PR24

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A3-24 RESERVOIR SAFETY

NES22

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1. INTRODUCTION

1.1. BACKGROUND

We are required to maintain and operate our raw water reservoirs in line with the requirements of the **Reservoirs Act 1975** and the Department of Environment, Food and Rural Affairs (Defra) / Environment Agency '**Reservoirs: owner and operator requirements**', June 2014.

Our programme of reservoir inspections, undertaken by experienced dam engineers in accordance with the Reservoirs Act 1975 requirements, allows us to effectively monitor and manage asset condition and risk. The cyclical nature of the inspection programme makes sure all reservoirs are reviewed by qualified specialists at a minimum frequency of 10 years, in line with national guidelines. Our reservoir inspection programme, and compliance with reservoir safety legislation is regulated by the Environment Agency. Maintaining our extensive reservoir assets forms a very important element of our base expenditure programme, and one that is increasingly challenging to deliver due to the age of assets and the consequences of asset failure.

We note that United Utilities has submitted a PR24 Cost Adjustment Claim[1] based on the higher historic cost of maintaining and operating reservoirs for companies with a high proportion of reservoir sources. In addition, the case references an increase in the number of regulatory actions required following statutory inspections, especially since the Toddbrook Reservoir emergency incident and the subsequent publication of the Balmforth Report[2] in 2021. As part of the claim, United Utilities has calculated a symmetrical adjustment which, if applied, would result in an increased allocation of £18m for Northumbrian Water.

This case focuses on the significant additional cost, over and above ongoing costs for reservoir maintenance, of addressing new standards for reservoir drawdown resulting directly from recent changes in regulatory guidance that are now being enacted by inspecting engineers as part of the statutory inspection programme. We note that the Water Services Regulation Authority (Ofwat) rejected a PR19 Cost Adjustment Claim for resilient reservoirs at Final Determination[3] and we do not believe that companies have been previously funded for the impact of this regulatory change on reservoir safety programmes.

Changes in the guidance for assessment of reservoir drawdown capacity, issued by Defra in 2017 (outlined in Section 2.1.1), and enacted via the reservoir inspection programme post-PR19 submission, will require significant investment during the 2025-30 period to ensure ongoing compliance with our reservoir safety obligations. Through analysis of our reservoir portfolio and in consultation with our appointed Qualified Civil Engineer (QCE) specialists, we have identified eight sites in our Northumbrian Water area where intervention is required to address a quantified shortfall against the new standard.

[1] PR24 Cost Adjustment Claim: Reservoir dam maintenance - UUW_CAC_001, Ofwat, 2023
[2] Independent Reservoir Safety Review Report, Prof. David Balmforth, 2021
[3] PR19 Final Determinations – United Utilities Final Determination, Ofwat, 2019

This case outlines the impact of the legislative change, the need for investment and our plan to implement a programme of investment to achieve compliance by the end of the 2025-2030 period, in line with regulatory obligations.

We have carried out an assessment of drawdown capacity across all our reservoirs and identified eight sites where there is a clear need for drawdown capacity increase in AMP8, in line with the changes. Three of these sites have already been assigned a compliance date by the inspecting engineer. As our assessment is based on engineering data and hydraulic analysis, it is possible that further sites (where we have not identified a calculated shortfall) may be assigned compliance action as part of future S10 inspections following real-world drawdown testing.

1.2. SUMMARY OF COSTS

Table 1 shows the summary of costs for the eight reservoir sites included in this case. Our cost estimation and appraisal process is detailed in Section 4. We are conducting ongoing and detailed drawdown site investigations for our eight sites, including outline design and feasibility assessment to further validate our cost data by May 2024, and inform Ofwat's Final Determination. The total AMP8 enhancement is **£80.578m** capex and **£0.042m** opex.

TABLE 1: SUMMARY OF AMP8 ENHANCEMENT COSTS FOR RESERVOIR DRAWDOWN

Reservoir	Total AMP8 Capex (£m)	Total AMP8 Opex (£m)
Cow Green	17.286	0.004
Derwent	12.608	0.006
East Hallington	12.077	0.004
Fontburn	5.336	0.008
Lockwood Beck	5.279	0.004
Scaling Dam	5.214	0.008
Whittle Dene Great Southern	12.077	0.004
Waskerley	10.701	0.004
Total	**80.578**	**0.042**

We have included this investment as Additional Line 3 in the business plan tables (CW3.134 and CW3.135) as it does not fit into other categories of enhancement investment.

2. NEED FOR ENHANCEMENT INVESTMENT

2.1. DRAWDOWN GUIDANCE CHANGES

2.1.1 Changes in Defra guidance for reservoir safety

In August 2017, Defra issued new guidance for reservoir safety[4], outlining a standardised approach and new methods for calculating reservoir 'drawdown' – the rate at which the level of a reservoir can be lowered during emergency situations to maintain reservoir safety.

Drawdown may be carried out as a precautionary measure until potential issues are investigated and risks determined or may be implemented as a direct emergency response. An emergency may be any circumstance in which an event occurs which threatens the structural integrity of the dam. In addition to its importance for risk management and emergency planning purposes, the facility to drawdown levels can also be important to facilitate routine inspection and maintenance of reservoir structures below the normal top water level.

Prior to the publication of the 2017 Defra guidance, there was no standard or prescribed approach to setting target drawdown levels and therefore methods employed in different contexts have varied historically. To inform the new guidance, Defra consulted reservoir owners, operators and inspectors, both in the UK and across the globe, and found a range of different approaches applied in practice.

Methods for setting drawdown levels among water companies in the UK also varied, with companies adopting a range of different approaches, resulting in a variety of drawdown target levels used in the design and asset management of reservoir assets in England and Wales. A primary aim of the Defra guidance was to standardise both the calculation and application of drawdown capacity performance across the UK, in line with current good practice for the management of reservoir safety risk.

Figure 1, taken from the Defra guidance, shows the flowchart for assessing the adequacy of installed drawdown rate for embankment dams. This illustrates that the basic standards are applied by the reservoir inspecting engineer considering a range of factors and using engineering judgement.

[4] Guide to drawdown capacity for reservoir safety and emergency planning, Defra, 2017

FIGURE 1: FLOWCHART FOR ASSESSING THE ADEQUACY OF INSTALLED DRAWDOWN RATE FOR EMBANKMENT DAMS[5]

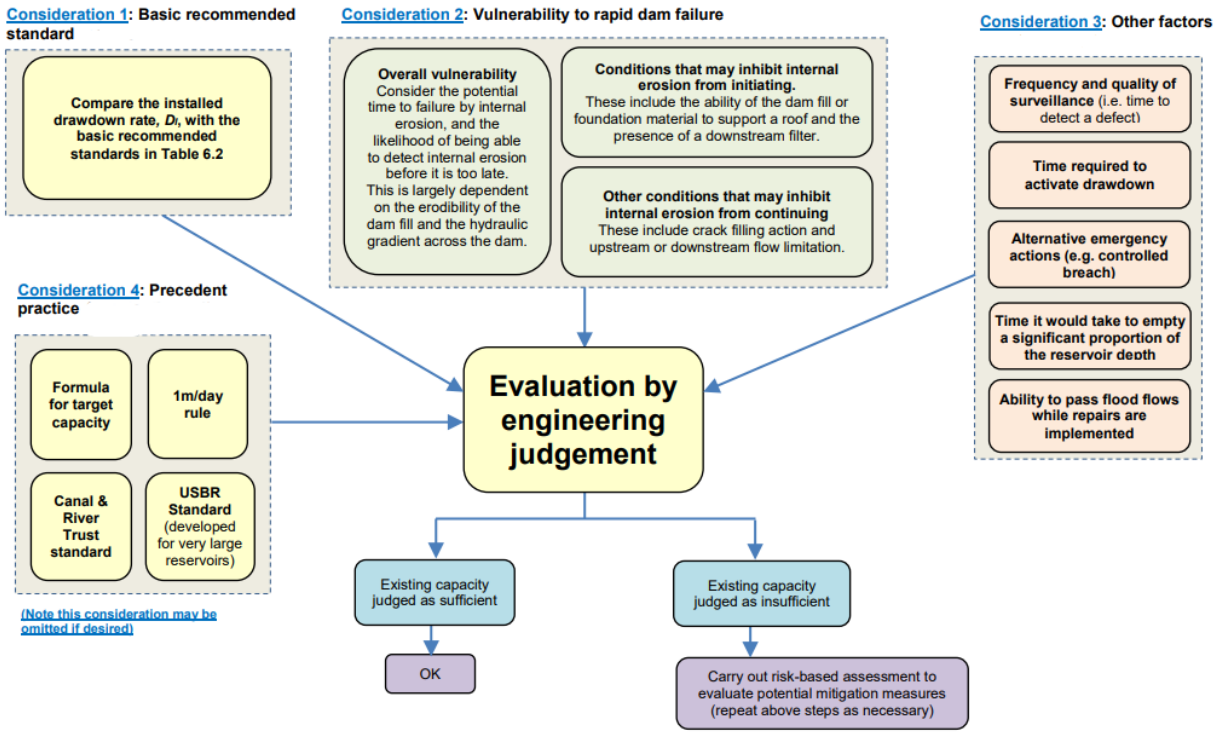


Figure 2 from the same document shows the standard drawdown requirements as defined by the Environment Agency, on which the inspecting engineer is required to base their assessment of site-specific drawdown requirement.

[5] Guide to drawdown capacity for reservoir safety and emergency planning, SC130001 Volume 1 – main guide, p36. Environment Agency 2017, ISBN: 978-1-84911-392-2

FIGURE 2: STANDARD FOR DRAWDOWN RATE[6]

Dam category (Note 1)	Recommended minimum rate (Note 2)	Upper cap on practical drawdown rate (Note 3)
A (Note 4)	5%H/day (Note 5)	1m/day
B	3%H/day (Note 5)	0.6m/day
C or D (Note 6)	2%H/day	0.3m/day

Notes:

1. The dam category is defined in *Floods and reservoir safety* (ICE 2015) based on the potential to life and damage downstream if the dam were to fail. Category C dams are those where there would be negligible risk to life and category D dams are those where no loss of life could be foreseen.
2. The rates are based on drawing the reservoir down from top water level.
3. The cap is considered justifiable on the basis that higher dams tend to conform to higher standards of design, construction and general management but where this is not considered the case then it may be appropriate to raise the cap.
4. Category A dams are those 'where a breach could endanger lives in a community'. For particularly large communities, e.g. where the likely loss of life (LLoL) exceeds 100 people, consideration could be given to increasing the recommended rates to drawdown from that shown above.
5. For low height dams where there is a risk to life the drawdown rate should be a minimum of 300mm/day unless there are alternative emergency actions which could be implemented to mitigate the risk.
6. For category C or D dams the recommended standard is based on protecting the value of the dam as an asset and avoiding potential reputational losses which may be associated with dam failure. Departure from the recommended standard could be considered if these potential losses can be tolerated.

This standard and assessment process are now being applied by our inspecting engineers as part of the Section 10 (S10) regulatory inspection cycle.

2.1.2 Ministerial direction (Defra 2021)

Following the 2017 guidance revision, a ministerial direction was issued by Defra in 2021 based on learnings from the 2019 **Toddbrook reservoir incident**.

The ministerial direction was issued under the Reservoirs Act 1975 (the Act) on 22 April 2021 instructing the preparation of Flood Plans (also referred to as On-Site Emergency Flood Plans or Emergency On-Site Plans) for all registered large-raised reservoirs in England. This requires Undertakers to prepare a Flood Plan under Section 12A of the Act, and meeting the requirements stated in Section 12AA of the Act. The Flood Plan must be prepared in consultation with the Appointed Engineer. Once the Flood Plan is produced, the Appointed Engineer is required to make sure it meets the legal requirements and confirm its completeness. Once satisfied, the Appointed Engineer will produce a certificate under Section 12AA(3) of the Act.

Production of the plan is required within 12 months of the ministerial direction, that is by 21 April 2022. Following its production, the Flood Plan must be tested at the times and in a manner directed by the Appointed Engineer. The Undertaker is also responsible for keeping the Flood Plan under review and to revise it as necessary.

[6] Guide to drawdown capacity for reservoir safety and emergency planning, SC130001 Volume 1 – main guide, p38. Environment Agency 2017, ISBN: 978-1-84911-392-2

The ministerial direction effectively placed an increased emphasis on drawdown, underlining the critical role of drawdown performance for the effective mitigation of flood risk, and driving a focus on compliance with the 2017 changes through the statutory reservoir inspection programme.

A copy of the ministerial direction and the associated guidance is available via the following links:

- Ministerial direction: **Reservoir on-site flood plans**
- Guidance documents: **Reservoir emergencies – on-site plans**

2.1.3 Drawdown capacity shortfall analysis

The revised guidance issued by Defra in 2017 included changes to the way drawdown capacity requirements should be calculated, which when subsequently applied in the context of our reservoir inspection programme, resulted in a calculated shortfall in reservoir drawdown capacity at several of our sites.

In response to the changes in guidance and the ministerial directive, we have completed an exercise to assess the drawdown capacity across our reservoir estate. Table 2 below shows the sites where we have identified and quantified the shortfall in capacity against the revised standard for drawdown calculation.

Our analysis quantifies the current and required reservoir drawdown performance expressed in two related metrics:

- Drawdown (DD) Flowrate measured in m^3/s, which defines the optimum capacity of the drawdown assets (commonly an overflow weir and siphon pipe arrangement) to deliver a specific volume and velocity.
- Drawdown (DD) Rate expressed in metres per day (m/d), quantifying the drop in reservoir water level within that can be achieved over a 24-hour period at maximum Drawdown Flowrate.

It should be noted that our assessment is theoretical, based on engineering data and hydraulic calculations, and not based on the outputs of real-world drawdown tests. We have identified 8 sites where there is a clear need for drawdown capacity increase in AMP8 in line with the guidance, 3 of which have already been assigned a compliance date by the inspecting engineer. However, given that our assessment is theoretical, it could be possible for further sites (where we have not identified a calculated shortfall) to be assigned compliance action as part of future S10 inspections following real-world testing.

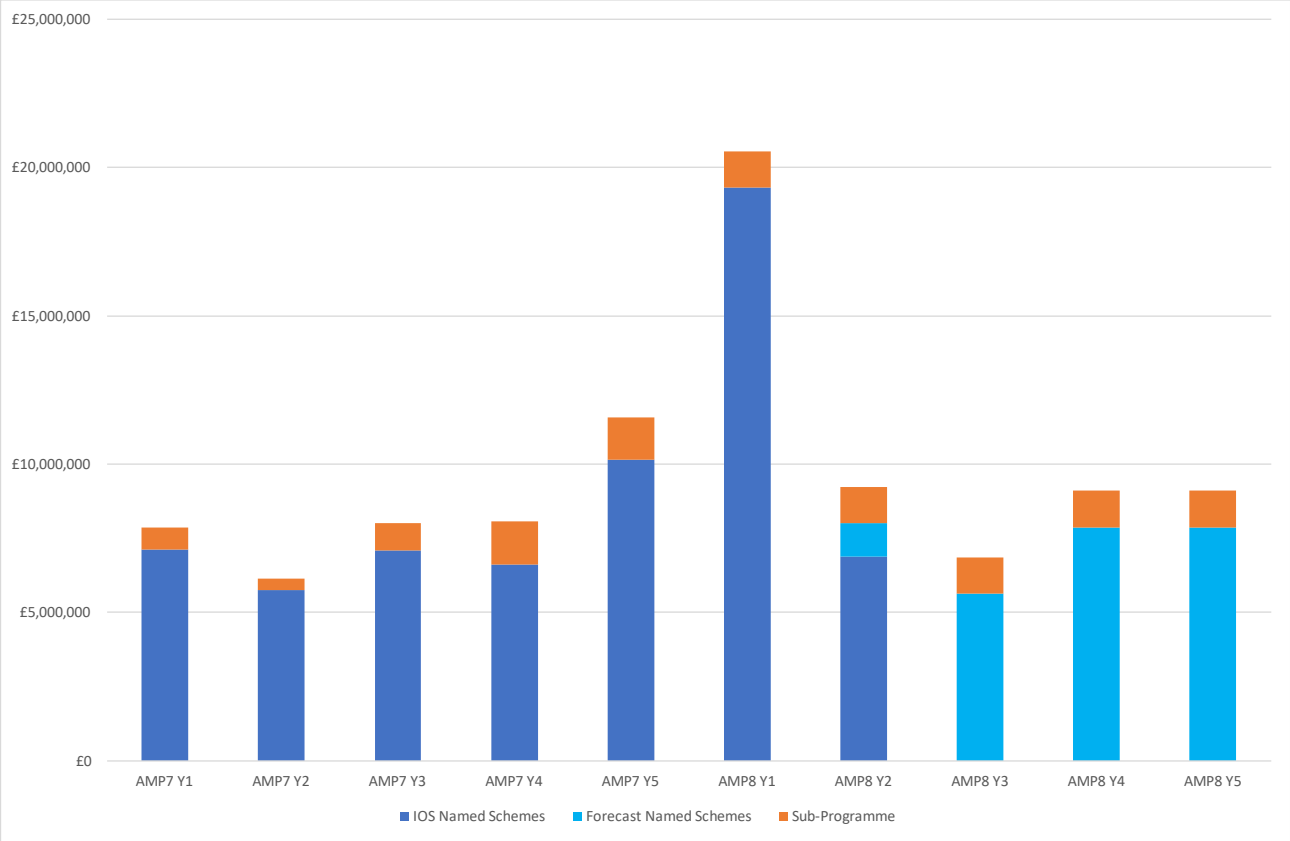
TABLE 2: RESERVOIR SITES WITH A DRAWDOWN SHORTFALL AGAINST DEFRA GUIDELINES

Reservoir	DD Rate Defra guidance (m/d)	DD Flowrate Defra guidance (m^3/s)	Current achievable DD Rate (m/d)	Current achievable DD Flowrate (m3/s)	Shortfall in DD Rate (m/d)	Shortfall in DD Flowrate (m3/s)
Cow Green	1.25 (Capped at 1)	42.8	0.49	20.83	0.51	21.97
Derwent	Physical validation of drawdown in progress. Shortfall estimated at 20 cumecs					20.00
East Hallington	Estimated as equivalent to West Hallington				0.43	2.22
Fontburn	0.65	2.75	0.53	2.25	0.12	0.5
Hury (AMP7 delivery)	1.6 (Capped at 1)	5.59	0.52	2.89	0.48	2.7
Lockwood Beck	0.57	0.94	0.23	0.38	0.34	0.56
Scaling Dam	0.37	1.84	0.2	1.1	0.17	0.74
Waskerley	0.76	2.55	0.33	1.12	0.43	1.43
Whittle Great Southern	0.5		0.54	0.45	0.49	0.05
West Hallington (AMP7 delivery)	0.65	3.76	0.22	1.54	0.43	2.22

2.1.4 Reservoir safety programme

Our reservoir safety investment programme, funded under base allowance, is delivering our statutory obligations under the Reservoir Safety Act, with capital maintenance interventions prioritised on the basis of expert engineering judgment provided via our cyclical inspection programme. This programme will continue in AMP8 with an estimated capital maintenance budget of approximately £55m, compared to our forecast outturn of £42m in AMP7, with spend targeted to address actions identified by our inspecting engineers, classified as either in the interest of safety (IoS) or interest of maintenance (IoM). Figure 3 below shows our Reservoir Safety Programme spend to date in AMP7, committed spend based on reservoir compliance actions already assigned, and our forecast for the remainder of AMP8. **Costs for compliance with the changes in drawdown guidance set out in this enhancement case have been excluded.** The peak in year 1 of AMP8 reflects the delivery of a tranche of named schemes launching in the current year with a compliance date falling in year 1 (non-drawdown related investment). The orange bar reflects our ongoing sub-programme for reactive spend and minor maintenance items, and the forecast is based on our AMP7 run rate.

FIGURE 3: RESERVOIR BASE SPEND ACTUAL & FORECAST (EXCLUDING DRAWDOWN CAPACITY SCHEMES)[7]



For reservoirs identified as having a shortfall in drawdown capacity, the following work is known to be required in AMP8 to maintain compliance with other actions designated by the Inspecting Engineers under the S10 inspection process. While costs are yet to be assessed, these activities will be delivered under our AMP8 Base programme and therefore the costs are excluded from this case, as shown in Table 3 below.

[7] Northumbrian Water capital planning

TABLE 3: AMP8 BASE INVESTMENT

Reservoir	AMP8 Base investment	Scope
Cow Green	Yes	Safety improvements to handrails and access structures
Derwent	Yes	Repairs to upstream face. Improvements to auxiliary spillway capacity and testing.
East Hallington	Yes	Spillway repairs, bridge replacement and seepage monitoring in line with S10 programme
Fontburn	None programmed	N/A
Hury	Yes	Spillway repairs and upgrade required in AMP8 in line with S10 programme
Lockwood Beck	None programmed	N/A
Scaling Dam	None programmed	N/A
Waskerley	None programmed	N/A
West Hallington	Yes	Scheme to address drawdown in progress for AMP7 compliance date. Delivered under AMP7 Base as S10 regulatory action assigned in Feb 2021.
Whittle Dene Great Southern	Yes	Addressing RARS risk: modification of pipework to mitigate risk from buried pipes.

2.1.5 Drawdown capacity enhancement programme

Investment to address the shortfall in drawdown capacity is driven specifically by a change in Defra guidance. While compliance with the Defra guidance does not directly become a regulatory requirement, inspecting engineers (QCEs) are now required to enact the guidance via the inspection programme. This results in an indirect statutory obligation where actions to address a drawdown shortfall are identified and the reservoir owner issued with a statutory date for compliance. Therefore, we have specifically identified works related to compliance with the change in Defra guidance as justified under enhancement funding.

Due to the cyclical nature of the reservoir inspection programme, we received the first regulatory compliance actions related to drawdown capacity after the PR19 submission and were therefore unable to quantify and include enhancement costs in our PR19 Business Plan. Actions were assigned for the first five reservoirs (Hallington West, Fontburn, Lockwood Beck, Scaling Dam and Hury) by the QCE between December 2020 and September 2022. Compliance dates vary, but all five sites are required to comply by 31 December 2025. Hallington West reservoir was assigned a compliance date of April 2024, and we are currently delivering an improvement scheme to achieve compliance.

The timing of the guidance change and the subsequent roll-out through the reservoir inspection process resulted in a wave of regulatory actions out of step with the periodic review five-year cycle. We are therefore investing in AMP7 at sites with an early compliance date in order to keep to our statutory obligations under the reservoir safety act. However, we believe that work to keep to the change in drawdown guidance fits the criteria for enhancement and are therefore seeking enhancement funding for ongoing investment required during AMP8.

Given that for several sites, our delivery programme to achieve compliance with the new drawdown capacity guidance spans both AMP7 and AMP8, we have categorised our sites according to those with action assigned in AMP7 for compliance in AMP7, as shown in Table 4, and for compliance in AMP8, as shown in Table 5.

TABLE 4: ACTION ASSIGNED IN AMP7 FOR COMPLIANCE IN AMP7

Reservoir	Shortfall in DD flowrate (m^3/s)	Regulatory action assigned	Compliance date
Hallington West	2.22	Feb 2021	April 2024
Hury	2.7	June 2021	May 2025

TABLE 5: ACTION ASSIGNED IN AMP7 FOR COMPLIANCE IN AMP8

Reservoir	Shortfall in DD flowrate (m^3/s)	Regulatory action assigned	Compliance date
Fontburn	0.5	December 2022	December 2025
Lockwood Beck	0.56	December 2020	December 2025
Scaling Dam	0.74	September 2022	September 2025

For a further five sites, our initial drawdown assessment has identified and quantified a drawdown capacity shortfall that will result in a regulatory action following the next inspection, as shown in Table 6 below. The S10 inspection report for Hallington East is due to be issued in Q3 2023. Work is currently ongoing at Derwent and Waskerley to undertake on-site validation of the initial shortfall assessment. A compliance date will be assigned following the outcome of the validation exercise.

Both Cow Green and Whittle Great Southern are scheduled for S10 inspection in Q4 2023, after which we expect an action to investigate and conduct on-site validation of the calculated shortfall will be assigned. A compliance date for completion of a solution to address the shortfall will then be set based on the outcome of the validation exercise. Given that compliance dates are usually assigned with a three-year window to allow investigation, design, and completion of the work, we anticipate a date for these sites of 2026/27.

TABLE 6: COMPLIANCE DATE ANTICIPATED 2026/2027

Reservoir	Shortfall in DD flowrate (m^3/s)	S10 inspection due	Compliance date
Cow Green	21.97	November 2023	Not yet assigned (anticipated 2026-2027)
Derwent	20	Validation of drawdown in progress	Not yet assigned (anticipated 2026-2027)
Hallington East	2.2	Inspection report due Q3 2023	Not yet assigned (anticipated 2026-2027)
Waskerley	2.6	Validation of drawdown in progress	Not yet assigned (anticipated 2026-2027)
Whittle Great Southern	0.05	October 2023	Not yet assigned (anticipated 2026-2027)

2.2. LINK TO LONG-TERM STRATEGY

This investment is needed as part of the ensuring sustainable water supplies and maintaining resilience investment areas under our Long-Term Strategy (LTS) core pathway.

We consider this is no regret investment because it is needed to meet statutory requirements in the 2025-2030 period. We have a legal obligation to deliver this investment by 2030, in line with the requirements of the Reservoir Safety Act 1975, enacted through the S10 reservoir inspection programme. Failure to comply with actions to address drawdown shortfall assigned by our Reservoir Inspecting Engineer would result in enforcement action. This would likely include restrictions to top water level (TWL) in reservoirs where a shortfall has been identified, which would have a material impact on supply resilience in our Northumbrian Water operational area.

We therefore consider this investment is necessary in the 2025-2030 period to deliver our LTS.

No further investment to address drawdown shortfalls is expected beyond AMP8, as the compliance dates for all reservoirs with an identified shortfall will fall within AMP8. We therefore anticipate full compliance with the new drawdown guidance by the end of the AMP.

3. BEST OPTION FOR CUSTOMERS

3.1. OPTIONS DEVELOPMENT

Identifying viable options to address shortfalls in drawdown capacity requires detailed feasibility and design, including hydraulic modelling to test options against the compliance criteria. Given the early stage of investigation and solution development, and the fact that for some sites we are anticipating work to be required following future S10 reservoir inspections, the optioneering process for all sites is not yet complete (and cannot yet be completed). A number of sites are currently under investigation and the initial options screening and development phase. Other sites are awaiting S10 inspection at the end of 2023. Ongoing work to conduct site investigations and carry out design and feasibility as part of our reservoir programme will make sure more detailed costing data is available in 2024, before Ofwat's Final Determination.

Therefore, for our business plan submission we have used expert judgement to define the most likely solutions for each of the nine reservoirs to build a sound basis for cost estimation. This is based on the preferred options being taken forward for those sites currently in initial optioneering and options screening, and expert knowledge of the site context and operating constraints for the remaining sites.

In most cases, viable solutions are limited to modifying existing drawdown siphon arrangements or installing additional siphons to increase total flowrate. Given the nature of the regulatory driver and the implications for Reservoir Safety, a 'Do Nothing' option is not viable unless the shortfall in drawdown capacity is deemed negligible by the inspecting engineer. Our analysis shows that none of the sites awaiting inspection in 2023/24 have a drawdown capacity likely to be deemed negligible. We note that while shortfall in drawdown flowrate at Whittle Great Southern reservoir was measured at only 0.05 m^3/s as part of our 2021 survey, this reservoir is one of four connected reservoirs operating in cascade. A holistic solution to address all four reservoirs will need to be implemented to make sure the level in each reservoir can be dropped simultaneously. The hydraulic investigation and the design and implementation of the solution are likely to be complex, and the total shortfall in flowrate to be addressed across all four reservoirs in the cascade is likely to be greater than the current 0.05 m^3/s.

Fontburn, Hury, Lockwood Beck, and Scaling Dam are currently progressing through the contractor investigation and options screening stage. A summary of the options being taken forward for design and feasibility are shown in Table 7 below.

TABLE 7: SHORTLISTED OPTIONS FOR SCHEMES WITH 2025 COMPLIANCE DATE

Reservoir	Initial Options/Scope
Fontburn	Valve operated pipework discharging to existing overflow shaft. New Siphon discharging into the tailbay.
Hury	New Siphon discharging into spillway structure, raising of spillway walls. Modifications to existing overflow arrangement.
Lockwood Beck	New siphon running through embankment and discharging into the spillway.
Scaling Dam	New siphon discharging to outlet chamber connecting to existing stilling basin.

For the remaining sites, we will undertake options development following assignment of S10 actions, compliance dates, and our issue of a brief to specialist contractors. To assess options and develop costs for our PR24 programme, we have carried out an options development workshop to define and quantify the most likely option to allow cost assessment via our iMOD costing system.

The workshop was conducted in June and involved the following specialists:

- Reservoir Programme Manager (Northumbrian Water)
- Water Reservoir Operational Lead (Northumbrian Water)
- Water Programme Lead (Northumbrian Water)
- Principal Engineer - Member of the Reservoirs Supervising Engineering Panel (Mott MacDonald)
- Principal Engineer - Member of the Reservoirs Supervising Engineering Panel (Stantec)
- Cost estimation lead (Mott MacDonald)
- Water Asset Management Specialist (Mott MacDonald)

Based on engineering judgment, knowledge of site operations and constraints, and the latest outputs from the four sites currently in initial optioneering and screening, we identified the most likely technically feasible option for each reservoir and the high-level scope requirements. We also assessed the site constraints and risk factors likely to have a material influence on cost uncertainty and benchmarked against contractor prices for West Hallington and Lockwood Beck. For example, because many sites are critical to supply, there are limits on the extent to which the reservoir TWL can be dropped to facilitate key elements of construction. In order to mitigate the supply risk, construction of a coffer dam and associated piling work will be required to enable construction and connection of a new siphon arrangement. We have used existing contract quotes for piling work at Lockwood Beck, to benchmark the piling cost estimates for other sites.

A summary of the output from the workshop is shown in Table 8 below and forms the basis of our cost assessment in iMOD, our cost estimation system.

TABLE 8: MOST LIKELY SOLUTIONS DEFINED BY EXPERT PANEL

Reservoir	Options developed	iMOD Scope	Cost risk factors
Cow Green	No – S10 report not due until end of 2023. Cost estimate based on likely solution identified by expert panel	• 4 x new 300m siphon pipes 1200mm through the weir • 4x discharge valve, 4x isolation valve & 4x air valve • Concrete inlet chamber 4m x 5m • Concrete discharge chamber 10m x 15m • Pump station to prime siphon (120 l/s) • Generator and hard standing • 2 bridges require strengthening • 2.7km access road widening/surfacing	Solution complexities. Concrete dam wall - unlikely to be able to route siphons through dam. Drilling through concrete dam walls is common internationally, but never been done in UK. Ground conditions are solid rock, unable to install piles. Very remote location and harsh environment - construction window limited to 6 months per year due to weather conditions. Reservoir located within a designated SSSI. Significant ecological factors will affect planning and permissions.
Derwent	No – I&B estimate due August 2023. Cost estimate based on likely solution identified by expert panel	• 3x 200m new siphon pipe 1200mm diameter, routed through the weir and discharging into spillway • Headwall to dissipate discharge • 3x discharge valve, 3x isolation valve & 3x air valve • Concrete chamber on dam crest 10m x 15m • Pump station to prime siphon (120 l/s) • Connection to power supply	Siphons will go through dam crest/core. Piling required due to supply constraints – unable to drop reservoir levels sufficiently to carry out work without construction of coffer dam. Ecological factors likely to affect planning and permissions. Protected species present. Criticality of supply likely to cause commissioning delay due to availability of water to allow siphon test at full flow.
East Hallington	No – Cost estimate based on likely solution identified by expert panel. Solution scope based on West Hallington project – same likely scope.	• 2x 100m new siphon pipe 700mm diameter • 2x discharge valve, isolation valve & air valve • Concrete chamber on dam crest 3m x 3m • Concrete discharge chamber 5m x 5m • Compressor unit to prime the siphon • Connection to power supply	Siphons will go through dam crest/core. Piling required due to supply constraints – unable to drop reservoir levels sufficiently to carry out work without construction of coffer dam. Poor ground conditions – history of seepage/leakage. Capped spring chamber on site. Ecological factors likely to affect planning and permissions. Protected species present include Crayfish Criticality of supply likely to cause commissioning delay due to availability of water to allow siphon test at full flow. Limited water course capacity – attenuation of flows may be required during testing.

Reservoir	Options developed	iMOD Scope	Cost risk factors
Fontburn	Yes – New siphon option is being carried forward to concept design. Cost based on I&B iMod project estimate	• 260m new siphon pipe 1200mm diameter, 260m • 130m new gravity pipe 1200mm diameter in a 7m deep tunnel • discharge valve, isolation valve & air valve • Concrete chamber on dam crest 3m x 3m • Concrete discharge chamber 5m x 5m • Pump station to prime siphon (40 l/s) • Connection to power supply • New bridge 30m long • Widen 1.4km access road	Siphons will go through dam crest/core. Piling required due to supply constraints – unable to drop reservoir levels sufficiently to carry out work without construction of coffer dam. Preferred option involves tunnelling at toe of dam, complex engineering operation. NWG does not own the access track. Access passes through residential area Significant ecological factors will affect planning and permissions. Protected species present include otters, bats, newts, slow-worms and badgers.
Hury (AMP7 delivery)	Yes – Option shown is being carried forward to concept design. Cost based on I&B iMod project estimate	• 2 x new 220m siphon pipes 700mm diameter • 2x discharge valve, 2x isolation valve & 2x air valve • 100m new gravity pipe 1200mm diameter • Concrete inlet chamber 4m x 5m • Concrete discharge chamber 5m x 5m • Pump station to prime siphon (40 l/s) • New power supply	Siphons will go through dam crest/core. Piling required due to supply constraints and maintaining critical supply to Lartington WTW – unable to drop reservoir levels sufficiently to carry out work without construction of coffer dam. Significant ecological factors will affect planning and permissions. Protected species present.
Lockwood Beck	Yes – Option 1A is being carried forward to concept design. Cost based on I&B iMod project estimate	• 150m new siphon pipe, 35m above ground, 115m below ground, 400mm diameter • Concrete inlet chamber 4m x 5m • discharge valve, isolation valve & air valve • Concrete siphon break chamber 5m x 5m • Headwall • Kiosk at crest to house isolation and air valve	Poor ground conditions, history of instability. Previous dam built on a fault line. Siphons will go through dam crest/core. Piling required due to supply constraints – unable to drop reservoir levels sufficiently to carry out work without construction of coffer dam. Significant ecological factors will affect planning and permissions. Protected species present.
Scaling Dam	No – I&B estimate due August 2023. Cost estimate based on likely solution identified by expert panel	• 95m new siphon pipe 500mm diameter • discharge valve, isolation valve & air valve • Concrete chamber on dam crest 3m x 3m • Concrete discharge chamber 5m x 5m • Pump station to prime siphon (40 l/s) • Connection to power supply	Siphons will go through dam crest/core. Piling required due to supply constraints – unable to drop reservoir levels sufficiently to carry out work without construction of coffer dam.

Reservoir	Options developed	iMOD Scope	Cost risk factors
Waskerley	No – Cost estimate based on likely solution identified by expert panel	• New 240m siphon pipe 700mm diameter • 1x discharge valve, 1x isolation valve & 1x air valve • Concrete inlet chamber 4m x 5m • Concrete discharge chamber 5m x 5m • Pump station to prime siphon (40 l/s) • Connection to power supply • 500m new access road (straightening)	Siphons will go through dam crest/core. Piling required due to supply constraints – unable to drop reservoir levels sufficiently to carry out work without construction of coffer dam. Reservoir located within a designated SSSI. Significant ecological factors will affect planning and permissions.
Whittle Dene Great Southern	No – Cost estimate based on likely solution identified by expert panel	• 2x 100m new siphon pipe 700mm diameter • 2x discharge valve, isolation valve & air valve • Concrete chamber on dam crest 3m x 3m • Concrete discharge chamber 5m x 5m • Compressor unit to prime the siphon • Connection to power supply	Siphons will go through dam crest/core. Piling required due to supply constraints – unable to drop reservoir levels sufficiently to carry out work without construction of coffer dam. Poor ground conditions – puddle clay construction with standard fill. History of leakage. Criticality of supply likely to cause commissioning delay due to availability of water to allow siphon test at full flow.

In addition to defining the scope and quantifying engineering elements for cost assessment, we carried out a review of the risk factors likely to have a material impact on project cost. Risks were categorised to align with the factors built into our iMOD cost assessment system as follows:

- Operational Impact – captures the level of operational/supply risk to be mitigated to enable work on a reservoir. Low impacts are associated with Lockwood Beck and Scaling Dam because they are used for recreational purposes. High and Very High impacts are ascribed to other sites due to their criticality to supply. In some cases, a reservoir provides the only source of water for some supply zones.
- Remote Location – captures proximity to urban centres and key infrastructure such as power supply. Remote reservoir sites are often those in upland locations where weather conditions may restrict construction work during the winter season.
- Access Constraints – captures the difference between a reservoir located in an urban or non-remote setting where access for plant and construction traffic is likely to be good, and remote or upland reservoirs where access may be narrow and winding, with unmade road surfaces. Land/access ownership and proximity to residential properties may also be a significant factor.
- Ground conditions – covers known issues of seepage/leakage as well as risks associated with geological faults or soil/substrate conditions.
- Commissioning – sites assessed as high risk are those where availability of water is likely to impact the commissioning process. To demonstrate the contractual requirements of the construction project have been satisfied, a drawdown siphon would need to be run for an extended period of time to demonstrate the design complies with the drawdown guidance. For some sites, criticality of supply will mean that the volume of water required to satisfy commissioning tests cannot be spared.
- Environmental / Ecological – many reservoir sites provide a habitat for numerous species and are located in areas of natural beauty, often with special designation. Sites assessed as Very High and High include those located within SSSI designated areas, as well as those where multiple protected species are known to present (including newts, bats, otters, badgers and slowworms). These factors have a material impact on planning requirements, timescales and costs.
- Dam Safety – in addition to the iMOD weighting factors listed above, we also assessed the likely solution in terms of construction complexity required to maintain compliance with reservoir safety legislation during the construction phase. For example, activities such as cutting through the crest of an embankment, or tunnelling at the toe of a dam, are highly specialist and require rigorous planning and management to mitigate risk.

A summary of the risk review is shown in Table 9. While we have reviewed these risks as part of our options development process, they are considered to be covered in the risk allowance included in our indirect costs, described in Section 4.2.

TABLE 9: SITE RISK AND COST UNCERTAINTY

Reservoir	Dam safety (construction complexity)	Operational impact	Remote location	Access constraints	Ground conditions	Commissioning	Environmental / ecological
Cow Green	H	H	VH	VH	VH	VH	VH
Derwent	H	VH	L	M	M	H	H
East Hallington	H	VH	L	M	H	H	H
Fontburn	VH	VH	H	VH	H	M	VH
Hury	H	H	H	VH	M	M	VH
Lockwood Beck	VH	L	M	H	H	M	VH
Scaling Dam	H	L	L	H	M	M	M
Waskerley	H	VH	VH	H	M	M	VH
Whittle Dene Great Southern	H	VH	L	M	H	H	H

3.2. BEST VALUE

Our Value Framework is embedded into our portfolio optimisation tool, Copperleaf, and contains a wide range of benefits which reflect measures that relate to performance commitments or other social and environmental values. First, we score the impact of continuing current levels of action or mitigation (business as usual) and then we score the difference in benefit delivered by each available option. Benefits are scored over both 30 and 40-year horizons beginning from the start of AMP8.

The list of options to address drawdown capacity shortfall for sites in AMP8 have been scored against the value models considered appropriate to demonstrate benefits to our customers, the environment and to our operations. However, the single value model in our Copperleaf tool relevant to this specific investment need is the 'Regulatory Compliance' model where financial penalties are assigned to model the consequence of non-compliance. As such, the value model does not adequately reflect the fact that this investment is driven by a statutory requirement for Reservoir Safety to a regulatory compliance date and will need to be delivered in AMP8 to comply with the change to our statutory obligations. We do not have the option to use Copperleaf assessment to weigh up benefit and optimise the timing of interventions.

3.3. CUSTOMER ENGAGEMENT

These projects are a consequence of statutory requirements, and so we have not discussed the specific and individual needs with customers. That is because our research shows that customers expect us to meet our statutory obligations, and it is not appropriate to discuss delaying or phasing investment when there are no alternatives to meet the statutory requirement to deliver these improvements.

We asked our customers in the North-east about their views on reservoir safety as part of our “must do” plan in our affordability and acceptability qualitative research (NES49) and quantitative research (NES50). Customers expect us to meet our “must do” obligations, though expressed concerns about affordability of this plan (as well as the “preferred” plan). The calculations for our research showed that meeting these obligations would add around £2 per year to water bills for customers in the north-east.

4. COST EFFICIENCY

4.1. COSTING METHODOLOGY

To support the enhanced needs identification and optioneering, together with the least cost/best value approach, there has been a significant increase in the quantity of cost estimates required at PR24 when compared to previous price reviews. To support this, as well as maximising the benefit and efficiency of the costing effort, a three-level estimating approach has been utilised for developing PR24 costs:

- Level 1 - Using iMOD Express or Costing Tools to develop order of magnitude estimating for rapid optioneering, elimination of non-beneficial solutions and aiding formulation of business cases
- Level 2 – Detailed cost estimates produced using Northumbrian Water's iMOD cost estimating system
- Level 3 – For complex and/or high value schemes to provide a traditional bottom-up cost estimate

The reservoir drawdown options developed by our experts have been costed to Level 2, using the iMOD system. iMOD is an engineering scoping and cost estimating software system, developed for Northumbrian Water, which provides an integrated platform for project scope definition, whole life costing and tender evaluation.

The cost estimates have been produced using Asset Policy Group (APG) Water Treatment specific cost curves for Process, Component, Contract and Project Overheads.

4.2. COST ESTIMATION

Building robust cost estimates for interventions of this type, prior to detailed investigation and design, is challenging for a number of reasons, including:

- A limited number of drawdown schemes have been implemented across the industry so far and access to robust outturn costs on which to build a cost model is very limited.
- Where schemes have been delivered in AMP7, for some sites, access constraints and complexity of delivery has increased costs significantly above initial estimates.
- While elements of a notional scheme can be estimated using unit cost models (for example, siphon pipe lengths, pumps), these elements do not have a material influence on the outturn cost. Material factors driving the cost are those more difficult to predict without detailed investigation, such as site access constraints and ground conditions. As a result, costs tend to be bespoke to each site and robust estimates can only be produced following detailed investigation and design.
- We collated a limited number of cost-data points from across the industry where available, but our analysis has confirmed that there is very limited correlation between the size of the drawdown shortfall to be addressed and the cost of the solution.

Therefore, as described in section 3.1 we have developed high-level bottom-up solution scopes for each of the sites based on engineering judgement and the costs for West Hallington drawdown scheme currently being delivered in AMP7. Level 2 costs have then been developed in iMOD and are shown in Table 10. The total cost includes project and contract overheads, 10% risk and 30% cost uncertainty.

TABLE 10: OPTION COSTS FOR SITES WITH AMP8 COMPLIANCE DATE

Reservoir	Scope cost	Total cost (including OH + risk)	Opex (annual)
Cow Green	7.746	17.286	0.002
Derwent	5.404	12.608	0.003
East Hallington	5.141	12.077	0.002
Fontburn	3.982	9.701	0.002
Lockwood Beck	3.932	9.598	0.001
Scaling Dam	3.875	9.481	0.002
Whittle Dene Great Southern	5.141	12.077	0.002
Waskerley	4.467	10.701	0.002

As described in section 2.1.5, investment for some sites will span AMP7 and AMP8. This applies to Fontburn, Lockwood Beck and Scaling Dam where compliance dates are in year 1 of AMP8 and work is already in progress to conduct site investigations and engineering feasibility. For these sites, we have estimated the proportion of AMP7 and AMP8 capex costs as 45% and 55% respectively by comparing our draft programme for each site to the spend profile of our in-flight AMP7 project at West Hallington reservoir. This takes into account the following factors:

- Projects require a significant amount of up-front planning to secure the necessary permissions to carry out construction work in environmentally sensitive areas (SSSI, AONBs etc). Therefore, the construction element of the programme typically falls within the last 12 months of the programme.
- Elements of site work and construction continue beyond beneficial completion (technical compliance with the statutory requirement for drawdown), and therefore some spend falls in the six-month period after the statutory compliance date.

The proportional split of investment between AMP7 and AMP8 for the three sites is shown in Table 11 below. Opex only applies to AMP8, once the projects have been completed in year 1. The impact on annual opex is minimal and has been calculated based on annual maintenance and power costs to run the pumping station required to prime the additional siphon capacity. The pumps will need to be run periodically to test emergency drawdown operation, therefore power costs have been based on two days of operation per year. **All AMP7 costs are excluded from the case.**

TABLE 11: AMP7 AND AMP8 CAPEX SPLIT FOR SITES WHERE WORK WILL BEGIN IN AMP7

Reservoir	Total Capex (£m)	AMP7 Capex (£m)	AMP8 Capex (£m)
Fontburn	9.701	4.365	5.336
Lockwood Beck	9.598	4.319	5.279
Scaling Dam	9.481	4.266	5.214

Table 12 shows our total enhancement costs for AMP8, which includes only the AMP8 element of costs for the three sites shown in Table 11. The total AMP8 opex figure is derived from the annual opex figure and the number of years following the statutory compliance date (actual or anticipated) to the end of the AMP.

TABLE 12: TOTAL AMP8 ENHANCEMENT COSTS

Reservoir	% Capex cost in AMP8	Total AMP8 Capex (including OH + risk)	Total AMP8 Opex (£m)
Cow Green	100	17.286	0.004 (2 years)
Derwent	100	12.608	0.006 (2 years)
East Hallington	100	12.077	0.004 (2 years)
Fontburn	55	5.336	0.008 (4 years)
Lockwood Beck	55	5.279	0.004 (4 years)
Scaling Dam	55	5.214	0.008 (4 years)
Whittle Dene Great Southern	100	12.077	0.004 (2 years)
Waskerley	100	10.701	0.004 (2 years)
Total		**80.578**	**0.0420**

4.3. COST BENCHMARKING

As a limited number of drawdown schemes have been implemented across the industry to date, sufficient data is not available to allow external benchmarking of complete schemes. However, we have benchmarked three of the main cost components from our estimates against comparable water and wastewater companies. These are siphon pipework (water mains), concrete chambers, and water pumping.

The benchmarking compares Northumbrian Water generated estimates for each of the three elements against five comparable water and wastewater companies in England and Wales. A mean average from company data has been used as the benchmark with a 25th percentile and 75th percentile provided as a suitable range. The cost comparisons have been calculated using the latest cost curve data from each company, and reflect the same data used by each company to build its PR24 submission. The costs generated by each cost curve are based on appropriate sizing metrics. We have added each of the costs for the water mains, chambers and pumping together, to provide a total value of benchmarked components for a sample group of the reservoirs (five sites).

The benchmarked costs have been adjusted for inflation using CPIH[8] and have a price base of Q2 2022.

Table 13 and Table 14 below show the outcome of the cost benchmarking analysis for the preferred solutions. Table 14 shows that on average, the benchmarked elements are 22% more efficient than the industry benchmark data.

TABLE 13: PREFERRED OPTION DIRECT COST BENCHMARKING OUTCOMES

Reservoir	Northumbrian cost	Benchmark cost	25th percentile	75th percentile	Delta	Delta %
Cow Green	£2,819,668	£2,775,154	£2,225,420	£3,377,997	£44,514	2%
Derwent	£1,637,174	£2,405,970	£1,967,117	£2,894,059	-£768,796	-32%
Fontburn	£915,824	£1,482,921	£1,203,902	£1,785,102	-£567,096	-38%
Lockwood Beck	£134,881	£261,637	£210,061	£326,748	-£126,756	-48%
Waskerley	£415,153	£704,285	£594,129	£841,709	-£289,132	-41%
Total	**£5,922,701**	**£7,629,966**	**£6,200,630**	**£9,225,615**	**-£1,707,265**	**-22%**

In addition to benchmarking project scope, we conducted analysis of client and contractor indirect costs, comparing our own project and contract overheads to data provided by the same five comparator water companies. Table 14 shows that our indirect costs are calculated as 63.40% of direct costs compared to the industry benchmark of 73.86%. Our indirect costs are therefore 10.46% below the industry benchmark.

TABLE 14: INDIRECT COST BENCHMARKING OUTCOMES

Indirect cost type	Northumbrian cost	Benchmark cost	Delta %
Total Contractor Indirect	36.88%	48.01%	-11.14%
Total Client Indirect	26.52%	25.84%	0.68%
Total Project Indirect	63.4%	73.86%	-10.46%

We have applied our standard 10% risk uplift, and a cost certainty allowance of 30% due to the investigation and feasibility work still to be undertaken to confirm detailed scope and price.

[8] Consumer Prices Index including owner occupiers' housing costs.

5. CUSTOMER PROTECTION

5.1. PERFORMANCE COMMITMENTS

Performance commitments (PCs) incentivise water companies to improve performance and maximise outcomes for customers and the environment. Our requirements for reservoir drawdown are set by Defra (see section 2) and have a limited impact on performance commitments, with a small impact on operational carbon emissions. As such, there are no performance commitments that will directly make sure protection of customers through non-delivery of our reservoir drawdown programme.

5.2. PRICE CONTROL DELIVERABLE

Our approach to determining Price Control Deliverables (PCD) is outlined in Section 12.3 of A3 – costs (NES04). In Table 15 below, we assess our reservoir drawdown enhancements to test if the benefits are linked to PCs; against Ofwat's materiality of 1%; and to understand if there are outcome measures that can be used.

TABLE 15: ASSESSMENT OF BENEFITS AGAINST THE PCD CRITERIA

Enhancement scheme	Benefits linked to PC?	Materiality	Possible outcomes?
Reservoir Drawdown Capacity (NES22)	Pass – benefits are not linked to PC	Pass– 2.0%	Could measure the shortfall met – but this is not directly related to costs. Could measure the delivery of individual schemes.

Despite the work carried out to reasonably quantify the costs to deliver this programme, there remains a high level of solution and cost uncertainty that will only be resolved by future detailed feasibility, investigation and design work. Our ongoing investigations and planning delivered through our reservoir programme will make sure more detailed costing data and therefore greater cost certainty are available in 2024, prior to Final Determination.

This uncertainty is because the inspections have not yet taken place – once these can be planned in more detail in 2024, we will be able to update these costs. It will likely be appropriate to apply a "scheme delivery" type PCD at this stage (as we describe in A3 – costs (NES04).

In this case, we propose that a PCD is not required at the moment. This is because:

- There is already scope for enforcement action if we do not deliver against our compliance dates, and this can – and would likely - include fully delivering this work. Customers do not need extra protection from a PCD because we must deliver these schemes to comply with the law.
- The precise schemes to be delivered are not completely clear until all schemes have been inspected, and regulatory actions and compliance dates are set. It is impossible to set a well-defined, ex-ante PCD based on scheme delivery – without this PCD needing adjustments to accommodate statutory deadlines set through inspections.