
Preferred dam safety programme	79.97%	20.03%	100%

In total the preferred schemes provide a significant benefit with improvements to health and safety providing the largest proportion of this.

3.2.1 Quantifying the Impact on Need and Performance Commitments

The options put forward in this enhanced investment case are specifically for addressing the need which has been identified for the sites listed in Table 1. The inspecting engineer will identify activities which must be delivered to manage the risk. There is no associated performance commitment, however we will continue to report internally our PRA position.

3.3 Uncertainties relating to Cost and Benefit Delivery

Have the uncertainties relating to costs and benefit delivery been explored and mitigated? Have flexible, lower risk and modular solutions been assessed?

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

3.3.1 How We have Managed Cost Uncertainty

We have found through our investment in AMP6 and AMP7 in this area that most solutions selected for our sites become bespoke. This is due to several factors but include:

- The type of construction of the dam i.e., earth embankment, concrete, etc.
- The capacity of the existing structure to manage climate change and the degree of capacity increase required.
- The original design of pipework and the accessibility for replacement.
- Access and egress to the site for construction activities.

We have been able to build in the considerable insight gained through recent experiences to better tune our costing approach to specific dams. The scope of works has been developed by our Dam

Engineering team who have a thorough understanding of each site and its requirements, this is supported through discussion with relevant inspecting engineers or existing MITIOS. This has allowed costing on an individual site basis to allow for site specific variations in scope allowing a bottom-up costing approach to be taken.

3.3.2 How We have Managed Benefit Uncertainty

We have high confidences in calculation of benefits. Our assessment of risk is well developed both through modelling and our PRA.

Fundamentally, the option being selected must satisfy the requirements of the inspecting engineer to allow the MITIOS to be signed off. Prior to construction our independent engineer will review the options being developed and agree that the chosen option will satisfy the need before it is constructed.

3.4 Third Party Cost Allocation

Has the scale of forecast third party funding to be secured been shown to be reliable and appropriate to the activity and outcomes being proposed?

– Ofwat’s final methodology for PR24, Appendix 9, A1.1.2f

Our dams programme contains specific cost-sharing mechanisms where water resources are used by more than one company (bulk supplies). This is a long-standing arrangement with well-established and transparent costing arrangements.

£1.735 million per year in AMP8 of NRW recharges and third-party adjustment for bulk water supply is accounted for in CW1.12 and excluded from the reported figures in CW3b.130.

4. 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.

4.1 Developing a Cost for Dam Interventions

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

The costing methodology utilised in pricing this programme of works is covered by the new areas (Bottom-Up) approach detailed in in WSH50-IP00 Our Approach to Investment Planning.

The scope of works was measured, and rates were derived from previous schemes along with framework rates to cost the individual schemes. Some UCD cost models were also used to support the costing, where possible, but given the bespoke nature of the works this was minimal.

It was appropriate to take this approach as we could utilise our own knowledge and experience and costs through our UCD where possible. Where there is not sufficient cost information through cost models, we are understanding the work involved and breaking the work items down for pricing with framework rates and uplifted historical costs to ensure the best possible cost confidence.

Due to the nature of the reservoir safety programme a fully comprehensive detailed scope cannot be developed until the Section 10 inspections have occurred and MITIOS has been issued. The scope has been determined by the Dam Safety Manager who have a detailed understanding of these assets, and this is the key assumption in the costing of this programme. Following the completion of the estimates the costs are reviewed by a panel of Dam Safety experts who have knowledge of the assets and experience of delivering these schemes and amendments are made where necessary.

Governance procedures, as outlined in our costing methodology, were adhered to with the costing of this enhancement case, providing sign offs throughout the different iterations of the costings, as it would if the estimates were carried out through our Unit Cost Database’s Cost & Carbon Estimating Tool (C&CET).

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.

On this case we employed both Turner and Townsend and Aqua Consultants to ensure that we were provided with an external view on cost. Please refer to WSH50-IP00 Our Approach to Investment Planning for more information regarding the review and assurance undertaken.

This has also been verified internally using our own governance processes as well as the internal work completed on the UCD which verifies its accuracy and relative efficiency.

4.2 Benchmarking Our Approach

Is there evidence that the cost estimates are efficient?

– Ofwat’s final methodology for PR24, Appendix 9, A1.1.3b

During AMP7 we have engaged independent consultants to undertake a benchmarking exercise and verify our cost efficiency.

Table 6 summarises the report and shows that the Welsh Water cost is 5.5% below the industry benchmark cost. Variations at the project level are due to the bespoke nature of the interventions required and the significant varying challenges from project to project. Nonetheless, in aggregate, Welsh Water is shown to be operating at the efficient level in AMP7.

Table 6: Extract from AMP7 Costing Review

Scheme	Breakdown	Welsh Water Cost	Aqua Benchmark Cost	Variance	Source of Welsh Water Cost
Cwmwernderi		£7.409M	£6.473M	-12.6%	Alliance Partner
	Direct Works	£2.158M	£2.116M	-2.0%	
	Indirect Works	£3.422M	£2.760M	-19.3%	
	Project Oncosts	£1.829M	£1.598M	-12.6%	
Cantref		£9.626M	£10.601M	10.1%	Welsh Water Cost Intelligence
	Direct Works	£4.711M	£4.342M	-7.8%	
	Indirect Works	£3.099M	£4.321M	39.4%	
	Project Oncosts	£1.816M	£1.938M	6.7%	
Lluest Wen		£8.831M	£9.505M	7.6%	Alliance Partner
	Direct Works	£3.994M	£3.935M	-1.5%	
	Indirect Works	£3.399M	£4.049M	19.1%	
	Project Oncosts	£1.439M	£1.520M	5.7%	
Llys y Fran		£1.096M	£1.085M	-1.0%	Welsh Water Cost Intelligence
	Direct Works	£0.351M	£0.334M	-5.0%	
	Indirect Works	£0.452M	£0.460M	1.9%	
	Project Oncosts	£0.263M	£0.291M	-0.8%	
Usk		£9.493M	£10.858M	14.4%	Welsh Water Cost Intelligence
	Direct Works	£5.185M	£4.690M	-9.6%	
	Indirect Works	£2.089M	£3.679M	76.1%	
	Project Oncosts	£2.219M	£2.489M	12.2%	
Wentwood		£1.297M	£1.300M	0.3%	Alliance Partner
	Direct Works	£0.530M	£0.473M	-10.6%	
	Indirect Works	£0.578M	£0.638M	10.2%	
	Project Oncosts	£0.188M	£0.189M	0.3%	
Total Sample		£37.752M	£39.822M	5.5%	

We have used the same costing approach for developing our AMP8 submission, prior to application of efficiencies as set out in WSH50-IP00 Our Approach to Investment Planning.

5. Providing Customer Protection

This area of investment has strong regulatory oversight from NRW and the governance processes established by the Reservoir Act (1975) and the Flood and Water Management Act (2010).

We are also proposing a Price Control Deliverable (PCD) to provide financial protection to customers.

In this section, we set out the template for the proposed PCD. This is designed to provide strong controls in terms of work delivered against funding allowed – if the proposed dam safety improvements are not delivered, funding will be returned to customers on a proportional basis.

There is no third-party funding in this enhanced investment case.

5.1 Proposed Price Control Deliverable (PCD)

Are customers protected if the investment is cancelled, delayed or reduced in scope?

Does the protection cover all the benefits proposed to be delivered and funded?

– Ofwat’s final methodology for PR24, Appendix 9, A1.1.4a and A1.1.4b

In addition to regulatory oversight from NRW, customers will be protected by means of a PCD which will return money to customers if work is not required at a particular site (and no appropriate substitution site arises).

Customer Facing Description of Enhancement Case	Increasing Safety of Impounding Reservoirs
Short Description of Enhancement Case / PCD Area	Dam Safety
PCD Number	PCD1
Summary of Deliverable	Count of schemes delivered
Description	<p>The Reservoirs Act 1975 (the Act) and the Flood and Water Management Act 2010 (the F&WM Act) places a duty on the company for the safe management of raised reservoirs containing more than 10,000 cubic meters of water.</p> <p>Compliance is regulated by Natural Resources Wales (NRW) to minimise the risk of dam failure and the subsequent flood risk.</p> <p>Pursuant to the Act, undertakers are required to appoint an independent qualified civil engineer (an Inspecting Engineer) to inspect reservoir structures on a periodic basis (a ‘Section 10 inspection’). Inspecting Engineers are appointed on behalf of DEFRA by the ICE, to specialist reservoir panels, to fulfil roles specifically required by the Act.</p> <p>The appointment of an Inspecting Engineer therefore assures NRW that an independent professional view of safety is provided in relation to activity at the relevant reservoir.</p> <p>During an inspection, the Inspecting Engineer may make a recommendation as to ‘measures to be taken in the interests of safety’ otherwise known as ‘MITIOS’. These recommendations are statutory requirements, and the Inspecting Engineer prescribes a timescale within which the MITIOS must be completed.</p>

Description (cont'd)	<p>Changing climatic conditions are leading to new MITIOS being raised with regards to increasing the size, or changing the configuration, of reservoir spillways to accommodate more intense rainfall events within reservoir catchments.</p> <p>Investment is not included for investigations, inspections or general maintenance. Investment to meet environmental obligations under the Habitats Directive is also excluded, as this is funded through a separate agreement with NRW.</p> <p>This investment programme, costed at £78.9M (post frontier shift and real price effects, and in 2022/23 price base) will deliver interventions at 29 sites across Wales. These investments are related to alterations to assets to meet legislation and guidelines.</p>
Measurement and Reporting	<p>The company have an established reservoir inspection programme which is in line with our obligations under the Reservoirs Act (1975). The completion of inspections, and the subsequent identification and remediation of MITIOS, are reported to NRW within 6 months.</p> <p>NRW produce a biannual report on reservoir safety for the Welsh Government, reporting our compliance position.</p> <p>During AMP8 the company expect to deliver MITIOS interventions across 29 sites related to this investment case. Based on previous inspections, we have estimated the likely scale of required interventions as set out below.</p>
Conditions on scheme	<p>No additional conditions identified.</p>
Assurance	<p>The company will agree an appropriate assurances framework with Ofwat as part of Final Determination.</p>
Price control deliverable payment rate	<p>At PR19 the company's 'Delivery of our reservoirs enhancement programme' performances commitment used a single rate of - £1.111M per unit for non-delivery.</p> <p>Given the range of expected costs within the forecasts programme, the company proposes that for PR24, it will apply a specific estimate for each site to protect customers.</p> <p>If the company does not deliver MITIOS compliance at one of the listed sites by the end of AMP8 (or is not in the process of constructing interventions within a timeframe agreed with the inspecting engineer):</p> <p>A change control process, as used in AMP7, will be applied to substitute another comparable intervention, or</p> <p>The forecast funding associated with work at that site will be returned to customers</p> <p>Table 7 lists the sites at which work will be delivered and the specific costs to be used in any return of funding to customers.</p>

Price control deliverable payment rate (cont'd)	Table 7: PCD Payment Rates	
	Site Name	Costs*
	ALED ISAF	£0.060M
	BEACONS	£12.187M
	BLAEN-Y-CWM	£0.339M
	BRITHDIR MAWR	£1.914M
	CANTREF	£4.595M
	CASTELL NOS	£12.866M
	CILCAIN NO 3	£0.009M
	CILCAIN NO 4	£0.009M
	CLYDACH	£2.680M
	COURT FARM	£0.015M
	CWM DULYN	£0.307M
	CWM WERN DERI	£5.361M
	DOLWYDDELAN	£2.680M
	LLWYN-ON	£0.766M
	LLYN ALED	£1.073M
	LLYN ANAFON (ABER LAKE)	£2.986M
	LLYN BRAN	£0.075M
	LLYN CEFNI (ANGLESEY)	£0.009M
	LLYN CELYN	£7.428M
	LLYN CWELLYN	£0.153M
	LLYN GELLI GAIN	£1.914M
	NANT HIR	£3.311M
	NANT MOEL	£3.979M
	PENDERYN	£3.034M
	POND-Y-GWAITH	£0.766M
	TYNYWAUN (BLAENRHONDDA)	£0.040M
	UPPER LLIW	£4.237M
	USK	£0.766M
	WENTWOOD RESERVOIR	£5.437M
	<i>* post frontier shift and real price effects, and in 2022/23 price base</i>	
Impact performance in relation to performance commitments	There is no common performance commitment associated with dam safety.	

5.1.1 Extent of Protection

The work proposed in this case is specific to delivering dam safety outcomes all of which are within the PCD. There are no other identified wider benefits.

Appendix A: Allocation of Costs in the Data Tables

Table 8 shows how the total AMP8 costs above base allowance for this case have been allocated to the following lines:

- CW1.12: Third party services
- CW3b.130: Additional line 1; Impounding Reservoirs - enhancement water CapEx
- CW3b.131: Additional line 1; Impounding Reservoirs - enhancement water OpEx

Our dams programme contains specific cost-sharing mechanisms where water resources are shared across companies. £1.735M per year in AMP8 of NRW recharges and third-party adjustment for bulk water supply is accounted for in CW1.12 and excluded from the reported figures in CW3b.130.

Table 8: Allocation of Costs in the Data Tables

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
CW3b.130	£14.172M	£13.945M	£13.939M	£14.040M	£14.225M	£70.321M
CW3b.131	£0.000M	£0.000M	£0.000M	£0.000M	£0.000M	£0.000M
Contribution to CW1.12	£1.735M	£1.735M	£1.735M	£1.735M	£1.735M	£8.675M
Total	£15.907M	£15.680M	£15.674M	£15.775M	£15.960M	£78.996M

What We Will Deliver: We will deliver investment at 29 dams, particularly on re-engineering spillways and overflow mechanisms. Details are provided in Appendix B.

Appendix B: Details of the Dam Safety Enhancement Programme

Table 9: Scheme Drivers, Scope and AMP8 Costs

Scheme Driver	Site name	Main Scope	Costs*
Existing MITIOS (~48% of value)	BEACONS	Spillway and associated work	£12.187M
	BLAEN-Y-CWM	Spillway and associated work	£0.339M
	COURT FARM	Pipework replacement	£0.015M
	CWM DULYN	Upsize valves	£0.307M
	LLYN CELYN	Upsize pipework	£7.428M
	NANT HIR	Spillway and associated work	£3.311M
	NANT MOEL	Spillway and associated work	£3.979M
	PENDERYN	Spillway and associated work	£3.034M
	POND-Y-GWAITH	Pipework upsize	£0.766M
	USK	Pipework and valve upsize	£0.766M
	WENTWOOD RESERVOIR	Spillway and associated work	£5.437M
Meet new standards, anticipated MITIOS (~30% of value)	ALED ISAF	Studies	£0.060M
	CANTREF	Spillway and associated work	£4.595M
	CASTELL NOS	Upsizing pipework and related	£12.866M
	CILCAIN NO 3	Spillway scheme	£0.009M
	CILCAIN NO 4	Flood study	£0.009M
	LLWYN-ON	Spillway and associated work	£0.766M
	LLYN ALED	Pipework replacement	£1.073M
	LLYN CEFNI (ANGLESEY)	Flood study	£0.009M
	LLYN CWELLYN	Pipework replacement	£0.153M
	TYNYWAUN (BLAENRHONDDA)	Spillway and associated work	£0.040M
	UPPER LLIW	Spillway and associated work	£4.237M
Alternative solution to specified MITIOS measures (~7% of value)	CWM WERN DERI	Pipework and valves upsizing	£5.361M
Aim to discontinue before next S10 as costly MITIOS otherwise expected (~15% of value)	BRITHDIR MAWR	Discontinuance	£1.914M
	CLYDACH	Discontinuance	£2.680M
	DOLWYDDELAN	Discontinuance	£2.680M
	LLYN ANAFON (ABER LAKE)	Discontinuance	£2.986M
	LLYN GELLI GAIN	Discontinuance	£1.914M
Legislative obligation to continue monitoring (<1% of value)	LLYN BRAN	Monitoring	£0.075M
			Total: £78.996M

* post frontier shift and real price effects, and in 2022/23 price base