WATER PR24 REFERENCES

Final Determinations Volume 6: Appendices A–G and Glossary

10 March 2026

Competition & Markets Authority

Website: www.gov.uk/cma

Members of the Competition and Markets Authority Panel who conducted these redeterminations (the group)

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The Competition and Markets Authority has excluded from this published version of the final determinations information which the group considers should be excluded having regard to section 206 of the Water Industry Act 1991.

Any omissions are indicated by [✂]. Any non-sensitive replacement content is indicated in square brackets.

CONTENTS

Appendix A: Conduct of our PR24 redetermination process

A.1 The CMA received five References from Ofwat on 18 March 2025.

A.2 Our administrative timetable was published on our case page. Our statutory deadline to issue the final report is 17 March 2026.[1] The CMA is required to issue the final report to Ofwat.[2] Ofwat (or the CMA on Ofwat's behalf) will then issue the final report to the Disputing Companies and the Secretary of State for Environment, Food and Rural Affairs.[3] The final report will be published not less than 14 days after the Secretary of State has received a copy of the final report.[4]

A.3 Our final determinations have been informed by extensive evidence from the main parties and third parties.

Evidence from main parties

A.4 We received and published a number of submissions from the main parties, including the Disputing Companies' statements of case, Ofwat's response to these statements of case (**Ofwat's Response**), replies from the Disputing Companies to these documents, and further submissions from the Disputing Companies and from Ofwat.[5]

A.5 The main parties made initial presentations to the CMA, and the Disputing Companies produced virtual site visit videos. The Disputing Companies (and their representatives) and Ofwat provided various technical teach-ins for CMA staff on analytical approaches and financial models. Ofwat also provided the CMA with some teach-in sessions on the regulatory process and PR24 ahead of the References (recordings of which were shared with the Disputing Companies).

A.6 We received responses from the main parties to many requests for information. In the interests of maintaining openness and transparency, the main parties copied each other into submissions and responses to our information requests, except where relevant information was commercially confidential.

A.7 We reviewed Ofwat's PR24 FD documents and certain supporting materials including draft decisions, methodologies and consultation documents. We considered the Disputing Companies' responses to and submissions on these materials.

A.8 On 28 May 2025 we published for consultation the CMA PR24 Approach document, setting out our proposed approach to the determinations (see chapter 3

[1] Having requested, and been granted by Ofwat, an extension of the statutory deadline to 12 months (Rules (CMA204), Rule 6.2).
[2] The Act, section 15(4); Rules (CMA204), Rule 12.6.
[3] The Act, section 15(5)(a).
[4] The Act, section 15(5)(b); Rules (CMA204), Rule 12.7; Guide (CMA205), paragraph 4.18.
[5] See the versions published by the CMA at Water PR24 price redeterminations (eg Disputing Companies' statements of case, Ofwat's responses to statements of case, Disputing companies' replies to Ofwat's responses to statements of case) and Main parties' responses to provisional determinations.

(Approach and prioritisation), paragraph 3.16), to which the main parties responded.

A.9 We held hearings with the main parties throughout late June and early July 2025. These included joint hearings to discuss cross-cutting issues as well as individual hearings to discuss concerns specific to each Disputing Company. Following these hearings, we received brief written submissions from the main parties focused on any perceived inaccuracies and/or new information.

A.10 The CMA PR24 PD was published on 9 October 2025, to which we received responses from the main parties. We published these, along with the main parties' replies to other main parties' base cost modelling representations.[6]

A.11 We published the base cost modelling working paper (**Working Paper**) on 18 December 2025. We received and are publishing, at the same time as publishing this report, responses to the Working Paper from the main parties.

Evidence from third parties

A.12 We received over 40 submissions from third parties in response to the References and statements of case including from environmental, conservation, business and consumer organisations, local government, academics, advisers, other water companies and other regulated businesses. We published non-sensitive versions of these third party submissions on our case page.

A.13 A further six third party submissions were received in response to the CMA PR24 Approach document, which we also published on our webpage.

A.14 We published 18 third party responses to the CMA PR24 PD.[7] We received 8 shorter third party submissions not published on our case page, which broadly raised one or more of the following points.

(a) The CMA should act in the interests of consumers and impose no increase (or only a limited increase) in customer bills.

(b) Water companies should use money paid to shareholders/directors (ie not higher customer bills) to fund infrastructure improvements.

(c) Any additional revenue arising from CMA decisions should be ring-fenced to be spent only on service/environmental improvements.

A.15 We received and are publishing, at the same as publishing this report, 11 third party responses to the Working Paper.

A.16 We engaged with the Consumer Council for Water (**CCW**), including through its own dedicated third-party hearing. We held calls with the Drinking Water Inspectorate (the **DWI**), and received responses to requests for information from

[6] See the versions published by the CMA at Main parties' responses to provisional determinations and Main parties' responses to other parties' base cost modelling representations in response to the provisional determinations.
[7] See the versions published by the CMA at Submissions on the provisional determination.

CCW, the DWI and the Environment Agency (the **EA**). We also met with representatives of the Thames Investor Group.

A.17 Although all submissions were considered carefully, we have not listed every relevant submission in relation to every point throughout our report.

A.18 We would like to thank everyone who provided us with evidence to consider for our redeterminations.

Engineering assistance

A.19 We employed a firm of engineering consultants, Water Research Centre Group (**WRc**) to provide specialist engineering expertise in relation to the redeterminations, after a procurement process assessing several factors including consultants' potential conflicts due to work done for any Disputing Company. WRc advised the CMA on various technical aspects of the water and sewerage sector. We treated WRc's advice as further evidence to aid the group's decision-making.

Appendix B: Background on economic regulation of sector

B.1 This Appendix B provides a brief introduction to economic regulation of the UK water sector, providing an overview of the regulatory bodies overseeing the water sector and their roles, the regulated companies, economic regulation of the sector and the factors determining the customer bills.

Water sector in England and Wales: privatisation and regulatory bodies

B.2 Following a brief period of government ownership, The Water Act 1989 privatised the 10 regionally operated water authorities in England and Wales.[8] As part of the process of privatisation and creation of 10 major water and sewerage companies (**WaSCs**), the following 3 new regulatory bodies were also created.

(a) The DWI, responsible for monitoring drinking water quality and ensuring that the water supply is safe to drink and meets the standards set in the relevant water quality regulations. The DWI is also responsible for agreeing and managing water company programmes to improve drinking water.[9]

(b) The EA and its Welsh counterpart Natural Resources Wales, responsible for environmental regulation.[10] The EA is the principal adviser to the government on the environment, and the leading public body protecting and improving the environment of England.[11] The EA has a duty to maintain and improve water quality, and exercises this duty through monitoring the quality of rivers, lakes the sea and ground water. The EA also issues water abstraction licences for activities such as drinking water supply, artificial irrigation and hydro-electricity generation, as part of its role in conservation and ecology.

(c) Ofwat, responsible for the economic regulation of the sector and setting the price control regime.

B.3 The Department for Environment, Food & Rural Affairs (**Defra**) is responsible for the policy, planning and regulatory framework for the water sector in England. It works with devolved administrations in Wales, Scotland and Northern Ireland.[12]

B.4 In Scotland and Northern Ireland, water services are publicly owned and are regulated by the Water Industry Commission for Scotland and The Northern Ireland Authority for Utility Regulation respectively.

B.5 Other relevant bodies include Natural England, which is the Government's adviser on the natural environment.

[8] At the time of privatisation, there already existed a significant number of private water-only companies.
[9] What we do - Drinking Water Inspectorate (accessed 26 February 2026).
[10] At the time of privatisation, the regulator was the National Rivers Authority. The National Rivers Authority was dissolved in 1996 and superseded by the EA and Natural Resources Wales.
[11] Natural Resources Wales undertakes the equivalent role in Wales.
[12] For example, in Wales the Welsh Government sets the legislative and regulatory framework for the water companies. The Welsh Government publishes statutory guidance setting out the strategic priorities that it expects Ofwat to pursue in its regulation of the water industry in Wales. See Our regulators | Dŵr Cymru Welsh Water (accessed 26 February 2026).

Water companies in England and Wales

B.6 Over time, water companies have been consolidated following mergers with other water companies or WaSCs.[13] Currently Ofwat regulates 6 regional water only companies (**WoC**s) and 10 regional WaSCs in England.[14]

B.7 Following privatisation, water services in England and Wales have been largely funded by customer bills and private investment. Water infrastructure networks require substantial capital investment and maintenance; the need for investment is sometimes large and unforeseeable. Expenditure is funded by raising debt and equity financing. Funds generated from customer bills typically cover costs of operation, contribution towards capital repayments and returns on the financing of previous expenditure.[15] This limits fluctuation in customer bills and allows long-lived water assets to be paid for over time by more of the users who ultimately benefit. In return, investors require a return on finance, which customers also pay for over time.[16]

B.8 Water companies are licenced to operate in certain geographic areas. The water companies are also monopoly suppliers for the wholesale (and associated retail) provision of household water and wastewater services.

Economic regulation

B.9 Ofwat is currently responsible for the economic regulation of the water industry. Within this responsibility, Ofwat also has roles to protect consumers' interests, encourage competition and investment within the industry (these duties are discussed further in chapter 3 (Approach and prioritisation), at paragraphs 3.4 to 3.13. These roles are primarily carried out through administration and enforcement of the water companies' licence regimes.

B.10 Every five years – known as a price control period, or asset management period (**AMP**) – Ofwat performs a price review of the upcoming AMP. These reviews are intended to protect customers' interests by ensuring the investments and expenditure that companies are asking for are efficient, permit water companies to make enough money to generate a reasonable return for investors and adhere to various statutory obligations designed to protect customers and the environment. These price controls do not specify the individual prices or tariffs that companies charge for water services, which are usually set annually. There are separate regulatory processes that apply to companies concerning how tariffs are structured and ultimately set, as they may vary between different customer groups.

B.11 Ofwat's price control framework for wholesale price controls is based around the regulatory capital value (**RCV**). The RCV comprises the value of investment by a

[13] Ofwat (2015) Structure of the water industry in England: does it remain fit for purpose? Annex A, paragraphs 5–7.
[14] Twelve small water and sewerage undertakers are also listed at Licences and licensees - Ofwat (accessed 26 February 2026).
[15] NAO (2025) Regulating for investment and outcomes in the water sector report, p7, Key finding 9.
[16] NAO (2015) The economic regulation of the water sector, p12, paragraphs 1.3 and 1.5.

water company in its licensed activities that is recognised as such by Ofwat. The RCV also reflects the accumulated allowed expenditure to be recovered from future customers. This investment, or accumulated allowed expenditure, is returned over time to investors through RCV run-off (or the rate at which the costs are recovered) that makes up a component of allowed revenues. The RCV is calculated as the opening value of investment at the start of the year, plus inflation, plus capital investment in the year less RCV run-off (the way investments are recovered over time through customer bills). This is also shown in Figure B.1.

Figure B.1: RCV calculation

Source: CMA.

B.12 These cost recovery charges make up part of the allowed revenue that Ofwat determines in its price control. In setting the revenue that each company can recover in AMP8, Ofwat determined:

(a) its assessment of efficient expenditure;

(b) its assessment of this expenditure to be recovered within the period;

(c) its assessment of this expenditure to be added to the RCV and recovered in the future;

(d) what it considered to be a reasonable level of return on the RCV, based on the cost of capital; and

(e) a tax allowance.

B.13 The above steps make up Ofwat's general methodology for setting price controls.

B.14 Under this approach, Ofwat assesses what each company's expenditure requirements would be if it were an efficient company. These expenditure requirements then formed part of its calculations of the wholesale price control, while factoring in elements of cost recovery and a reasonable level of return.

B.15 Ofwat uses comparative analysis of all the water companies to inform its assessment of the efficient expenditure requirements of each individual company (along with target performance and incentive rates); by looking at all the water companies and making allowances for differences between them, it seeks to estimate what revenues an efficient company performing its functions would require, given the geographic area in which it operated. For example, it uses econometric models to estimate an efficient benchmark based on costs and characteristics of different companies' actual operations. Ofwat uses actual data where available, and/or forecast data (see chapter 9 (Other issues), paragraphs 9.1 to 9.6, for a description of Ofwat's blind year reconciliation process).

B.16 However, there are limits in relying purely on comparative regulation. Differences between companies may mean that Ofwat is not able to fully determine and measure efficiencies between companies. This could be for a variety of reasons, including factors that contribute to efficiencies, limited number of comparators, and possible information asymmetries between Ofwat and the companies. There are various ways in which Ofwat sought to address some of these challenges in PR24, and which are discussed in our main report.

B.17 For PR24, Ofwat emphasised the need for companies to submit stretching business plans in terms of efficiency,[17] and introduced a quality and ambition assessment (**QAA**) of the initial business plans submitted by companies to Ofwat. Ofwat said that the QAA's goal was to encourage companies to provide business plans that included ambitious levels of service at efficient costs and delivered more for customers and the environment for AMP8 and beyond. Where Ofwat thought the plan was insufficiently ambitious or complete, in its PR24 DD it applied penalties in the form of a reduction in returns allowed. Where the companies subsequently improved their business plans, these penalties were removed.[18]

B.18 The level of detail at which company operations are examined, the number of overlapping regulatory requirements and the overall process of determining price controls have become increasingly complex over successive price control periods. This has been indicated in various recent sector reviews.[19]

B.19 The CMA has conducted these PR24 redeterminations within the existing regulatory framework. Following the IWC Final Report, in January 2026 the UK government published a white paper setting out its action plan for water (**Defra White Paper**), which includes reform of the regulatory framework. It will publish a transition plan in 2026 setting out a roadmap to guide reforms to the sector.[20]

Water and wastewater bills

B.20 A combined household water and wastewater bill is made up of:

(a) current costs;

(b) RCV run-off (similar to depreciation and related to expenditure recovered over time - the return on capital investment in assets);

(c) return on capital (financing debt and providing a return to shareholders); and

(d) a small remaining percentage relates to tax, the cost of retail activities and other less material items.

[17] Ofwat (2022) Our final methodology for PR24, p77 and Figure 11.2.
[18] Ofwat (2024) PR24 draft determinations: Quality and ambition assessment summary, eg pp1, 5 and 7. The Defra White Paper stated that the new regulator for water will abolish the QAA, to ensure companies are not incentivised to bid for less investment than they need: Defra White Paper, p38.
[19] See eg IWC Final Report, pp8–9, recommendations 12 and 15.
[20] Defra White Paper, eg at pp45–48.

B.21 Household water and wastewater bills vary significantly between the different service areas. This is due to a variety of reasons including:

(a) the state of existing infrastructure;

(b) the availability of raw water and how it is abstracted, stored and transported;

(c) the scale of treatment required;

(d) population density; and

(e) the pace of investment programmes.

B.22 Ofwat sets price controls for the total revenue a water company can earn for each of the following.

(a) A water network, ie the infrastructure and services used to supply clean water to customers.[21]

(b) A wastewater network, ie the infrastructure and services used to convey wastewater and stormwater from properties to sewage treatment works.[22]

(c) Wastewater treatment works.

(d) Bioresources.[23]

(e) Retail, ie customer-facing services such as meter reading or call centres.[24]

[21] This includes water mains (large pipes, usually laid under public land or highways and maintained by a water company); and communication pipes that connect water mains to private properties. Responsibility for pipes and pumping stations - Ofwat (accessed 26 February 2026).
[22] This includes sewer networks which transport wastewater to treatment facilities, and pumping stations to move wastewater through the network.
[23] This refers to the semi-solid by-product of wastewater treatment, also known as sewage sludge. Ofwat (2022) Creating tomorrow, together: our final methodology for PR24, p41, paragraph 3.7.1.
[24] Defra (2013) Water Bill: water glossary.

Appendix C: Estimating water sector productivity changes

C.1 Ofwat used total factor productivity (**TFP**) estimates from the KLEMS database when setting the frontier shift. To inform our decision, we estimated productivity changes in the water sector and compared these with the KLEMS TFP estimates.

C.2 The KLEMS TFP estimates are derived from national accounts using an approach known as 'growth accounting'. It is not possible to apply directly this methodology to the water sector since the UK national accounts do not report data at that level of disaggregation.[25] However, it is possible to use the econometric models of base costs (both under our approach and under Ofwat's) to derive estimates of productivity changes that are conceptually equivalent to the KLEMS TFP estimates, and consistent with the concept of the frontier shift in Ofwat's models.

C.3 The first section of this Appendix C outlines the theoretical basis for the approach; the second discusses its implementation; and the third presents the results.

Methodology

C.4 The TFP benchmarks available in the KLEMS database are estimated using the following equation:[26]

$$a_{jt} = y_{jt} - v_{jt}^{L} l_{jt} - v_{jt}^{K} k_{jt} \tag{1}$$

where:

a_{jt} is the log of productivity for industry j in year t

y_{jt} is the log of output for industry j in year t

l_{jt} and k_{jt} are the logs of labour and capital used in industry j in year t

v_{jt}^{L} and v_{jt}^{K} are the expenditure shares of labour and capital in nominal output, which are defined as follows:

$$v_{jt}^{L} = \frac{W_{jt} L_{jt}}{P_{jt} Y_{jt}} \quad v_{jt}^{K} = \frac{R K_{jt}}{P_{jt} Y_{jt}} \tag{2}$$

where W_{jt} is the wage rate and R_{jt} is the cost of capital.

C.5 The expenditure shares satisfy $v_{jt}^{L} + v_{jt}^{K} = 1$.

[25] Economic Insight reports results for 'Water supply; sewerage, waste management and remediation activities' because this is the closest industry classification to the regulated water sector within the EU KLEMs data set. Economic Insight (2024) 'The importance of a balanced approach to frontier shift', chapter 3.

[26] O'Mahony, M., & Timmer, M. P. (2009), 'Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database', *The Economic Journal*. The model used in KLEMS has more inputs, but for simplicity we limit the exposition to a simple model with labour and capital.

C.6 The KLEMS model can be motivated by a Cobb-Douglas production function with constant returns to scale.[27]

$$Y_{jt} = A_{jt} L_{jt}^{\alpha} K_{jt}^{\beta} \quad s.t. \quad \alpha + \beta = 1 \tag{3}$$

C.7 If firms minimize costs and face competitive input markets, this Cobb-Douglas production function is equivalent to the following cost function:[28]

$$C_{jt} = \left(\frac{Y_{jt}}{A_{jt}}\right)^{\frac{1}{\alpha+\beta}} W_{jt}^{\frac{\alpha}{\alpha+\beta}} R_{jt}^{\frac{\beta}{\alpha+\beta}} \left[\left(\frac{\alpha}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} + \left(\frac{\beta}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}}\right] \tag{4}$$

C.8 It follows that productivity in the water sector can be estimated as the (transformed) residuals in the following regression:

$$c_{jt} = \kappa + \delta y_{jt} + \boldsymbol{\gamma}' \boldsymbol{x_t} + \tilde{a}_{jt} \tag{5}$$

where:

c_{jt} is log expenditure

y_{jt} is a measure of log output (or a cost driver – see below)

$\mathbf{x_t}$ is a vector of relevant log input prices

$\kappa, \delta, \boldsymbol{\gamma}$ are parameters (or parameter vectors)

C.9 The residuals of this regression map onto the structural productivity parameters as follows:

$$\tilde{a}_{jt} = \frac{1}{\alpha + \beta}(a_{jt} - \bar{a}) \tag{6}$$

where $\bar{a}$ is the average productivity over the firms and years (this is subsumed into the constant).

C.10 Therefore, we can recover the change in productivity for each company in each year using the following correspondence:

[27] To see this, note that the firm's profit-maximization problem (assuming competitive output and input markets) is:

$$\max_{L_{jt},K_{jt}} P_{jt} A_{jt} L_{jt}^{\alpha} K_{jt}^{1-\alpha} - W_{jt} L_{jt} - r_{jt} K_{jt}$$

The two first order conditions are:

$$\alpha P_{jt} A_{jt} L_{jt}^{\alpha-1} K_{jt}^{1-\alpha} - W_{jt} = 0$$

$$(1-\alpha) P_{jt} A_{jt} L_{jt}^{\alpha} K_{jt}^{-\alpha} - r_{jt} = 0$$

Substituting the expression for Y_{jt} in equation (3) above in both first order conditions, this simplifies to:

$$\alpha = \frac{W_{jt} L_{jt}}{P_{jt} Y_{jt}}$$

$$1 - \alpha = \frac{R_{jt} K_{jt}}{P_{jt} Y_{jt}}$$

Substituting these quantities in the production function in log form gives:

$$y_{jt} = \frac{W_{jt} L_{jt}}{P_{jt} Y_{jt}} l_{jt} + \frac{R_{jt} K_{jt}}{P_{jt} Y_{jt}} + a_{jt}$$

Which is the KLEMS model.

[28] Bounthavong, M (2019), 'Cobb-Douglas production function and costs minimization problem' for a detailed derivation. The assumption of constant returns to scale is not necessary to support this equivalence.

$$\Delta a_{jt} = \frac{1}{\delta}(\tilde{a}_{jt} - \tilde{a}_{j,t-1}) \quad (7)$$

where all the quantities on the right-hand side have been estimated.

C.11 These productivity improvements for water companies can be approximated using our provisional decision base costs econometric models and the Ofwat models, and they can be meaningfully compared to the TFP estimates from the KLEMS database. Furthermore, productivity improvements can be seen as comparable to a frontier shift applied.

Estimating productivity changes using our econometric and Ofwat's cost models

C.12 Building on the theoretical framework described above, to inform our final decision, we estimate equation (5) at paragraph C.8 above using our provisional decision base cost econometric models and Ofwat's cost models.

C.13 As we place less weight on this analysis in our final decision relative to our provisional decision (please see section 'Our view on water sector historical productivity' in chapter 4 (Base costs)), we did not update our analysis to use our final decision models. However, our analysis was also based on the Ofwat models which did not change.

C.14 For our models, we use the models described in our provisional decision.[29]

C.15 For Ofwat's models we use the same dependent and independent variables and include random effects in the estimations, in line with Ofwat's approach. The only change we make to the models is the addition of the input price variables that Ofwat has identified as relevant for RPEs.[30] This is required to make the resulting estimates of productivity comparable conceptually to the TFP estimates derived by KLEMS (equation (1) at paragraph C.4 above). These are:

(a) regional median hourly earnings for the manufacturing SIC code, based on ONS ASHE data;[31] and

(b) the energy price index.[32]

C.16 Under Ofwat's approach, each cost model comprises multiple sub-models, estimated using different regression specifications. For illustration, we focus on the wholesale water model, which includes a total of 24 regressions divided across three sub-models: water resources plus (6 regressions), treated water distribution

[29] CMA PR24 PD Volume 1, paragraphs 4.46–4.55.
[30] Ofwat (2025) PR24 final determinations: Expenditure allowances, section 4.1. These are price indices rather than input prices, but this did not affect the coefficient on the output or the residuals.
[31] CMA PR24 PD Volume 1, paragraph 4.51(a) and Southern SoC, supporting document 'SOC-2-0069_Southern_Water_Error_4-Regional_Wages-Within_model_adjustment.xlsx'.
[32] CMA PR24 PD Volume 1, paragraph 4.51(b).

(6 regressions), and wholesale water (12 regressions).[33] Ofwat aggregates results from these regressions using a two-step process. First, within each sub-model, the results from individual regressions are combined using regression-specific weights. Second, the weighted sub-model results are aggregated using a triangulation approach: the combined water resources plus and treated water distribution sub-models are assigned a total weight of 50%, and the wholesale water sub-model receives the remaining 50%.

C.17 Where models include aggregation, we apply the same aggregation process in our analysis of productivity changes. The process of aggregation across models of cost involves the aggregation of cost functions after a log transformation. In such cases the theoretical approach outlined above does not directly apply due to the fact there is not separability of the productivity term. As such for consistency in our analysis we use an approximation of (7) whereby we estimate the change in productivity as:

$$\Delta\alpha_{jt} \approx ln\left(\frac{\hat{Y}_{j,t}}{Y_{j,t}}\right) - ln\left(\frac{\hat{Y}_{j,t-1}}{Y_{j,t-1}}\right) \qquad (8)$$

Where $Y_{j,t}$ represents the observed historical costs for company j in period t and $\hat{Y}_{j,t}$ is the resulting predicted costs.

C.18 Note equation (8) at paragraph C.10 above does not include the scaling factor $\frac{1}{\delta}$ that appears in equation (7) paragraph C.17above as there is no way to combine coefficients across models that have been aggregated by an arithmetic average. In effect this assumes constant returns to scale.

Results

C.19 In this section, we present the productivity changes estimated using our provisional decision models and Ofwat's models. For each activity (wholesale water and wastewater), we show the estimated productivity change for each company in each year, together with the mean and median across companies (in each year). Productivity changes reported in this analysis are expressed in approximate percentage terms, as they are calculated from changes in the residuals of a log-linear cost model. For example, a value of 0.02 indicates that productivity has increased by approximately 2% relative to the previous year.

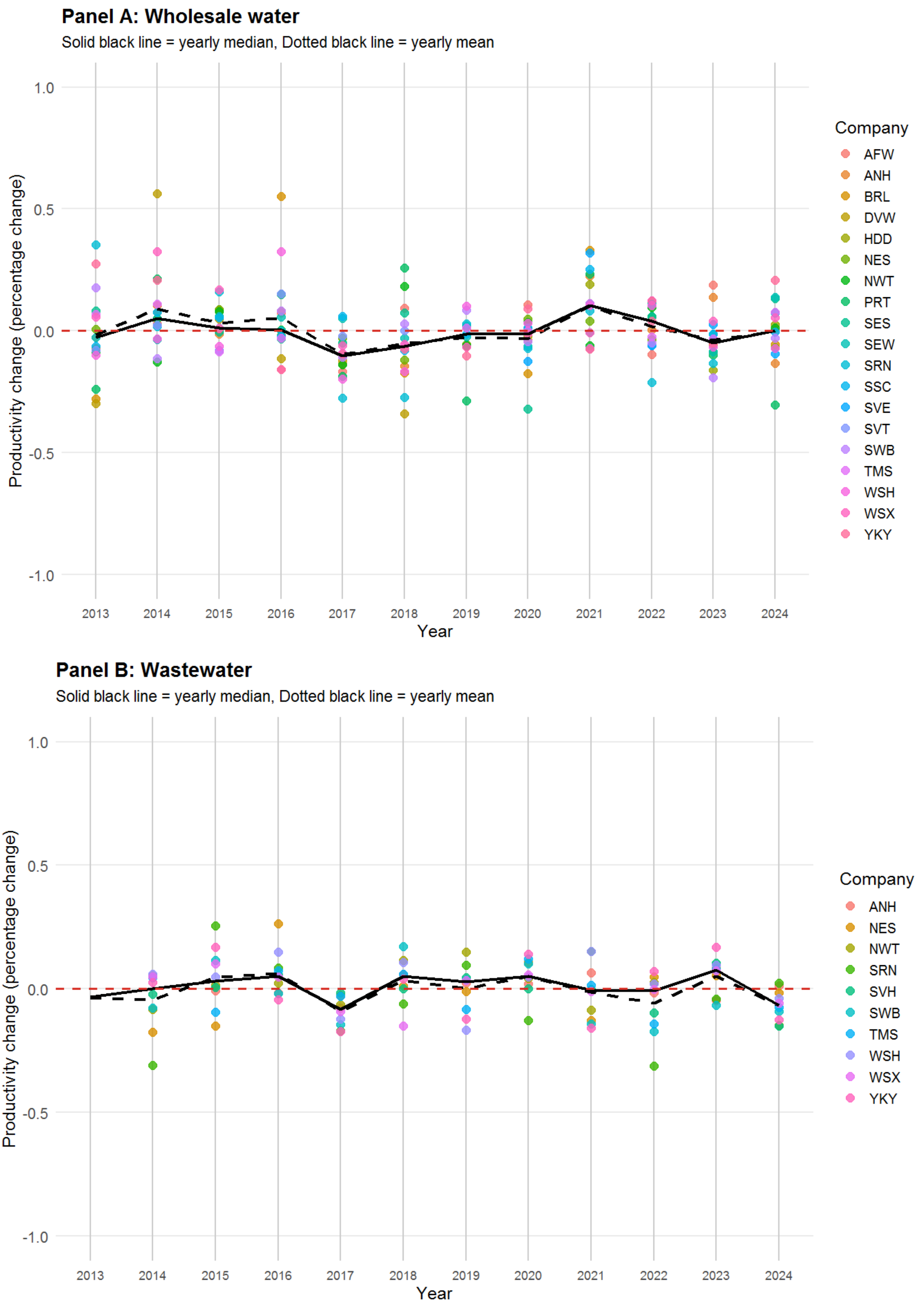
C.20 As explained above, these estimates of productivity changes are effectively transformed regression residuals, and therefore they incorporate the effect of unobserved cost drivers as well as genuine changes in productivity. For this reason, it is important to not over-interpret results for individual companies and individual years and focus on broad patterns instead. If the water industry as a whole had seen significant productivity increases over the past 12 years, we

[33] Ofwat (2024) PR24 draft determinations: Expenditure allowances – Base cost modelling decision appendix sets out a detailed explanation of all Ofwat's cost models, including the exact model specifications and definitions of all variables used.

should see a large share of productivity increases for individual company and years in these charts.

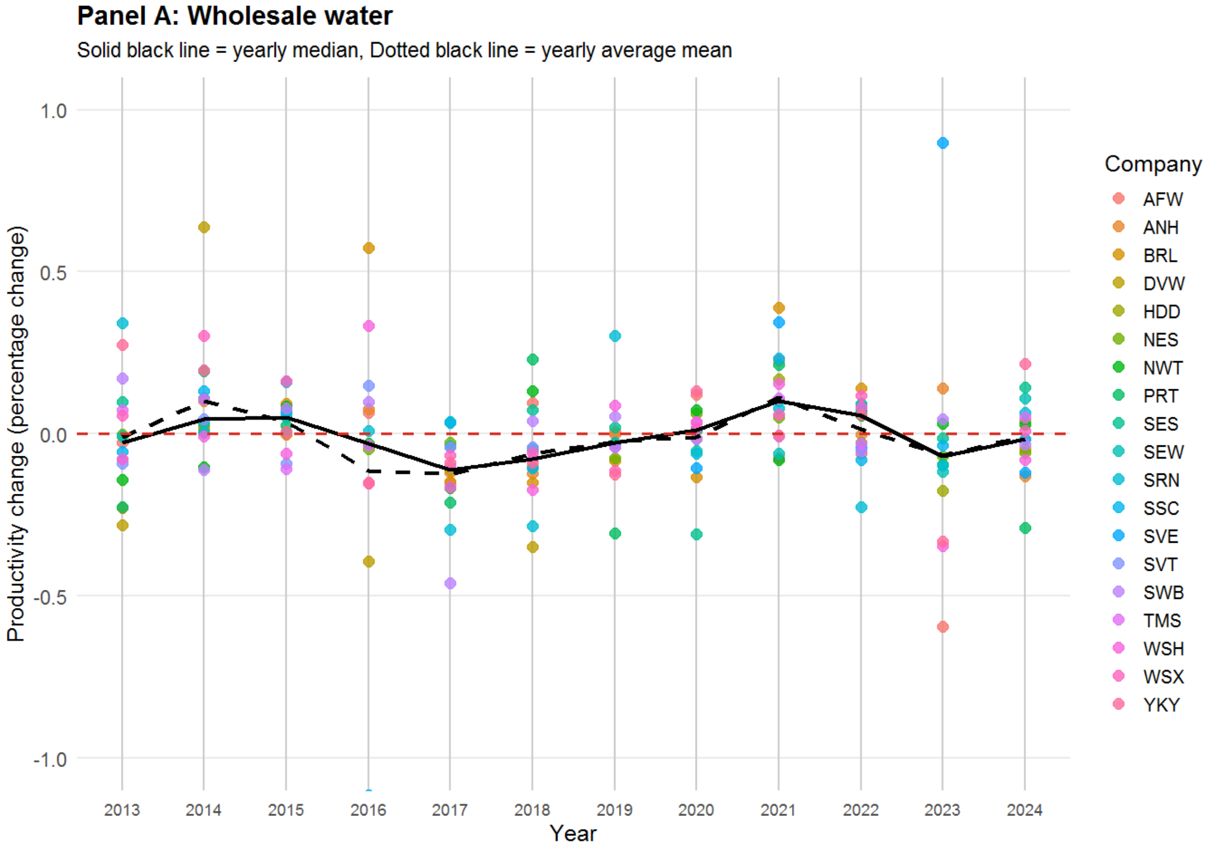
C.21 Figure C.1 below shows estimated productivity changes for our provisional decision models in wholesale water (Panel A) and wastewater (Panel B), and Figure C.2 below shows equivalent results under Ofwat's models. For presentational purposes, in the figures company dots are excluded if they lie below -1 or above 1. Overall, Figure C.1 and Figure C.2 below show that average and median productivity changes vary from positive to negative over years and are generally not very large.

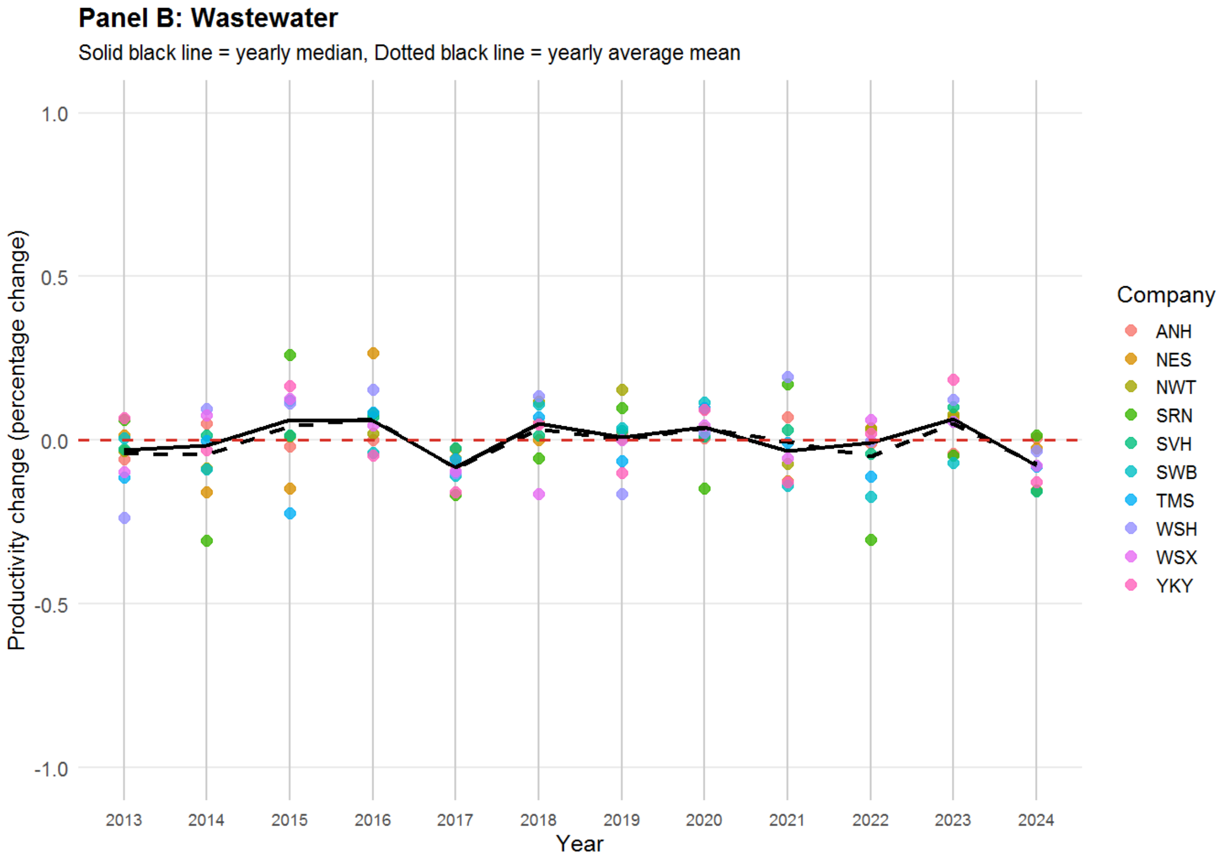
Figure C.1: CMA provisional decision models - estimated productivity changes by UK water company and year



Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.

Figure C.2: Ofwat models - estimated productivity changes by UK water company and year





Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.

C.22 Table C.1 below shows the mean and median productivity changes across all company-year observations under our provisional decision and Ofwat's approaches. Overall, this analysis suggests that productivity changes in the water sector have not been significant.

Table C.1: Mean and median productivity change estimates over all companies and years in the CMA provisional decision and Ofwat models

	CMA provisional decision model		***Ofwat PR24 FD model***	
	Mean	**Median**	**Mean**	**Median**
Wholesale water	0.31%	-0.66%	-1.23%	-0.23%
Wastewater	-0.51%	0.92%	-0.53%	0.42%

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

Appendix D: Base cost modelling

D.1 This Appendix D provides additional technical details relating to the modelling and cost adjustment claims (see chapter 4 (Base costs), sections titled 'Base cost modelling' and 'Cost adjustment claims (CACs) and other claims'), covering:

(a) technical details regarding least absolute shrinkage and selection operator (**LASSO**) (Part A below);

(b) implementing LASSO using Least Angle Regression (Part B below);

(c) technical details regarding a principal component analysis (**PCA**) (Part C below);

(d) technical description of our bootstrap procedure (Part D below);

(e) coefficient tables for our models (Part E below);

(f) correlation between cost drivers and input prices (Part F below);

(g) economies of scale at WTWs CAC (Part G below); and

(h) coastal CAC (Part H below).

Part A: LASSO

D.2 LASSO is a regression technique that simultaneously estimates model coefficients and performs variable selection. It does this by applying a penalty on the size of the coefficients, which shrinks some of them (in some cases to zero). In effect, this means that LASSO excludes variables that do not contribute meaningfully to explaining variation in the outcome.

D.3 The equation below shows a mathematical description of the LASSO estimator, where:

(a) β (beta) is the vector of coefficients;

(b) X is a matrix of cost drivers where each row corresponds to the cost drivers for a given company-financial year pair;

(c) Y is a vector of costs for each company-financial year pair;

(d) λ (lambda) is the penalty level;

(e) q is the number of candidate variables in the LASSO;

(f) N observations in the model; and

(g) $||\,.\,||_p$ indicates the ℓ^p-norm. This is a representation of different distance measures depending on the value of p eg. for $p = 2$ the ℓ^2-norm represents a straight-line distance.

D.4 The difference from the standard ordinary least squares equation is the addition of the penalty term $\lambda||\beta||_1$ which applies a penalty to the sum of the absolute value of the coefficients.

$$\min_{\beta \in \mathbb{R}^q} \frac{1}{N} ||Y - X\beta||_2^2 + \lambda||\beta||_1$$

D.5 The most common approach to determining the appropriate level of penalisation uses a technique called cross-validation. This essentially measures the performance of the model across different candidate values of the penalty parameter, to identify the value likely to generate the most precise predictions. The data is divided into parts, or 'folds'. We use Leave-One-Out Cross-Validation. This method leaves out one observation at a time, fitting the model to the remaining data and evaluating predictive performance. In each iteration, the model's performance is measured using the mean squared error (**MSE**) in the testing fold, which quantifies the average difference between the model's predictions and the actual observed values. The MSE is then averaged over the results to obtain an average indicator of model performance for each candidate value of the penalty parameter.

Part B: Implementing LASSO using Least Angle Regression

D.6 In the CMA PR24 PD, the implementation of LASSO used coordinate descent to solve the optimisation problem. Coordinate descent is computationally efficient and widely adopted in high-dimensional modelling contexts.[34] However, responses to the CMA PR24 PD highlighted concerns about its stability when predictors exhibit high correlation – a common feature in regulatory cost models where scale, density, and network topology variables are inherently related.

D.7 With strong correlation between our cost drivers, small changes in data or penalty parameters may lead to different sets of selected variables using coordinate descent. This instability can undermine transparency and reproducibility, which are important in a regulatory setting to enable stakeholders to understand and replicate modelling decisions. In addition, when parameters are correlated coordinate descent can lead to the ordering of variables impacting the model selection.

D.8 To address these concerns, our updated methodology considered an alternative algorithm – Least Angle Regression – as the basis for the LASSO implementation.[35] Unlike coordinate descent, which updates coefficients one variable at a time along coordinate axes, Least Angle Regression works in a different way. Least Angle Regression incrementally builds the model by selecting

[34] Friedman, Jerome, Trevor Hastie, and Robert Tibshirani (2010), 'Regularization Paths for Generalized Linear Models via Coordinate Descent', *Journal of Statistical Software, Articles,* pp1–22.
[35] Efron, B. et al (2004), 'Least angle regression', *The Annals of Statistics.*

the variable most correlated with the current residuals and then adjusting all active coefficients simultaneously.

D.9 As such, we consider that Least Angle Regression is well suited for our setting. In particular, its properties mean that it performs well for small samples and with correlated data.[36] Least Angle Regression is not as commonly used as other methods typically due to its low computational efficiency which can make it slow for large problems, however, that is not a concern in this case.[37]

Part C: Principal Component Analysis

D.10 A principal component is a new variable that is constructed by taking a weighted combination of the original variables. It is designed to capture as much of the variation in the underlying data as possible. A PCA, or principal component analysis, summarises the underlying data by producing as many principal components as there are original variables. They are ordered by the amount of variation they represent in the original data.

D.11 The first principal component is the single direction in the data that captures the maximum amount of variance. Each original variable contributes to this principal component with a specific weight (called a 'loading'). These weights measure how strongly each original variable influences that component. High positive weights mean the variable strongly pushes the component in one direction. High negative weights push it the opposite way.

D.12 If several of the original variables are highly correlated, they will tend to load heavily on the same principal component – often because they are all measuring aspects of the same underlying phenomenon. Variables that do not correlate with each other will load on different principal components.

D.13 Subsequent principal components capture the next largest amount of remaining variance, but with a crucial constraint: it must be completely uncorrelated (orthogonal) with the first component. The third principal component is orthogonal to both the first and second, and so on. This orthogonality means each component captures independent information – there is no redundancy between them, unlike the original variables.

D.14 Once calculated, a subset of the principal components can be included in a model in place of the original variables. For example, if the original variables are highly correlated, the first principal component may adequately capture the variation in the underlying data (eg 95% or more of the variation overall and in each of the underlying variables is explained by the first principal component). More generally, different combinations of principal components can explain the variation in each of

[36] Bach, F., Jenatton, R., Mairal, J., & Obozinski, G. (2012), 'Optimization with sparsity-inducing penalties. Foundations and Trends® in Machine Learning', pp1–106.
[37] Zhou, Y., & Li, X. (2023), 'A comprehensive survey on Lasso and its variants'.

the underlying variables. This may inform which principal components might be added to the model.

D.15 The advantage of this approach is the elimination of the effect of multicollinearity on the model from correlations between these variables.[38] This can aid model interpretability and stability. The main drawback of using principal components in a model can be the loss of a direct interpretation in terms of the original variables and statistical inference on them. However, the resulting model coefficients on the included principal components can be transformed back into the original variables using the PCA loadings.

D.16 For example, suppose there are 3 variables X_1, X_2, and X_3 that are different measurements of the same underlying feature of the model (ie the same cost driver in a cost model) that we would like to account for. However, given they all measure the same thing – albeit in slightly different ways – they are highly correlated. As such, one might be concerned about the multicollinearity created by including them all.

D.17 Rather than create a separate model for each variable and risking bias in the model estimates by virtue of omitting 2 of the 3 variables, a subset of their principal components can be included. To calculate the principal components, first the X variables are standardised and their scales: σ_i for $i = 1,2,3$ are calculated.

D.18 Given their high correlation and common purpose, further suppose that the first principal component captures almost all of the variance of each of the X variables (ie around 95%). The resulting first principal component provides a composite measure of the original variables by attaching PCA loadings α_1, α_2, and α_3 to the standardised variables, $\tilde{X}_i$ for $i = 1,2,3$.

$$PC_1 = \sum_{i=1}^{3} \alpha_i \tilde{X}_i$$

D.19 The first principal component may be included in the model to parsimoniously control for this feature of the model without inducing multicollinearity and $\hat{\gamma}$ is the estimated coefficient on PC_1. Unfortunately, however, this coefficient has no direct interpretation. However, substituting the definition of PC_1 into the regression and adjusting for the rescaling, we can recover that the effective estimated coefficient on each original variable contributing to PC_1 is:

$$\widehat{\beta_i} = \hat{\gamma}\frac{\alpha_i}{\sigma_i} \;\; for\ i \in \{1,2,3\}$$

D.20 Thus, each original variable's contribution is proportional to its loading in PC_1 and the regression coefficient on PC_1. Once transformed back into the original variable's units the resulting coefficient contribution to the model can be

[38] The principal components may still be correlated with other regressors not included in the PCA.

interpreted, though inference is not as straightforward. A similar approach can be used to recover the coefficients on quadratic PCA terms.

Part D: Implementation of Bootstrap LASSO

D.21 As discussed in chapter 4 (Base costs), to model the stability of modelled results, we perform repeated random sampling analysis using a bootstrapping procedure. We implement the bootstrap in a standard way. In particular:

(a) for each run resample the data with replacement to achieve a dataset of the same length of as the original;

(b) run the analysis and compute allowances and efficiency scores; and

(c) repeat the above sets 5,000 times saving results for each completed run.

D.22 Pooling results generates a distribution of efficiency scores and modelled allowances. We then compute the distribution of the inter-quartile range of results.

Part E: Coefficient tables for our selected models

Estimated coefficients (CMA PR24 FD models)

D.23 Table D.1 and Table D.2 below present the estimated coefficients for the cost drivers in the top-down wholesale water and wastewater models.

Table D.1: Coefficients in the CMA's top-down wholesale water model

Cost drivers	Estimate	Standard error	Significance
Intercept	3.838	0.545	***
(log) Scale combined	-0.683	0.010	***
(log) Density combined	0.050	0.010	***
Squared (log) density combined	0.026	0.003	***
Weighted average complexity (log)	0.450	0.078	***
Average pumping head TWD (log)	0.096	0.049	*
Booster pumping stations per length of mains (log)	0.318	0.063	***
Energy index (log)	0.108	0.049	**
Construction wages (log)	0.303	0.198	

Source: CMA analysis of Ofwat (2025) PR24 FD models data and ONS (2025) ASHE data.
*Note: *** indicates significance at the 1% level, ** at the 5% level, * at the 10% level*
Estimate refers to the coefficient in the model, the standard error is a measure of precision of the estimate, significance refers to statistical significance, which highlights the likelihood that an estimate is different from zero; for example, a significance level of 5% would provide evidence that the estimate is different from zero. Standard errors are not clustered or heteroskedasticity robust.

Table D.2: Coefficients in the CMA's top-down wastewater model

Cost drivers	Estimate	Standard error	Significance
Intercept	5.045	0.415	***
Scale combined (log)	-0.307	0.012	***
Pumping capacity per sewer length (log)	0.467	0.060	***
Weighted average treatment size (log)	-0.018	0.026	
Load treated in size bands 1 to 3 (%)	0.004	0.008	
Load treated with ammonia consent <3mg/l	0.006	0.001	***
Urban rainfall per sewer length (log)	0.115	0.028	***
Energy index (log)	0.160	0.049	***

Source: CMA analysis of Ofwat (2025) PR24 FD models data and ONS (2025) ASHE data.
*Note: *** indicates significance at the 1% level, ** at the 5% level, * at the 10% level. Estimate refers to the coefficient in the model, the standard error is a measure of precision of the estimate, significance refers to statistical significance, which highlights the likelihood that an estimate is different from zero; for example, a significance level of 5% would provide evidence that the estimate is different from zero. Standard errors are standard and not clustered or heteroskedasticity robust.*
Estimate refers to the coefficient in the model, the standard error is a measure of precision of the estimate, significance refers to statistical significance, which highlights the likelihood that an estimate is different from zero; for example, a significance level of 5% would provide evidence that the estimate is different from zero. Standard errors are not clustered or heteroskedasticity robust.

Estimated coefficients for bottom-up models

D.24 Table D.3 and Table D.4 below present the estimated coefficients for the cost drivers in the wholesale water treated water distribution (**TWD**) and water resources plus (**WRP**) models.

Table D.3: Coefficients in the CMA's TWD model

Cost drivers	Estimate	Standard error	Significance
Intercept	-7.629	0.587	***
Length of mains (log)	1.046	0.013	***
(log) Density combined	0.154	0.012	***
Squared (log) density combined	0.039	0.003	***
Average pumping head TWD (log)	0.296	0.040	***
Booster pumping stations per length of mains (log)	0.338	0.064	***
Energy index (log)	0.119	0.049	**
Construction wages (log)	0.556	0.211	***

Source: CMA analysis of Ofwat (2025) PR24 FD models data and ONS (2025) ASHE data.
*Note: *** indicates significance at the 1% level, ** at the 5% level, * at the 10% level. Standard errors not clustered or heteroskedasticity robust.*

Table D.4: Coefficients in the CMA's WRP model

Cost drivers	Estimate	Standard error	Significance
Intercept	-11.679	1.060	***
Properties (log)	1.048	0.025	***
(log) Density combined	-0.091	0.017	***
Squared (log) density combined	0.017	0.004	***
Weighted average complexity (log)	0.673	0.132	***
Energy index (log)	0.172	0.093	*
Construction wages (log)	-0.224	0.357	

Source: CMA analysis of Ofwat (2025) PR24 FD models data and ONS (2025) ASHE data.
*Note: *** indicates significance at the 1% level, ** at the 5% level, * at the 10% level. Standard errors not clustered or heteroskedasticity robust.*

D.25 Table D.5 and Table D.6 below present the estimated coefficients for the cost drivers in the wastewater sewage water collection (**SWC**) and sewage water treatment (**SWT**) models.

Table D.5: Coefficients in the CMA's SWC model

Cost drivers	Estimate	Standard error	Significance
Intercept	-4.444	0.497	***
Sewer length (log)	0.825	0.037	***
Density combined PC1 (log)	0.099	0.009	***
Pumping capacity per sewer length (log)	0.431	0.059	***
Urban rainfall per sewer length (log)	0.118	0.039	***
Energy index (log)	0.132	0.051	**

Source: CMA analysis of Ofwat (2025) PR24 FD models data and ONS (2025) ASHE data.
*Note: *** indicates significance at the 1% level, ** at the 5% level, * at the 10% level. Standard errors not clustered or heteroskedasticity robust.*

Table D.6: Coefficients in the CMA's SWT model

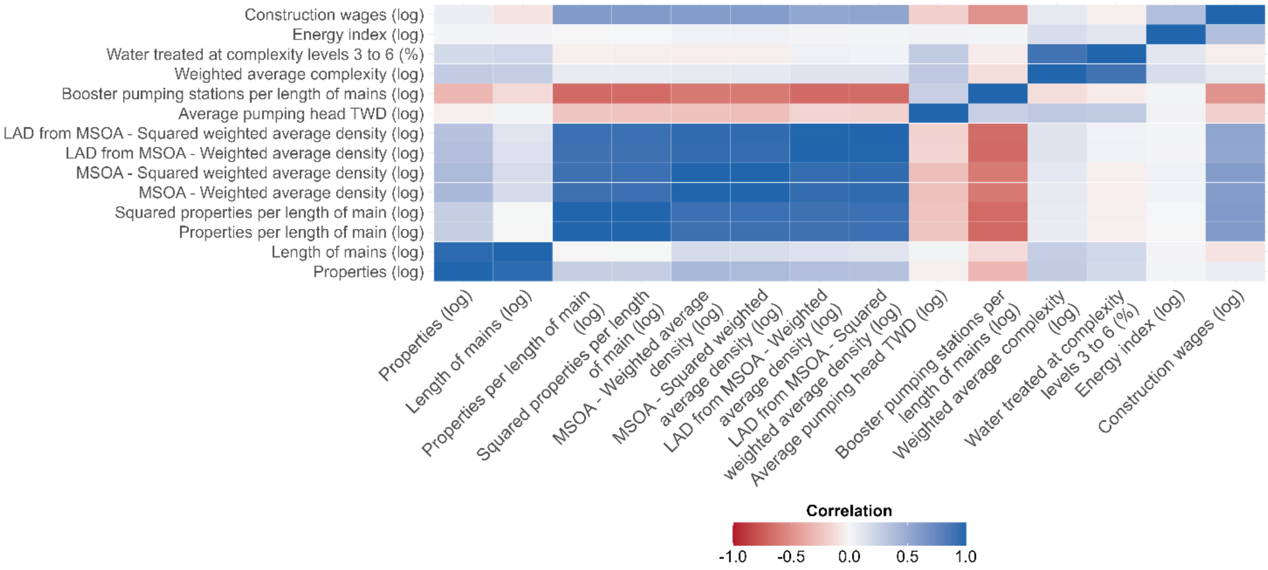
Cost drivers	Estimate	Standard error	Significance
Intercept	-5.316	0.870	***
Load (log)	0.843	0.043	***
Weighted average treatment size (log)	-0.215	0.022	***
Load treated with ammonia consent <3mg/l	0.004	0.001	***
Construction wages (log)	0.081	0.282	
Energy index (log)	0.281	0.060	***

Source: CMA analysis of Ofwat (2025) PR24 FD models data and ONS (2025) ASHE data.
*Note: *** indicates significance at the 1% level, ** at the 5% level, * at the 10% level. Standard errors not clustered or heteroskedasticity robust.*

Part F: Correlation between Ofwat cost drivers and input prices

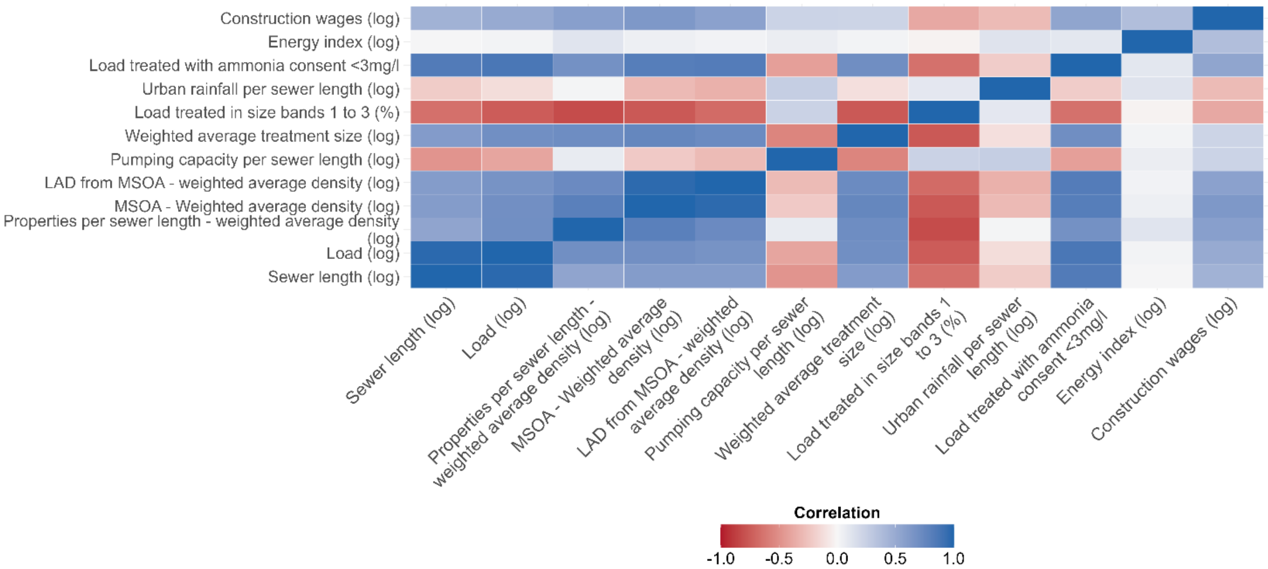
D.26 Figure D.1 and Figure D.2 below show the correlation between the cost drivers and input prices as they enter Ofwat's PR24 FD for wholesale water and wastewater cost models and the energy and regional wages indices added to the set of cost drivers in our updated approach. Red shaded cells indicate that the two corresponding cost drivers are negatively correlated and blue shaded cells that they are positively correlated. Darker colours show stronger correlation.

Figure D.1: Correlation between Ofwat wholesale water cost drivers and input prices



Source: CMA analysis of Ofwat (2025) PR24 FD models data and ONS (2025) ASHE data.

Figure D.2: Correlation between Ofwat wastewater cost drivers and input prices



Source: CMA analysis of Ofwat (2025) PR24 FD models data and ONS (2025) ASHE data.

Part G: Economies of scale at WTWs CAC

D.27 This section sets out our methodology and estimates for the CAC arising from economies of scale at WTWs. Consistent with Ofwat's approach, we use the water-WATS variable to capture scale effects. However, rather than estimating the CAC by comparing model allowances with and without the water-WATS variable, we adopt a two-stage estimation methodology. This approach isolates the incremental effect of economies-of-scale-related cost drivers, conditional on the factors already controlled for in the baseline WRP model.

D.28 We estimate economies of scale at WTWs using the following two-stage approach.

(a) In the first stage, we estimate the CMA's baseline WRP cost model estimated using LASSO (see Table D.4 above). For each company and financial year from 2011/12 to 2023/24, we calculate residuals from the WRP cost model. These residuals contain cost variation not explained by the baseline WRP model.[39]

(b) In the second stage, the WRP residuals from the first stage are regressed on:[40]

(i) the log of water-WATS;[41]

(ii) the log of connected properties;

[39] We estimate the post-LASSO cost model for bottom up WRP model: $\log C_{it} = \alpha + x_{it}^{\top}\beta + \log \varepsilon_{it}$, where x_{it} are the covariates selected by the LASSO. The corresponding fitted values are $\widehat{\log C_{it}} = \hat{\alpha} + x_{it}^{\top}\hat{\beta}$. The residuals are $\widehat{\varepsilon_{it}} = \log C_{it} - \widehat{\log C_{it}}$.
[40] We estimate the second-stage regression: $\widehat{\varepsilon_{it}} = \gamma_0 + z_{it}^{\top}\gamma_1 + u_{it}$, where z_{it} is log of water-WATS, log of connected properties, and their interaction.
[41] This variable was provided by company and financial year in Ofwat response to Ofwat RFI29, Q7, tab 'WATS input'.

(iii) their interaction; and

(iv) an intercept.

(c) Including treatment size tests whether operating smaller plants is associated with higher costs than operating larger plants. The properties variable and its interaction with treatment size allow for potential (dis)economies of scale linked to the network size.

D.29 Once estimated, we use the results from the second stage regression to predict incremental costs for each company in each year from 2025/26 to 2029/30 in 2022/23 prices.[42] The sum of incremental costs for each company is the economies of scale at WTWs CAC estimate.

D.30 Table D.7 below presents the results of regression from the second stage. All coefficients are statistically significant at the 1% level.[43] The coefficient on log water-WATS is negative, while the coefficient on the interaction between water-WATS and connected properties is positive.

Table D.7: Coefficients in the CMA's residual WRP model for economies of scale at WTWs

Cost Driver	Coefficient	Standard Error	Significance
Intercept	6.027	1.844	***
WTW Weighted average treatment size (log)	-1.829	0.515	***
Properties (log)	-0.403	0.128	***
WTW Weighted average treatment size (log) x Properties (log)	0.122	0.035	***

*Note: *** indicates significance at the 1% level, ** at the 5% level, * at the 10% level*
Source: CMA analysis of Ofwat (2025) PR24 FD models data, Ofwat response to Ofwat RFI29, Q7, tab 'WATS input', ONS (2025) ASHE data.

D.31 The negative coefficient on log water-WATS indicates that, conditional on the cost drivers included in the baseline WRP model, higher water-WATS is associated with lower total costs, consistent with economies of scale in treatment operations. The positive coefficient on the interaction between connected properties and water-WATS implies that the cost-reducing effect of increasing water-WATS diminishes as network scale increases. This is consistent with increasing operational or coordination complexity at larger network scale.

D.32 Finally, we use the results in Table D.7 above to estimate company-level economies of scale at WTW CACs. These are shown in Table D.8 below. The Disputing Companies with relatively smaller WTWs – South East, Southern, and Wessex – are estimated to incur higher costs, resulting in positive CACs of £17 million, £13.5 million, and £28 million respectively. In contrast, Anglian and Northumbrian, which operate larger and more efficient WTWs, are estimated to have negative CACs. Although South East operates smaller WTWs on average

[42] We calculate a CAC as $CAC_{it} = \left(\exp(\widehat{\gamma_0} + z_{it}^{\top}\widehat{\gamma_1}) - 1\right)\widehat{C_{it}}$, where $\hat{C}_{it} = \exp\left(\hat{\alpha} + x_{it}^{\top}\hat{\beta}\right)$ for the bottom-up WRP baseline model.
[43] We note with multiple variables the intercept is often hard to interpret. Its main role is to shift the model to the right level for the data, ensuring predictions are unbiased on average.

than Wessex, it receives a smaller proportionate increase, reflecting the larger number of connected properties it serves.

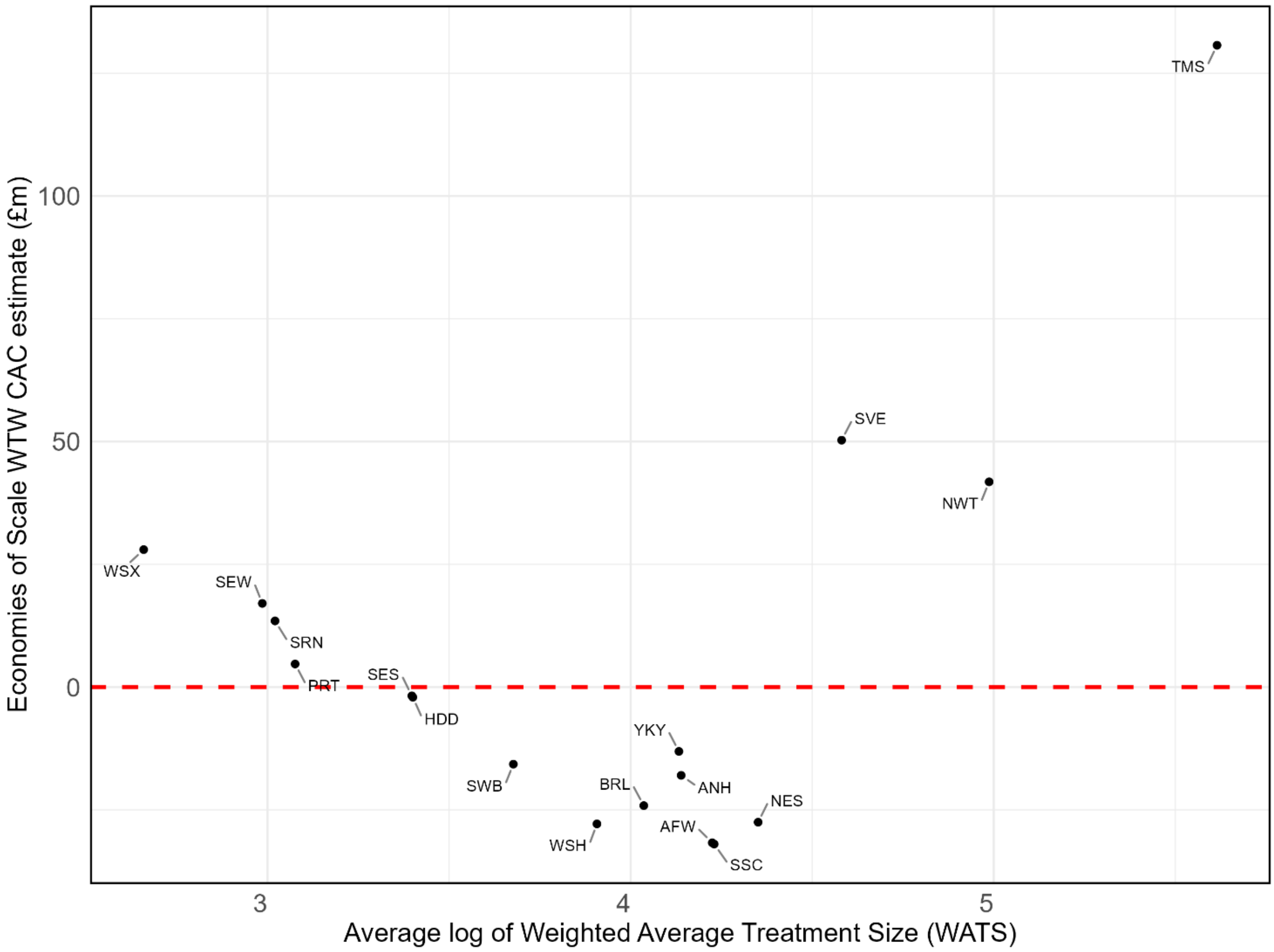
Table D.8: Economies of scale at WTWs cost adjustment claim by company

Company	Average WATS (2011-2024)	CAC estimate (£m)	% change to bottom-up costs	FD EoS at WTW CAC allowance (£m)
Anglian	55.5	-18.0	-1.9%	0.0
Northumbrian	81.1	-27.5	-4.1%	0.0
South East	12.6	17.0	4.7%	17.0
Southern	19.2	13.5	4.0%	13.5
Wessex	15.4	28.0	13.6%	28.0
All Disputing Companies	**36.7**	**13.0**	**0.5%**	58.5
Industry	**65.8**	**92.1**	**1.0%**	285.9

Source: CMA analysis of Ofwat (2025) PR24 FD models data, Ofwat response to Ofwat RFI29, Q7, tab 'WATS input', ONS (2025) ASHE data.

D.33 Figure D.3 below illustrates how the estimated CAC varies with water-WATS across companies. It shows that operating fewer, larger plants is generally associated with lower costs (eg Anglian or Northumbrian), whereas companies with very large network scale may face higher costs overall (eg Thames).

Figure D.3: Economies of scale at WTW CAC estimate by water-WATS



Source: CMA analysis of Ofwat (2025) PR24 FD models data, Ofwat response to Ofwat RFI29, Q7, tab 'WATS input', ONS (2025) ASHE data.

D.34 We considered alternative approaches including: (i) replacing the WRP baseline with the CMA's PR24 FD top-down wholesale water model; and (ii) using unweighted average treatment size (as used in CMA PR24 PD) in place of water-WATS. In both cases, we find the second stage regression coefficients are not statistically significant at the 10% level. We therefore rely only on the results of the second stage regression of residuals on log of water-WATS (and log of properties, and their interaction).

D.35 We apply the CAC asymmetrically for the reasons set out in chapter 4 (Base costs). Positive CACs are granted to South East, Southern, and Wessex, but we do not reduce base cost allowances for Anglian or Northumbrian.

Part H: Coastal CAC

D.36 This section sets out our methodology and estimates for the CAC arising from coastal processes.

D.37 We construct the percentage coastal load variable using Ofwat published data on large STWs for each wastewater company for the financial years between 2011/12 and 2023/24.[44] We allocate each large STW to coastal or inland using Ofwat's STW to coastal lookup.[45] We keep only STWs that are considered coastal, and aggregate their load by company and financial year to calculate coastal load. We assume costal load between 2024/25 and 2029/30 remains fixed at 2023/24 levels. We consider that this is reasonable given the historical stability of the variable.[46] Coastal load is divided by total load (from Ofwat's cost dataset) to derive percentage coastal load.[47]

D.38 We estimate the coastal processes CAC using the following two-stage approach.

(a) In the first stage, we estimate the CMA's baseline SWT cost model estimated using LASSO (see paragraph D.25) For each company and financial year from 2011/12 to 2023/24, we calculate residuals using the SWT model.

[44] Ofwat (2024) Large Sewage Treatment Works (STWs) dataset version 4.1.
[45] Ofwat (2025), Response to SoC, supporting document 'RtSoC CMA Source Databook', tab '10. Figure 14'. There were 17 STWs missing from the lookup. We consider Southern's Sidlesham WTW and United Utilities' Morecambe WWTW to be coastal. We assume the remaining 15 are inland: Belmont STW; Dambridge Wingham WTW; Belper STW; Packington STW; Brentwood; High Wycombe; Reigate; Darwen WWTW; Kidsgrove WWTW; Penrith WWTW; Royton WWTW; Bath (Saltford); Dronfield STW; Salterhebble STW; and Bridgewater.
[46] We note Northumbrian increases its coastal load materially for 3 STWs in 2021/22: Bran Sands Domestic; Hendon; and Seaton Carew Domestic. This was caused by a change in reporting methodology in estimating coastal load, changing from estimated to measured coastal load from 2021/22 onwards. Joint Northumbrian and Ofwat response to Northumbrian and Ofwat RFI01, paragraph 4. Northumbrian notes that this data would be less comparable to other STWs, however, in the absence of alternative evidence, we consider this data to be the best available information on coastal load.
[47] We note percentage coastal load is correlated with existing SWT cost drivers. The R-squared estimated from regressing percentage coastal load on existing regressors in the baseline SWT model is 0.65. This suggests that a portion of the variance in percentage coastal load is explained by the selected regressors in the SWT model.

These residuals contain cost variation not explained by the baseline SWT model.[48]

(b) In the second stage, the SWT residuals are regressed on:[49]

(i) percentage coastal load; and

(ii) an intercept.

D.39 Once estimated, we use the results from the second stage regression to predict incremental costs for each company in each year from 2025/26 to 2029/30.[50] The sum of incremental costs for each company is the coastal CAC estimate.

D.40 This approach isolates the effect of coastal processing related cost-drivers, conditional on all other cost drivers already controlled for in the baseline SWT model. To the extent that coastal processing is not fully captured by the baseline cost drivers, their effects are reflected in systematic residual cost variation associated with coastal load.

D.41 Table D.9 below presents the results of the residual regression from the second stage. The percentage of coastal load coefficient is positive and statistically significant at the 1% level. This is consistent with economic and engineering expectations that coastal processing increases costs. The intercept is negative and statistically significant at the 1% level, indicating that the baseline SWT model overestimates costs for a company with 0% coastal load (ie Thames, Severn Trent).

Table D.9: Coefficients in the CMA's residual STW model for coastal CAC

Residual Cost Driver	Coefficient	Standard Error	Significance
Intercept	-0.063	0.019	***
Percentage coastal load	0.226	0.064	***

*Note: *** indicates significance at the 1% level, ** at the 5% level, * at the 10% level*
Source: CMA analysis of Ofwat (2025) PR24 FD models data, Ofwat (2024) Large Sewage Treatment Works (STWs) dataset version 4.1, Ofwat (2025), Response to SoC, supporting document 'RtSoC CMA Source Databook', tab '10. Figure 14', and ONS (2025) ASHE data.

D.42 Finally, we use the results in Table D.9 above to estimate company-level coastal CACs. These are shown in Table D.10 below. The Disputing Companies with relatively higher percentage coastal load (more than 35%) – Northumbrian, Southern, and Wessex – are estimated to incur higher costs, resulting in positive CACs of £13.2 million, £56.8 million, and £14.8 million respectively. Anglian has a relatively lower percentage coastal load (less than 16%) and the SWT model overestimates the cost allowance by £37.2 million.

[48] We estimate the post-LASSO cost model for bottom up SWT model: $\log C_{it} = \alpha + x_{it}^{\top}\beta + \varepsilon_{it}$, where x_{it} are the covariates selected by the LASSO. The corresponding fitted values are $\widehat{\log C_{it}} = \hat{\alpha} + x_{it}^{\top}\hat{\beta}$. The residuals are $\widehat{\varepsilon_{it}} = \log C_{it} - \widehat{\log C_{it}}$.
[49] We estimate the second-stage regression: $\widehat{\varepsilon_{it}} = \gamma_0 + z_{it}^{\top}\gamma_1 + u_{it}$, where z_{it} is % costal load.
[50] We calculate the coastal CAC as $CAC_{it} = \left(\exp(\widehat{\gamma_0} + z_{it}^{\top}\widehat{\gamma_1}) - 1\right)\widehat{C_{it}}$, where $\hat{C}_{it} = \exp\left(\hat{\alpha} + x_{it}^{\top}\hat{\beta}\right)$ for the bottom-up SWT baseline model.

Table D.10: Coastal CAC cost adjustment claim by company

Company	Average % Coastal Load (2011-2024)	Coastal CAC estimate (£m)	% change to bottom-up costs	FD Coastal CAC allowance (£m)
Anglian	15.9%	-37.2	-3.0%	0
Northumbrian	36.8%	13.2	3.2%	13.2
Southern	58.7%	56.8	6.6%	56.8
Wessex	41.3%	14.8	2.9%	14.8
All Disputing Companies	38.2%	47.6	1.6%	84.8
Industry	27.8%	-162.1	-1.7%	129.0

Sources: CMA analysis of Ofwat (2025) PR24 FD models data, Ofwat (2024) Large Sewage Treatment Works (STWs) dataset version 4.1, Ofwat Response supporting document 'RtSoC CMA Source Databook', tab '10. Figure 14', and ONS (2025) ASHE data.

D.43 We considered alternative approaches using the following.

(a) A different first-stage model. We estimate the residuals based on the CMA's top-down model rather than the SWT model. In this case, we find that the second stage regression coefficients are not statistically significant at least at the 10% level. We therefore do not rely on this specification in estimating the CAC.

(b) Percentage coastal population instead of percentage coastal load in the second stage regression. This regression shows that the coefficient on percentage coastal population is statistically significant at the 1% level. While this specification is econometrically plausible, it does not improve model performance in terms of the R-squared and statistical significance, and we find percentage coastal load has a better economic and engineering justification. In qualitative terms, the resulting CACs are similar to our preferred specification.[51]

D.44 We apply the CAC asymmetrically for the reasons set out in chapter 4 (Base costs). Positive CACs are granted to Northumbrian, Southern, and Wessex, but we do not reduce Anglian's base cost allowance.

[51] Using coastal population instead of percentage coastal load in the second stage regression estimates CACs of £6.6 million for Northumbrian, £56.3 million for Southern and £5.5 million for Wessex. Relative to the baseline coastal load CAC estimate, these CACs are 50% lower, 1% lower, and 62.9% lower for Northumbrian, Southern and Wessex, respectively. This reason for the larger percentage drop for Northumbrian and Wessex is because their percentage coastal population is materially lower relative to percentage coastal load. Anglian's CAC estimate remains negative at -£31.3 million and therefore would have no coastal CAC adjustment applied.

Appendix E: Enhancement Expenditure – Econometric Benchmark Modelling

E.1 In this Appendix E we describe the CMA's assessment of the phosphorus econometric modelling (Part A below) and supply interconnectors econometric modelling (Part B below). Within each of Part A and Part B, we also describe how these models should be used to set non-delivery PCDs.

Part A: Phosphorus

E.2 Part A of this Appendix E provides a technical overview of the specification of our p-removal cost model. The Gaussian Mixture Regression model (**GMR**) we used to model p-removal enhancement scheme costs in our CMA PR24 PD is retained for our CMA PR24 FD. The description of the model, the approach to estimation, its specification, and its estimated parameters are, therefore, unchanged from the CMA PR24 PD.

E.3 As noted in chapter 5 (Enhancement costs), for the purposes of the CMA PR24 FD we have amended how we use the model's output to predict each AMP8 p-removal scheme's totex. The technical details of the new probability-weighted predicted totex are described in section A.6 below.

E.4 In section A.7 below, we describe additional quantitative analysis conducted for the purposes of our CMA PR24 FD that shows the stated solution type can help predict the group the scheme most likely belongs to. This supports a view that the cost groupings capture meaningful engineering and economic differences rather than being purely statistical in nature.

E.5 Finally, in section A.9 below, we describe how our CMA PR24 FD model can be used to compute updated modelled allowances, where there are changes in scheme scope, for the purpose of updating non-delivery PCDs.

A.1: CMA model overview

E.6 Our GMR can be expressed mathematically as follows.

$$\ln L(\beta, \sigma, \lambda) = \frac{1}{N}\sum_{n=1}^{N} \ln \sum_{g=1}^{G} \lambda_g N(y_n \mid x_n' \beta_g, \sigma_g^2)$$

Where:

(a) $L(\beta, \sigma, \lambda)$ is the likelihood function.

(b) y_n is a transformation of scheme n's totex and x_n is the vector of transformed cost drivers for schemes included in the model. There are N schemes in total.

(i) There are G Gaussian components - or groups - in the model.

(ii) Each group, g, has errors are assumed to follow a Normal distribution whose mean is zero and standard deviation is σ_g.

(c) λ_g is the mixing coefficient for the g-th group that estimates the proportion of schemes in the sample that belong to group g, where $\sum_{g=1}^{G} \lambda_g = 1$.

(d) $N(y_g \mid x'_n\beta_g, \sigma_g^2)$ is the probability density function of the Gaussian distribution for the g-th component, defined as:

$$N(y_n \mid x'_n\beta_g, \sigma_g^2) = \frac{1}{\sqrt{(2\pi)}\sigma_g} \exp\left(-\frac{\left(y_n - x'_n\beta_g\right)^2}{2\sigma_g^2}\right)$$

E.7 We transform scheme totex using the inverse hyperbolic sine transformation ($asinh$) used to better visualise model output in the figures in chapter 5 (Enhancement costs). As noted above, the same transformation is applied to continuous cost drivers. These include:

(a) the size of the population served by the scheme;

(b) the 'enhanced consent' level (ie the phosphorus reduction target measured in mg/l);

(c) the change in permit consent-level associated with the scheme;

(d) variables measuring heterogeneity in local population density; and

(e) average hourly median construction wages in the area operated by each firm.

E.8 In addition, the expected increase in future costs affecting all firms' totex forecasts over the next price control enters as a dummy variable.

A.2: Estimation

E.9 As noted in chapter 5 (Enhancement costs), our model is estimated on the combined historical and forecast data (ie pooled data). Prior to estimation we exclude some, but not all, schemes Ofwat identified as statistical outliers in its PR24 FD. The subset of schemes excluded from our estimation sample as outliers corresponds to the top 1.5% most expensive schemes and tend to be considerably larger than other schemes. Almost all these excluded schemes for our model are the statistical outliers that were awarded non-zero cost recovery ratios through deep dives by Ofwat in its PR24 FD.[52]

[52] Ofwat classifies almost all the excluded schemes to be 'inefficient' outliers because their requested amounts are substantially higher than the modelled amount in their forecast models. Ofwat award these 'inefficient' outliers a positive fraction of the cost gap when modelled totex is less that requested totex. The portion of this cost gap – the cost recovery rate – is set by Ofwat in its deep dives. The median and modal cost recovery rate for most expensive inefficient schemes is 75% and results in the average of these inefficient schemes being awarded 85% of its requested costs. The one exception among the top 1.5% most expensive schemes is a Severn Trent scheme, Strongford STW. Ofwat classified this scheme as an 'efficient' statistical outlier because its modelled allowance in their forecast models was higher than the requested amount. As an efficient statistical outlier, Ofwat assigned the Strongford STW scheme a 0% cost recovery rate and sets the awarded allowance equal to the request if the modelled allowance is greater than the requested

E.10 To estimate the model's parameters, we maximise the log-likelihood described above using an EM algorithm. To implement the EM algorithm, we use the 'mixtools' package in R. The standard errors are computed using a bootstrap. Specifically, they are calculated using the standard deviation of the sample of parameter values resulting from 1,000 bootstrap iterations.

A.3: Model Specification

E.11 In arriving at our preferred model, we considered four different specifications of the model. Each specification included a different set of cost drivers, as follows.

(a) **Model A** includes population served, the change in the permit level, and the new permit level. We also include a dummy variable that takes the value 1 if it is a new scheme (ie from forecast data) and is 0 otherwise.

(b) **Model B** is the same as model A but includes a variable controlling for the population density typically served by each company.[53]

(c) **Model C** is the same as model A but includes a variable measuring the average hourly median construction wages in the area operated by each company in each price control period.[54]

(d) **Model D** is the same as model A but includes both the average wage and population density variables from models B and C.

A.4: Model Selection

E.12 For each model, we estimate the GMR model assuming that there are 2, 3 or 4 mixture components (groups). We use the Bayesian Information Criterion (**BIC**) to choose the number of groups. The BIC trades off the fit of the model with a penalty that is increasing in the number of parameters in the model. For a given cost

amount. Therefore, for its two forecast models (PR1 and PR2), Strongford STW receives its requested amount. However, when evaluated using the model fitted on historical data, its modelled allowance is smaller than the requested and there is a positive cost gap. When the outcomes of the outlier adjusted models are averaged, Strongford STW only recovers 73% of its requested allowance. This is a lower proportion than the average inefficient outlier in the top 1.5% most expensive schemes – arguably a counterintuitive outcome for an efficient outlier. Since we are not re-determining Severn Trent's p-removal allowances we do not revisit the outcome of Ofwat's deep dive. However, we note that it would be necessary to award a positive cost recovery rate to ensure it is not notably worse off relative to similarly expensive inefficient statistical outliers. As such, we treat all the top 1.5% of most expensive schemes as statistical outliers for the purpose of our modelling. Ofwat (2025) PR24-FD-CA60 Wastewater – p removal: enhancement expenditure model.

[53] This variable is added by Thames Investor Group's advisers Compass Lexecon in its analysis of Ofwat's p-removal models. Compass Lexecon motivated its inclusion by noting its importance for base models and stating that the cost of building additional capacity at a sewage treatment works can depend on how rural or urban the site is. Compass Lexecon used the MSOA-weighted average density for each company averaged over AMP7 for historical schemes and averaged over AMP8 for forecast schemes. Compass Lexecon also demonstrated that when added to Ofwat's models there is a considerable increase in the R-squared values – especially for AMP8 schemes. See Thames Investor Group (2025) Third party submission on the Water PR24 References, Annex 4: Compass Lexecon (2025) Third-party submission on behalf of Investor Group, p50, paragraphs 4.41–4.43.

[54] As a risk protection measure, Ofwat has put in place an RPE and an ex-post 'true-up' using construction labour costs for enhancement expenditure. In line with this approach and noting that construction wages are likely to vary geographically and affect build costs, we consider that there is a clear economic and engineering rationale to include regional construction labour costs in its modelling. Wage data is constructed from median construction ONS ASHE wage data for differing regions in England. See chapter 4 (Base costs), paragraph 4.104.

model specification, the number of groups chosen is the one that results in the lowest value of the BIC.

E.13 Table E.1 below shows the BIC scores for each of the models assuming that there are 2, 3 or 4 groups. For each model, the lowest BIC score is achieved with 3 groups. Across the groups, model D always has the lowest BIC score. This suggests that the inclusion of regional construction wages and a measure of local population density both lead to significantly improved model fit. As such, model D with 3 groups is our preferred model.

Table E.1: BIC scores for models A, B, C and D

Number of Groups	Model A	Model B	Model C	Model D
G=2	2,541.8	2,398.7	2,545.8	2,351.8
G=3	2,498.7	2,333.1	2,499.3	2,269.1
G=4	2,563.4	2,432.1	2,581.0	2,390.3

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.

A.5: Model Results

E.14 Table E.2 below shows the estimated parameters of the 4 models with 3 groups. It shows that the coefficients on the transformed cost drivers and the forecast scheme dummy included in model A (and Ofwat's models) have the expected sign and are relatively stable within groups across models. However, the magnitude of their coefficients differs across groups. This suggests that the model is grouping together different types of schemes with different relationships between cost and cost drivers.

(a) **Group 1**: Compared to the other groups, the larger the gap between the existing and new permit levels, the higher the costs for schemes in group 1. Their costs also increase when the new permit level is tighter, though to a lesser extent than schemes in group 2. Unlike schemes in the other two groups, the size of the population does not appear to be a particularly prominent cost driver. Finally, the coefficient on the forecast indicator shows that otherwise similar schemes are expected to be moderately more expensive in AMP8.

(b) **Group 2**: The introduction of new tighter permits also appears to lead to appreciably higher costs for schemes in group 2 – more so than for schemes in other groups. Schemes costs are also higher when the change in consent level increases and when serving larger populations – though to a lesser extent than schemes in groups 1 and 3, respectively. Finally, it appears that schemes in this group might be especially sensitive to expected supply chain cost pressures.

(c) **Group 3**: The size of the population served appears to be a key cost driver for group 3 schemes. Moreover, the effect of introducing new tighter permits also appears to lead to higher scheme costs – though to a lesser degree than schemes in groups 1 and 2. However, unlike the other two groups, the change in consent level is generally statistically insignificant (at the 10% level) and does not appear to be a key cost driver for schemes in group 3. Finally, the costs associated with forecast schemes are typically higher – though only once wage and population density are controlled for.

E.15 As noted above, models B, C and D differ from model A due to the inclusion of one or both of local population density and regional construction wages. Once included in model B, the coefficient of the population density is, as expected, positive, statistically significant at the 1% level and is stable across groups. The coefficient of regional construction wages introduced in model C is, as expected, positive but only statistically significant at the 1% level in group 2 and at the 10% level in group 3.

E.16 However, when both population and regional construction wages are controlled for in model D, the coefficient on wages becomes negative and large – particularly for groups 2 and 3. At the same time, the intercept in these two groups is larger than in the other models. Noting that the measures of construction wages and population density that enter the model are strongly positively correlated (their correlation is 0.72), one possible explanation for the counter intuitive sign on wages and the increase in the intercept is multicollinearity.

E.17 To explore whether multicollinearity is a likely explanation for the changes in the intercept, wage, and population density coefficients in model D we extract the principal components of the wage and population density data. By construction, the principal components of two variables, PC1 and PC2, capture their covariance by identifying the directions in which the data varies the most. These principal components are also uncorrelated with each other and do not, therefore, suffer from multicollinearity. Their inclusion in model E in place of the original variables allows us to explore the effect of multicollinearity on the estimated parameters in model D.

E.18 Even though the signs and magnitudes of coefficients on the principal components are difficult to directly interpret, we can assess the effect they have on scheme totex by comparing them across groups. Compared to model D, the results for model E in Table E.2 below show that replacing the original variables with their principal components exhibits the following features.

(a) The coefficients on PC1 and PC2 across models are much more stable. For example, both principal components are statistically significant at (at least) the 10% level in groups 1 and 2 and have similar coefficient values – though the coefficients are slightly closer to zero for group 1 schemes.

(b) Only PC2 is statistically significant at the 1% level in group 3, but both wage and population density are in group 3 of model D. This suggests that the high statistical significance of both original variables in model D was largely driven by a shared correlation between them. As a result, the coefficients become considerably larger in opposing directions and the intercept term adjusts accordingly.

(c) The intercept term in group 2 in model E is also much lower than model D and more comparable to the other model's intercepts. This indicates that multicollinearity may also be affecting group 2's parameters, but in a less pronounced way than in group 3.

Table E.2: Model results with 3 groups – Models A, B, C, D and E

Dep var: asinh(totex)	Group 1					Group 2					Group 3				
Variables	**Model A**	**Model B**	**Model C**	**Model D**	**Model E**	**Model A**	**Model B**	**Model C**	**Model D**	**Model E**	**Model A**	**Model B**	**Model C**	**Model D**	**Model E**
Intercept	0.315*	-0.706**	-2.982	1.721	0.190	1.181***	0.347**	-3.949**	4.271**	1.551***	1.825***	1.102***	-1.378	23.274***	1.919***
	(0.184)	(0.296)	(2.574)	(3.462)	(0.201)	(0.122)	(0.152)	(1.585)	(1.882)	(0.107)	(0.130)	(0.204)	(1.818)	(1.938)	(0.112)
asinh(population-equivalent served)	-0.073**	-0.072**	-0.069**	-0.043	-0.043	0.183***	0.171***	0.196***	0.144***	0.144***	0.305***	0.297***	0.303***	0.273***	0.273***
	(0.031)	(0.031)	(0.031)	(0.033)	(0.033)	(0.019)	(0.016)	(0.019)	(0.017)	(0.017)	(0.020)	(0.021)	(0.020)	(0.017)	(0.017)
asinh(Consent Change)	0.677***	0.739***	0.702***	0.681***	0.681***	0.251***	0.187***	0.245***	0.163***	0.163***	0.059	0.000	0.046	0.008	0.008
	(0.060)	(0.065)	(0.062)	(0.065)	(0.065)	(0.042)	(0.038)	(0.043)	(0.037)	(0.037)	(0.043)	(0.046)	(0.045)	(0.037)	(0.037)
asinh(Enhanced Consent)	-0.682***	-0.633**	-0.666***	-0.614**	-0.614**	-0.973***	-0.938***	-0.896***	-1.014***	-1.014***	-0.457***	-0.287***	-0.400***	-0.449***	-0.449***
	(0.190)	(0.209)	(0.195)	(0.208)	(0.208)	(0.098)	(0.085)	(0.095)	(0.089)	(0.089)	(0.098)	(0.100)	(0.096)	(0.085)	(0.085)
1[New Scheme in forecast data]	0.269***	0.267***	0.226***	0.347***	0.347***	0.578***	0.536***	0.536***	0.488***	0.488***	0.142**	-0.007	0.067	0.292***	0.292***
	(0.086)	(0.090)	(0.092)	(0.096)	(0.096)	(0.058)	(0.051)	(0.061)	(0.051)	(0.051)	(0.060)	(0.063)	(0.065)	(0.051)	(0.051)
asinh(MSOA Density)		0.556***		0.523***			0.591***		0.787***			0.470***		1.253***	
		(0.129)		(0.178)			(0.067)		(0.093)			(0.096)		(0.108)	
asinh(Hourly Construction Wage)			0.923	-0.685				1.438***	-1.149**				0.916*	-6.654***	
			(0.719)	(1.028)				(0.444)	(0.554)				(0.507)	(0.570)	
asinh of density and wage: PC1					-0.120***					-0.175***					-0.030
					(0.043)					(0.025)					(0.031)
asinh of density and wage: PC2					0.191*					0.294***					0.716***
					(0.097)					(0.050)					(0.054)
λ_g: group g share	0.155***	0.158***	0.157***	0.154***	0.154***	0.467***	0.511***	0.476***	0.508***	0.508***	0.378***	0.332***	0.367***	0.338***	0.338***
	(0.020)	(0.018)	(0.019)	(0.020)	(0.020)	(0.047)	(0.042)	(0.046)	(0.036)	(0.036)	(0.045)	(0.040)	(0.044)	(0.033)	(0.033)
σ_g : group g sd.	0.357***	0.364***	0.360***	0.382***	0.382***	0.384***	0.374***	0.380***	0.374***	0.374***	0.403***	0.374***	0.397***	0.314***	0.314***
	(0.035)	(0.034)	(0.035)	(0.038)	(0.038)	(0.027)	(0.021)	(0.025)	(0.020)	(0.020)	(0.027)	(0.027)	(0.028)	(0.020)	(0.020)
Number of Observations	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378

**** indicates significance at 1% level, ** at 5% level, * at 10% level*
Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

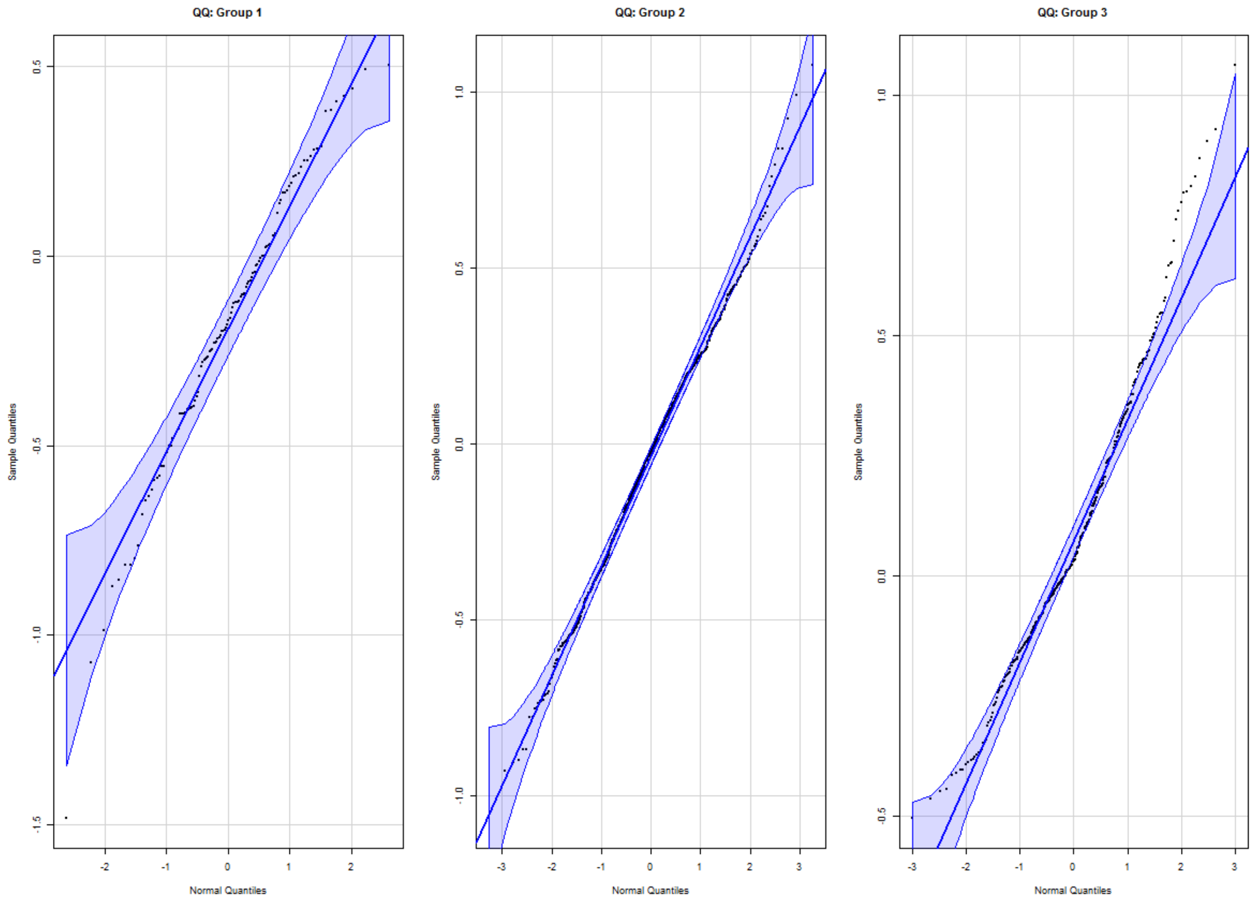
E.19 The above analysis suggests that the counterintuitive signs on wages in model D are likely to be the result of multicollinearity, rather than model misspecification. Since multicollinearity, unlike model misspecification, does not affect the in-sample model predictions, we consider that model D – with the lowest BIC score – is best suited to use to set p-removal enhancement allowances.

E.20 Finally, as a cross-check on the implicit assumption that the errors of the GMR are normally distributed, we visually compare the distribution of model errors to a normal distribution in Figure E.1 below.[55] The figure contains three Q-Q charts. Each chart plots each scheme's modelled residual in the group it has the highest probability of belonging to against a theoretical normal distribution as a 'dot'. If, in each chart, the dots fall along the straight diagonal line, the data are close to normal. If the dots bend away from the line, especially in the corners, it shows that the data are skewed or have heavier tails than a normal distribution.

E.21 From left to right, the figure contains a Q-Q plot for group 1, 2, and then 3, respectively. Except for a handful of schemes in group 3, almost all scheme's 'dots' are covered by, or are adjacent to, the blue band representing a 95% confidence interval for normal distribution.

[55] A Q-Q plot compares the model residuals to a normal distribution. If the dots fall along the straight diagonal line, the data are close to normal. If the dots bend away from the line, especially in the corners, it shows that the data are skewed or have heavier tails than a normal distribution.

Figure E.1: Q-Q plots of model errors for schemes in each of the groups they have the highest probability of belonging to



Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.

A.6: Probability-weighted predicted scheme totex

E.22 To calculate our posterior probability-weighted predicted scheme totex, we first transform each scheme's predicted totex for each component back to £ million. In doing this, we apply an adjustment to account for the non-linear transformation used. We then construct a weighted average of each scheme's predicted totex, using the prediction from each group weighted by the posterior probability of the scheme belonging to the respective group.

E.23 The probability-weighted totex for each scheme can be expressed as follows:

$$TOTEX_n = \sum_{g=1}^{3} \Pr\left(n \in \mathcal{G}_g | x_n, \hat{\theta}\right) \widehat{TOTEX}_{ng}$$

where:

(a) $\mathcal{G}_g$ is the set of all schemes in group g;

(b) $\hat{\theta} := \{\hat{\theta}_1, \hat{\theta}_2, \hat{\theta}_3\}$ is the set of all estimated parameters and $\hat{\theta}_g \coloneqq (\hat{\beta}_g, \hat{\sigma}_g, \hat{\lambda}_g)$ is the vector of estimated parameters in group g;

(c) The posterior probability of scheme n with characteristics x_n belonging to group g is:

$$\Pr(n \in \mathcal{G}_g | x_n, \hat{\theta}) = \frac{\hat{\lambda}_g N(y_n \mid x_n' \hat{\beta}_g, \hat{\sigma}_g^2)}{\sum_{k=1}^{3} \hat{\lambda}_k N(y_n \mid x_n' \hat{\beta}_k, \hat{\sigma}_k^2)}$$

(d) $\widehat{TOTEX}_{ng}$ is the expected value of scheme n's totex in £ million in group g and is calculated as:

$$\widehat{TOTEX}_{ng} = E[TOTEX_n | n \in \mathcal{G}_g] = \sinh(x_n' \hat{\beta}_g) \exp\left(\frac{\hat{\sigma}_g^2}{2}\right)$$

A.7: GMR groupings and solution type choices

E.24 The GMR groupings are intended to capture economically meaningful heterogeneity across schemes that is not observed in the cost data. One potential source of such heterogeneity is solution type, which refers to the treatment approach adopted by a scheme (eg chemical or biological treatment). Solution type is likely to be an important cost driver but was not included in the GMR estimation because it is not observed for historical schemes.

E.25 Solution type is, however, available for forecast schemes. This allows us to test whether the GMR groupings capture differences in treatment approach. Specifically, if solution type helps predict which GMR group a scheme is assigned to, this suggests the groupings reflect (at least partly) engineering-relevant heterogeneity, rather than being purely statistical constructs with no engineering rationale. Conversely, if GMR groups were driven primarily by inefficiency or arbitrary cost inflation by companies, then knowing a scheme's solution type would not help predict which group it belongs to. We test this empirically by examining whether solution type predicts GMR group membership.

E.26 Each scheme is assigned to 1 of the following 8 categories:

(a) chemical treatment only;

(b) combined chemical and CNB;

(c) combined chemical and nature-based;

(d) biological treatment only;

(e) combined chemical and biological;

(f) combined biological and nature-based;

(g) pump away;[56] and

[56] The 'pump away' category does not appear in the sample used.

(h) other.[57]

E.27 We test whether GMR group assignment reflects heterogeneity associated with solution type by modelling its posterior probabilities. Specifically, for each scheme *n* we use the posterior probability vector across the three groups obtained from the GMR model (ie $\Pr\left(n \in \mathcal{G}_1 | x_n, \hat{\theta}\right), \Pr\left(n \in \mathcal{G}_2 | x_n, \hat{\theta}\right), \text{and } \Pr\left(n \in \mathcal{G}_3 | x_n, \hat{\theta}\right)$).

E.28 Since the three posterior probabilities sum to one by construction, the outcome is compositional. We therefore apply two complementary methods that are appropriate for this data structure:[58]

(a) Additive Log-Ratio regressions, which transform the compositional outcome into log-ratios of group membership probabilities by expressing each component relative to a reference group;[59] and

(b) Dirichlet regression, which models the full vector of posterior probabilities jointly as a function of solution type.

E.29 For both methods, we conduct two complementary tests. First, we compare an intercept-only specification with a model including solution type as the sole predictor. This provides an unconditional test of whether knowing a scheme's treatment technology helps predict which cost group it was assigned to.

E.30 In the second test, we compare a baseline model including only observed cost drivers (PE served, consent change, enhanced consent, density, and construction wages) with an augmented specification that additionally includes solution type. This is a stricter test: if solution type retains explanatory power after controlling for the observed cost drivers, it implies that solution type explains variation in group membership beyond what is captured by observable scheme characteristics alone.

E.31 In both cases, because the augmented model nests the baseline, we measure the incremental explanatory power of solution type using the following tests.

(a) Likelihood Ratio (**LR**), which tests whether solution type adds statistically significant explanatory power. The LR statistic is asymptotically chi-squared, with degrees of freedom equal to the number of additional parameters in the augmented model. A large LR statistic (small p-value) indicates that the

[57] Ofwat's solution-type data is granular, with some categories containing very few schemes (for example, the BIO-ASP category includes only two observations). We therefore asked WRc to consolidate, where feasible, Ofwat's categories into a smaller number of technically meaningful groups. WRc provided the mapping used to define the 8 groups listed in paragraph E.26 above. The number of observations in each group is as follows: chemical only (545); biological only (21); combined chemical and biological (6); combined chemical and nature-based (16); combined chemical and CNB (11); and other (169). In robustness checks, we also tested an alternative grouping approach in which all combined treatment categories (ie combined chemical and biological, combined chemical and nature-based, and combined chemical and CNB) are consolidated into a single 'Combined' category (33 observations), to confirm that the results are not sensitive to the specific consolidation adopted.

[58] Standard regression methods such as OLS are inappropriate because they ignore the sum-to-one constraint, treating each posterior probability as an independent outcome when in fact a shift in one component must be offset by an equal and opposite shift in the others.

[59] Specifically, we use three pairwise log-ratios: log(Pr(group 1)/Pr(group 3)), log(Pr(group 2)/Pr(group 3)), and log(Pr(group 1)/Pr(group 2)). Each log-ratio is then regressed on solution type using OLS.

augmented model fits significantly better and that the additional variables are jointly significant.

(b) Akaike Information Criterion (**AIC**), which is a model selection criterion that rewards goodness of fit while penalising model complexity. Because each additional parameter incurs a complexity penalty, AIC falls only when the improvement in fit outweighs the cost of adding that parameter. A lower AIC in the augmented model therefore provides evidence of an increase in explanatory power, rather than simply improved fit through the addition of more parameters.

E.32 We find that adding solution type produces a substantial and statistically significant improvement in model performance for both methods. In the Additive Log-Ratio regressions, solution type significantly predicts group membership relative to an intercept-only model. AIC decreases in all 3 pairwise comparisons, and LR tests are significant at the 1% level: group 1 vs 3 (LR=33.2, ΔAIC=-23.2), group 2 vs 3 (LR=19.2, ΔAIC=-9.2), and group 1 vs 2 (LR=40.2, ΔAIC=-30.2).

E.33 After controlling for observed cost drivers, solution type remains statistically significant across all 3 pairwise comparisons — group 1 vs 3 (LR = 27.4, ΔAIC = −17.4), group 2 vs. 3 (LR = 17.2, ΔAIC = −7.2), and group 1 vs. 2 (LR = 32.0, ΔAIC = −22.0) — all at the 1% level, indicating that solution type explains residual variation in group membership beyond observable cost drivers.

E.34 The Dirichlet regression, which has the advantage of jointly modelling the full posterior probability vector simultaneously rather than through pairwise comparisons, yields an LR statistic of 173.9, significant at the 1% level, with an AIC reduction of 143.9 points, indicating that solution type significantly predicts the posterior group membership probabilities. This result holds after controlling for observed cost drivers (LR=132.3, $p<0.01$; ΔAIC=-102.3), suggesting that solution type retains substantial explanatory power over group membership beyond observed cost drivers. This is consistent with the GMR capturing unobserved heterogeneity in costs that is correlated with treatment technology and cannot be explained by scheme characteristics alone.[60]

E.35 Together, these results provide evidence consistent with the GMR groupings capturing heterogeneity associated with solution type choices and therefore reflecting meaningful engineering and economic differences across schemes, rather than being purely statistical groupings.

A.8: Future forecast cost pressure pass-through uncertainty

E.36 In this section we use simple regression analysis to test the hypothesis that companies have a common view of the effect of expected increases in input cost

[60] Results are robust to the alternative categorisation described above in footnote 57 above. When all combined treatment types are consolidated into a single ‘Combined’ category (33 observations), the LR tests continue to reject the null hypothesis of no explanatory power of solution type, and the models including solution type continue to exhibit a reduction in AIC relative to the corresponding baseline specifications.

over 2025 to 2030 on the totex needed to implement AMP8 p-removal schemes. To implement this test we choose one of Ofwat's p-removal cost model specifications (PR1 and PR3), extend it, and estimate on a pooled data set including all historical and forecast schemes.

E.37 Table E.3 below shows the regression results of two extensions of Ofwat's models (PR1 and PR3). The rightmost column, the 'full model', extends Ofwat's model to include company fixed effects, a forecast dummy, and their interactions. The second column is a restricted version of the 'full model' that restricts the coefficients on the interactions between the forecast and company indicators to be equal to zero.

E.38 If companies do have a common view on the average expected totex increase in AMP8 due to future expected cost increases over the period 2025 to 2030, then the restriction under the null model should hold. We test this using a likelihood ratio test but find that we reject this hypothesis at the 1% significance level.

E.39 This provides statistical support for the possibility that there may be considerable uncertainty about the magnitude of these cost pressures across the sector, and different approaches to reflecting these cost pressures in cost forecasts.

Table E.3: Pooled OLS version of Ofwat's PR1 and PR3 models

Variable	Null Model Dep Var: totex	Full Model Dep Var: totex
Intercept	3.405***	4.321***
	(0.706)	(0.799)
Population-equivalent served	0.092***	0.092***
	(0.003)	(0.003)
Enhanced Consent	-9.535***	-10.434***
	(1.716)	(1.743)
Enhanced Consent squared	3.926***	4.418***
	(1.049)	(1.058)
Consent Change	0.249*	0.272**
	(0.103)	(0.103)
1[forecast scheme]	1.502***	0.193
	(0.331)	(0.644)
1[forecast scheme] x 1[Company = HDD]		-1.920
		(6.901)
1[forecast scheme] x 1[Company = NES]		0.002
		(2.093)
1[forecast scheme] x 1[Company = UU/NWT]		1.786
		(1.191)
1[forecast scheme] x 1[Company = SRN]		0.300
		(1.099)
1[forecast scheme] x 1[Company = SVE]		3.524***
		(0.982)
1[forecast scheme] x 1[Company = SWB]		-0.020
		(1.824)
1[forecast scheme] x 1[Company = TMS]		3.949
		(2.060)

Variable	Null Model Dep Var: totex	Full Model Dep Var: totex
1[forecast scheme] x 1[Company = WSH]		-3.671*
		(1.806)
1[forecast scheme] x 1[Company = WSX]		2.493*
		(1.086)
1[forecast scheme] x 1[Company = YKY]		1.321
		(1.189)
Company Fixed Effects	Yes	Yes
Observations	1,399	1,399
R-squared	0.552	0.561

**** indicates significance at 1% level, ** at 5% level, * at 10% level*
Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.

A.9: Non-delivery PCDs

E.40 In this section A.9 we outline our approach to non-delivery PCD payments. In line with the approach set out by Ofwat, we decide that non-delivery payments will be calculated using the methodology described in section 4.3.2 of the Ofwat PR24 FD Price Control Deliverables Appendix, with one change. We use our GMR model in place of the average of Ofwat's four PR24 FD models to set updated model allowances.[61]

E.41 To update non-delivery PCDs for changes in scheme scope, below we describe how to update modelled allowances for:[62]

(a) new values of the population-equivalent served;

(b) changes in the scheme's level of consent; and

(c) any changes in the scheme's enhanced consent level.

E.42 First, we need to calculate the scheme's new totex to reflect its new characteristics. Encoding the changes in scheme n's new characteristics in $\tilde{x}_n$, the first step is to calculate:

$$\widetilde{TOTEX}_{ng} = \sinh\left(\tilde{x}_n'\hat{\beta}_g\right)\exp\left(\frac{\hat{\sigma}_g^2}{2}\right)$$

using the estimated parameters, $\hat{\theta}_g$ shown in Table E.2 under Model D, for each group, $g = 1, \ldots, G$.

E.43 Next, following the same steps as described in section A.6 above, compute the new posterior probability-weighted totex for the schemes with revised characteristics.

[61] Ofwat PR24 FD Price Control Deliverables Appendix, pp83–91.
[62] The values of the MSOA Density and Hourly Construction Wage variables do not vary across schemes of the same company over the AMP8 period. We consider that is appropriate to hold fixed the values of the average MSOA density and the average of hourly construction wages for AMP 8 fixed at the values they took at CMA PR24 FD. We also note that because we are updating AMP8 schemes only, the forecast indicator variable will take the value of one for all schemes, and therefore the coefficient on this variable is essentially added to the intercept term for the purpose of calculating a PCD.

E.44 Finally, the revised totex estimates for schemes should be pasted into the 'CMA_ModelledTotex' worksheet in the same format as they enter in the CMA PR24 FD p-removal feeder model.[63] This will automatically update the 'Modelled costs' worksheet and the allowances listed in column U of the 'Modelled costs' contain the allowances adjusted for statistical and engineering outliers and development allowances.

E.45 We make no further changes to the process described in section 4.3.2 of the Ofwat PR24 FD Price Control Deliverables Appendix.

Part B: Supply Interconnectors

E.46 Part B of this Appendix E provides key technical details behind our redetermination of enhancement allowances for supply interconnectors. For the CMA PR24 FD, we have included a section B.3 below, which describes how to amend Ofwat's PR24 FD process to calculate non-delivery PCDs.[64]

B.1: Exclusion of a forecast indicator from Ofwat's pooled models

E.47 Following its PR24 FD, Ofwat tested a pooled version of its cost model (ie estimated on both the historical and forecast data) for the inclusion of a forecast scheme indicator variable. Ofwat reported that the forecast variable is statistically insignificant and that this suggests that the historical and forecast datasets are not statistically different.[65]

E.48 On this basis, Ofwat excluded the forecast indicator from its pooled model. The submitted output of the resulting pooled model is reproduced in the second column of Table E.4 below.[66] It shows the number of observations, the R-squared values, the model coefficients and their robust standard errors.

E.49 The third column in Table E.4 below shows the output of the pooled model estimated on the same sample of schemes - but with a forecast indicator included. As was the case in Ofwat's pooled model, the statistical significance of the model coefficients is evaluated using robust standard errors. In this regression, the forecast indicator is significant at the 10% level and has a p-value of 0.066. Given that such a small sample is used, our view is that this is an acceptable level of statistical significance and the exclusion of the forecast variable from the model is not warranted.

E.50 If, however, we deviate from the assumptions on the nature of standard errors in Ofwat's pooled model, then the forecast indicator variable can be shown to be insignificant at the 10% level. For example, if the modelling errors were assumed to be clustered at the company level within each AMP, then the forecast indicator's

63 CMA analysis of Ofwat's FD P-Removal Feeder Model.
64 Ofwat PR24 FD Price Control Deliverables Appendix, pp83–91.
65 Ofwat (2025) Response to common issues on expenditure allowances, pp99–100, paragraph 4.16.
66 Ofwat (2025) OF-CA-065 Supply Interconnectors - post FD modelling, sheet 'Model Coefficients'.

p-value is greater than 0.10.[67] However, in this case there are only 11 clusters – arguably too few to conduct reliable inference.[68]

E.51 Another notable aspect of the output from Ofwat's pooled model in the second column of Table E.4 below is that it is estimated using 36 of the full sample of 39 schemes.[69] This is because Ofwat's post-Ofwat PR24 FD implementation of pooled model combines:

(a) 18 schemes not judged to be statistical outliers by Ofwat's PR24 FD historical model; and

(b) 18 schemes not judged to be statistical outliers by Ofwat's PR24 FD forecast model.

E.52 However, if Ofwat's PR24 FD sequential procedure that used Cook's distance to identify and remove statistical outliers is applied to Ofwat's pooled model, then only 2 of the 39 schemes are identified as statistical outliers. As a result, the version of the pooled model that is consistent with the Ofwat's PR24 methodology should be estimated on this larger sample of schemes.

E.53 The output of the pooled model estimated on the revised sample of 37 schemes is shown in the fourth column of Table E.4 below. As above, and in line with Ofwat's post-Ofwat PR24 FD pooled model, we report robust standard errors. To see whether this revised pooled model estimation more strongly supports Ofwat's decision to omit the forecast indicator variable, we repeat the testing of its statistical significance in the pooled model above.

E.54 Table E.4 below shows the coefficient on the forecast indicator variable is statistically significant at the 5% level and has a p-value of 0.017. Even if the modelling errors are assumed to be clustered at the company level within each AMP and inference is based on only 11 clusters, then the forecast indicator's p-value is still statistically significant at the 10% level.[70] Only when clustering at the company level across AMPs and inference is based on only 9 clusters is the forecast indicator variable insignificant at the 10% level.[71]

E.55 In summary, we again find little empirical support to drop the forecast indicator variable. If anything, the output of the revised pooled model estimation more strongly supports its inclusion.

[67] Stata and R have different approaches to computing cluster robust standard errors and can have different p-values – particularly in small samples. The p-value in R using the default settings in its 'sandwich' library is 0.1695 and in Stata it is 0.190.
[68] If the errors were assumed to be clustered at the company level across AMPs (notwithstanding the fact that this pools errors in outturn and forecast, business plan data), then the p-value is 0.249 in R and 0.274 in Stata. However, this results in only 9 clusters – too small for reliable inference.
[69] Ofwat (2025) Response to common issues on expenditure allowances, p104, paragraph 4.32, states that the sample size for the pooled model was 39 (ie all schemes in both the historical and forecast data).
[70] The p-value in R using the default settings in its 'sandwich' library is 0.066 and in Stata it is 0.087. Though, again, we caution there are only 11 clusters and this is arguably too few to conduct reliable inference.
[71] The p-value in R using the default settings in its 'sandwich' library is 0.136 and in Stata it is 0.165.

Table E.4: Results of Ofwat's regression models for supply interconnector schemes

Cost Drivers	Ofwat – Pooled Post-Ofwat PR24 FD Dep Var: log(Cost)	Ofwat – Pooled Post-Ofwat PR24 FD Dep Var: log(Cost)	Ofwat – Pooled Ofwat PR24 FD method Dep Var: log(Cost)
Intercept	0.458*	0.374	0.362
	(0.256)	(0.285)	(0.255)
log(Benefit)	0.706***	0.678***	0.537***
	(0.088)	(0.088)	(0.071)
log(Length)	0.506***	0.509***	0.632***
	(0.071)	(0.078)	(0.076)
1[Forecast Scheme]		0.286*	0.382**
		(0.150)	(0.152)
Number of obs.	36	36	37
R-squared	0.88	0.89	0.90

**** indicates significance at 1% level, ** at 5% level, * at 10% level. Robust standard errors are reported.*
Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.

B.2: CMA cost model

E.56 The estimation of our cost model, like Ofwat's pooled model, is based on the following cost function for scheme i:

$$Cost_i = Benefit_i^{\beta_1} Length_i^{\beta_2} \, exp(\beta_0 + \beta_3 1[Forecast\ Scheme_i])$$

E.57 In our case, this model is directly estimated using a Poisson likelihood function however the estimation does not assume the data follows a Poisson distribution or require costs to take integer values.[72]

E.58 In the CMA PR24 PD, our pooled model was estimated on the full sample of 39 schemes – 20 historical and 19 forecast. For the CMA PR24 FD, as noted in paragraphs 5.225 to 5.228 in chapter 5 (Enhancement costs), we have re-estimated the model using 2024/25 outturn data for supply interconnectors. While the model is unchanged, the updated data has one fewer historical schemes. The R-squared value is 0.95 – indicating that the fit of the CMA PR24 FD model using the Pseudo-Poisson Maximum Likelihood (**PPML**) is good.[73] The coefficients of the CMA PR24 PD model and the CMA PR24 FD model and their robust standard errors are shown in the two rightmost columns in Table E.5 below.

E.59 The relationship between cost and the two cost drivers used by Ofwat can be compared to their historical, forecast and pooled OLS cost models. For ease of reference, the outputs of these models are reproduced in the second to fifth columns of the Table E.5 below.

E.60 The coefficient on the forecast indicator variable is statistically significant at the 5% level – even if standard errors are clustered at the company level. This reinforces

[72] To get an estimation equation for Ofwat's pooled model the logarithmic transformation is applied to both sides of the cost model and an error term is added. Under some (restrictive) assumptions on the relationship between the error term and the cost drivers, the parameters of the model can be consistently estimated using OLS.
[73] Formally, this is McFadden's proxy for R-squared commonly used in nonlinear and generalized linear models. See Hardin, J. W., Hilbe, J. M. (2007). Generalized linear models and extensions. USA: Taylor & Francis. p60.

our view that, on balance, the forecast indicator variable should be included in the cost model when estimated using pooled scheme data. Once included, our CMA PR24 FD model implies that forecast schemes are 24% more expensive than similar historical schemes – lower than to the 32% to 33% cost uplift implied by Ofwat's post-Ofwat PR24 FD pooled model and the CMA PR24 PD model, respectively.

E.61 We can also use the model outputs in Table E.5 below to compare the estimated relationship between costs and the two cost drivers across all models. We find that the effect that the cost drivers have on cost in our model is not, broadly speaking, dissimilar to Ofwat's PR24 FD cost model estimated only on forecast data.

E.62 Both of these findings are consistent with Southern's contention that historical schemes in supply interconnectors are poor predictors of future costs and that they tend to systematically understate them.[74]

Table E.5: Results of the CMA PR24 PD and CMA PR24 FD PPML models and Ofwat's historical, forecast and pooled cost models for supply interconnectors

Cost Drivers	Ofwat – Historical Ofwat PR24 FD Dep Var: log(Cost)	Ofwat– Forecast Ofwat PR24 FD Dep Var: log(Cost)	Ofwat – Pooled Post-Ofwat PR24 FD Dep Var: log(Cost)	Ofwat – Pooled Ofwat PR24 FD method Dep Var: log(Cost)	CMA – Pooled PPML CMA PR24 PD data Dep Var: Cost	CMA – Pooled PPML CMA PR24 FD data Dep Var: Cost
Intercept	0.465	0.543*	0.374	0.362	0.333	0.320
	(0.413)	(0.222)	(0.285)	(0.255)	(0.212)	(0.215)
log(Benefit)	0.719***	0.659***	0.678***	0.537***	0.652***	0.669***
	(0.176)	(0.067)	(0.088)	(0.071)	(0.059)	(0.061)
log(Length)	0.433***	0.575***	0.509***	0.632***	0.567***	0.574***
	(0.139)	(0.030)	(0.078)	(0.076)	(0.041)	(0.043)
1[Forecast			0.286*	0.382**	0.287***	0.219**
Scheme]			(0.150)	(0.152)	(0.088)	(0.093)
Number of obs.	18	18	36	37	39	38

**** indicates significance at 1% level, ** at 5% level, * at 10% level. Robust standard errors are reported.*
Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.

B.3: Non-delivery PCDs

E.63 Here we outline our approach to non-delivery PCD payments. In line with the approach set out by Ofwat, we decide that non-delivery payments will be calculated using the methodology described in section 4.6.2 of the Ofwat PR24 FD Price Control Deliverables Appendix with one change. We use our CMA PR24 FD PPML model in place of the Ofwat's PR24 FD models to set updated model allowances.[75]

[74] Southern SoC, pp235–237, paragraphs 84–91.
[75] Ofwat PR24 FD Price Control Deliverables Appendix,pp115–119.

E.64 To update non-delivery PCDs for changes in scheme scope, below we describe how to update modelled allowances for:[76]

(a) new values of the length of pipe; and,

(b) a change in the benefit of the scheme.

E.65 First, we need to calculate the scheme's new totex to reflect its new characteristics. Using the same $\tilde{}$ notation as we did in the p-removal PCD section and taking the estimated parameters, $\hat{\beta}$, in the CMA PR24 FD specification (shown in Table E.5 under 'CMA – Pooled PPML CMA PR24 FD data'), the update cost for scheme i is:

$$\widetilde{Cost}_i = \widetilde{Benefit}_i^{\hat{\beta}_1} \widetilde{Length}_i^{\hat{\beta}_2} exp\left(\hat{\beta}_0 + \hat{\beta}_3\right)$$

E.66 Finally, the revised totex estimates for schemes should be pasted into the 'CMA Model Output' worksheet in the same format as they enter in the CMA FD supply interconnectors feeder model.[77] This will automatically update the 'Model calculations' worksheet and the allowances listed in column L of the 'PCD' worksheet contain the allowances adjusted for crossings, treatment, and pipe material uplifts, alongside Ofwat's frontier shift adjustment factor.

E.67 We make no further changes to the process described in section 4.6.2 of the Ofwat PR24 FD Price Control Deliverables Appendix.[78]

[76] We note that because we are updating AMP8 schemes only, the forecast indicator variable will take the value of one for all schemes, and therefore the coefficient on this variable is essentially added to the intercept term.
[77] CMA analysis of Ofwat's FD Supply Interconnectors Feeder Model.
[78] Ofwat PR24 FD Price Control Deliverables Appendix, pp115–119.

Appendix F: Multi-factor models and inference analysis

F.1 This appendix comments on technical aspects of two specific pieces of analysis put to us by the Disputing Companies in relation to the allowed return.[79]

Multi-factor models

F.2 This section sets out KPMG's and Kairos's multi-factor model (**MFM**) methodology, and a more detailed discussion of the technical aspects of the analysis.

F.3 Kairos estimated the MFM cost of equity under a q-factor model[80] for a United Utilities and Severn Trent portfolio, and a United Utilities, Severn Trent and Pennon portfolio.[81] Kairos's estimated MFM cost of equity range is 6.1–6.6% (CPIH real), compared to its CAPM cost of equity range of 5.5–5.9% (CPIH real).[82] Kairos noted that the CAPM is not providing adequate remuneration for systematic risks proxied by factors including firm size, level of investment and profitability.[83]

F.4 KPMG also estimated the MFM cost of equity using a q-factor model. KPMG estimated the cost of equity differentials between the q-factor and CAPM models of 43 to 181bps (with the lower bound based on a United Utilities/Severn Trent portfolio and the upper bound on Pennon). KPMG concluded the differential reflected the water portfolio's exposure to factors not captured by the CAPM.[84]

F.5 Kairos and KPMG estimated the same Hou et al (2015) q-factor model[85], using the factor and test portfolio data (available on Northumbria University website) as described in Tharyan et al (2024).[86]

F.6 The formulation of the q-factor model tested in Tharyan et al (2024) on UK data is expressed as follows.

$$R_i = R_{ft} + \beta_i \left(R_{mt} - R_{ft}\right) + s_i SIZE + j_i \, INV_t + r_i \, ROE_t + \varepsilon_{it}$$

F.7 Where R_i is the stock's return, R_{mt} is the market return, R_{ft} is the risk-free rate, SIZE, INV, and ROE are size (small minus big), investment (low minus high) and profitability (high minus low) factors respectively. β_i, s_i, j_i, r_i are the factor loadings or ('betas'), which measure the sensitivity of the stock's return to the return on each factor premium. Tharyan et al (2024) construct the q-factors by sorting stocks into 2 by size, 3 by investment, and 3 by profitability, and create 18 portfolios in total through the intersection of these individual portfolios, in line with Hou et al (2015). The SIZE factor estimates the average excess return on the 9 small size portfolios relative to the return on the 9 big size portfolios, the INV factor estimates

[79] We note that Professor Jason Sturgess of Queen Mary University, who is a member of the CMA's Corporate Finance panel, has reviewed this appendix.
[80] Kairos used market capitalisation weighting, with zero-weight to Pennon prior to the completion of the Viridor spinoff. Kairos also adjusted to account for the effect of the restrictions during the COVID-19 period.
[81] Kairos (2025) Setting the Allowed Return on Equity for PR24, p64, paragraph 218.
[82] Kairos (2025) Setting the Allowed Return on Equity for PR24, p66, paragraph 222.
[83] Kairos (2025) Setting the Allowed Return on Equity for PR24, p66, paragraph 222.
[84] KPMG (2025) Estimating the Cost of Capital for PR24, p17, paragraphs 9.2.11–9.2.12.
[85] Hou et al (2015) 'Digesting Anomalies: an Investment Approach' *The Review of Financial Studies,* pp650–705.
[86] Chen, B, Gregory, A and Tharyan, R (2024) 'An investigation of multi-factor asset pricing models in the UK'.

the average excess return on the 6 low investment portfolios relative to the return on the 6 high investment portfolios, and the ROE factor estimates the average excess return on the 6 high profitability portfolios relative to the return on the 6 low profitability portfolios.[87]

F.8 While the market beta factor is equal to one by construction, the average factor loadings (known as betas) for the additional factors are zero by construction.

F.9 Both Kairos and KPMG estimate statistically significant coefficients for SIZE and ROE factors for their chosen water portfolios/stocks.[88] The ROE factor appears to be the main driver of the positive difference between the MFM and the CAPM cost of equity estimates.

The Hou et al (2015) q-factor model

F.10 The economic intuition behind the q-factor model is to price assets from the perspective of suppliers (firms), rather than buyers (investors). The motivation behind the INV and the ROE factors is based on the basic net present value (**NPV**) rule of corporate finance, which says that firms should only invest in projects when the NPV is greater or equal to zero.[89]

F.11 NPV is the discounted value of all future cash flows minus investment costs today. In a single period set up, this relationship can be rearranged as follows: discount rate = expected profitability / investment costs.[90]

F.12 In the context of the q-factor model, we understand this to imply that firms with relatively high profitability or relatively low investment will have relatively higher required rates of return. If this was not the case, the firm would continue to invest at the margin increasing investment and lowering profitability (because the firm would increasingly invest in less NPV positive projects until the marginal benefit (profit) from further investment equals the marginal investment cost).

Applicability of the q-factor model to regulated utilities

F.13 One of the common issues with the use of MFMs is whether the additional factors which appear to explain observed returns are picking up spurious relationships and do not provide any insight into the underlying drivers of expected returns. When it comes to the q-model, there does appear to be an economic intuition to it, which may suggest we should give greater weight to this MFM over others.

F.14 In the CMA PR24 PD, we noted that we were not aware of any theoretical or empirical work on the q-model for firms in regulated markets. The economic intuition which we set out above – that firms will continue to invest until all

[87] Hou et al (2015) 'Digesting Anomalies: an Investment Approach' *The Review of Financial Studies*, p660.
[88] At 1% significance, see Kairos (2025) Setting the Allowed Return on Equity for PR24, p87; KPMG (2025) Estimating the Cost of Capital for PR24, p158.
[89] See Allen, F, Brealey, RA, Edmans, A and Myers, SC (2022) *Principles of Corporate Finance: Fourteenth edition*.
[90] Zhang, L (2019) 'q-factors and investment CAPM' (working paper), *National Bureau of Economic Research.* The rationale for the q-model is also set out in Hou et al (2015) 'Digesting Anomalies: an Investment Approach' The Review of Financial Studies, section 1.

marginally profitable opportunities are exhausted – does not obviously apply to regulated water companies. Investment levels are effectively set for five-year periods, and the regulator's intention is to set prices such that the NPV of these investments is expected to be zero. While firms have some flexibility around investment during the period, and there is scope for value generation through out-performance, we question the direct applicability of the intuition of the q-factor model in a regulated setting.

F.15 Kairos and KPMG estimates of the MFM for the water companies estimate positive factor betas both for the investment and the profitability factors although only the factor beta on the profitability factor is statistically significant. (Kairos and KPMG also estimated a statistically significant coefficient for size but the sign differs depending on the comparator/portfolio used.)[91]

F.16 The inference from the estimated q-model is that water companies should have a higher cost of equity because they have higher profits and lower investment, else they would continue to invest positive NPV projects. This does not seem logical given that these are capital-intensive industries with returns constrained through price controls.

F.17 In response to the CMA PR24 PD, KPMG submitted that our interpretation of the q-model above was consistent with the neoclassical investment story adopted in Zhang (2005),[92] however, KPMG submitted that the validity of the q-factor model does not hinge exclusively on this interpretation. An alternative interpretation, consistent with the Arbitrage Pricing Theory, was adopted by Hou et al (2015). In the Arbitrage Pricing Theory framework, the model factors are treated as proxies for unobservable risk factors[93]

F.18 KPMG also stated that positive factor betas on profitability and investment do not indicate high profitability and high capital intensity respectively, as factor betas measure exposure to systematic risks proxied by the factors, not actual investment levels or profitability. [94]

F.19 We are aware of these alternative interpretations of the q-factor model and indeed other MFMs. However, this serves as another reason why MFMs are potentially unsuitable in a regulatory setting. Without any economic intuition behind the factors, it is challenging to assess whether an empirical finding that these factors explain historical returns is informative of the risks which should be priced in on a forward-looking basis. We consider that economic intuition is an important consideration in selecting appropriate cross-checks to the CAPM.[95]

[91] Kairos (2025) Setting the Allowed Return on Equity for PR24, Appendix B; KPMG (2025) Estimating the Cost of Capital for PR24, pp158–159, Tables 65 and 66.
[92] Zhang, L (2005) 'The Value Premium', *The Journal of Finance*, 60(1), pp67–103.
[93] KPMG (2025) Analysis of WACC in the PR24 Provisional Determination, paragraph 12.5.4.
[94] KPMG (2025) Analysis of WACC in the PR24 Provisional Determination, paragraph 12.5.8.
[95] We note that Hou et al (2015) also make this point, by concluding that their empirical results 'highlight the importance of understanding the driving forces behind the q-factors'. Hou et al (2015) 'Digesting Anomalies: an Investment Approach', *The Review of Financial Studies*, p685.

F.20 For these reasons we do not consider that we can place weight on the q-factor model as a cross-check on the CAPM cost of equity. To do so in future price controls we consider that it would be necessary to develop the economic rationale for this model further, specifically in the context of regulated firms, supported by empirical testing.

Other issues raised by the parties

F.21 We do not repeat the ongoing dialogue between Ofwat and the Disputing Companies on MFMs, as we rule out the MFMs mainly for the reasons set out above – a lack of a clear economic intuition for the q-factor model and sufficient testing in the context of regulated firms.

F.22 We provide some high-level comments on several specific issues raised which we consider to be further contributing reasons for not placing weight on MFMs.

Stability and statistical significance of factor betas

F.23 In its PR24 FD, Ofwat stated that betas of water companies have had a strikingly stable mean since the early 2000s, whereas rolling estimates of additional factor betas for MFMs show clear signs of drifting even over long rolling samples and over shorter rolling samples some factor betas change sign.[96]

F.24 KPMG stated that the CAPM market beta has an expected coefficient mean of 1 (ie the beta of the market) while the additional factor portfolios are all hedge portfolios with an expected coefficient mean of zero, and therefore, it is more likely for any portfolio to have changes in beta signs for the additional factor as it is closer to zero.[97]

F.25 Tharyan et al (2025) submitted that it considered that the consistency in factor beta signs was not an appropriate criterion for assessing the stability of additional factors, while the CAPM beta is unlikely to turn negative, it is more likely for the additional factors to change sign over time.[98]

F.26 We consider that in principle, factor betas may change sign as, by design, the average factor loading must be zero. However, especially given the low statistical significance of some of the factor betas, it is difficult to place reliance on spot estimates of the factor betas and to interpret them without a richer set of rolling estimates, covering different time periods and data frequencies, to understand the underlying trends in these factor betas.

F.27 This is further complicated by the fact that both Kairos and KPMG include adjustments for COVID-19 (which, as explained in chapter 7 (Allowed return), we disagree with), and that additionally, KPMG de-levers and re-levers the factor

[96] Ofwat (2025) PR24 final determinations: Aligning risk and return - Allowed return appendix, p72, Table 17.
[97] KPMG (2025) Estimating the Cost of Capital for PR24, section 15.3.
[98] Chen, B, Gregory, A and Tharyan, R (2025), Responses to Mason, Robertson and Wright, p3 (see KPMG (2025) Estimating the Cost of Capital for PR24, section 15.2).

betas in the same way as the CAPM beta, without any evidence on the relationship between leverage and the factor premia.

Stability and statistical significance of factor excess returns

F.28 In the PR24 FD, Ofwat stated that UK factor excess returns have only been measured since the early 1980s, and in the USA since the early 1970s, and these are only marginally statistically significant from zero. Ofwat also noted that academic literature usually points to a need for higher levels of statistical significance given the increased risk of data mining.[99]

F.29 KPMG submitted that the early 1980s is the furthest period to go back to with comprehensive daily and monthly return and accounting data for the construction of MFM.[100]

F.30 Tharyan et al (2025) questioned Ofwat's approach to only apply the test of stability to factors additional to the CAPM. They stated that if Ofwat demands the requirement of stability, then the basic CAPM fails the test, as the market risk premium shows considerable variability.[101]

F.31 We agree that the market risk premium is variable, and therefore, a finding of variable factor premia in itself is not a reason to discount the q-factor model. However, while the expected market risk premium is highly uncertain, this is an area of extensive research and the approach to estimating the TMR/ERP in a regulatory setting is one which has evolved over many years, taking different evidence into account. In contrast, the only estimates of the UK factor premia we have come from Tharyan et al (2024).

F.32 We recognise that expecting the same breadth and depth of research into these additional factors as we have for the market risk premium is unrealistic, however, we are cautious about relying on results of a single academic paper on the topic.

F.33 With regard to statistical significance, Tharyan et al (2025) agree with Mason, Robertson and Wright that the observed factor premia should be statistically significant from zero. The 'price' of size and profitability is not statistically significant at portfolio level (in Tharyan et al (2024)), however, this is not the case for the investment factor, which carries a substantial positive risk premium. However, Tharyan et al (2025) caution against removing variables as it would introduce omitted variable bias into the regressions, which can distort the regression results.[102]

F.34 While we understand the issues with omitted variable bias, we are also mindful of the concerns around the risks of data mining in empirical finance, and that

[99] Ofwat (2025) PR24 final determinations: Aligning risk and return - Allowed return appendix, p72, Table 172.
[100] KPMG (2025) Estimating the Cost of Capital for PR24, section 15.3.
[101] Chen, B, Gregory, A and Tharyan, R (2025), Responses to Mason, Robertson and Wright, p3 (see KPMG (2025) Estimating the Cost of Capital for PR24, section 15.2).
[102] Chen, B, Gregory, A and Tharyan, R (2025), Responses to Mason, Robertson and Wright, p6 (see KPMG (2025) Estimating the Cost of Capital for PR24, section 15.2).

statistical significance is an important criterion for factor inclusion.[103] The 2018 UKRN Study noted that if the missing factors are not statistically significant, they disappear in expectation, leaving only the impact of the expected market return.[104] This reinforces our view that further work is needed on MFMs in the UK before they can be applied in a regulatory setting.

F.35 In response to the CMA PR24 PD, KPMG submitted that the q-model is well established as a leading MFM and has undergone extensive testing and peer review internationally, and therefore it is not clear why the q-model cannot be relied on when applied to the UK market. [105]

F.36 We do not dispute the wider research on the q-model outside the UK and overall we welcome the emergence of empirical testing in the UK market. However, we consider that the various points discussed above still stand.

Conclusions

F.37 While the CAPM may 'have fallen out of favour' in the academic world, and has a number of known limitations, in the context of estimating the allowed return in a consistent and predictable manner, in particular for regulated firms, we do not consider that the development of MFMs in the UK is sufficiently advanced to allow us to draw any inference on the appropriate cost of equity for UK water companies.

Inference analysis

F.38 This section sets out KPMG's inference analysis methodology, and a more detailed discussion of the technical aspects of the analysis.

F.39 KPMG's inference analysis is derived based on Merton's (1974)[106] contingent claim framework and its empirical application by Campello, Chen and Zhang (2008).[107]

F.40 KPMG explained that in Merton's framework, debt and equity are considered contingent claims on a firm's assets. When the firm's asset value rises, equity holders benefit from larger residual claims, and the debt holders benefit from a decrease in leverage and a lower likelihood of default. Conversely, an increase in asset value reduces residual claims and increases the likelihood of default. Therefore, all else equal, the expected returns on debt and equity are expected to be positively correlated.[108]

[103] Hou et al (2015), p662.
[104] UKRN (2018) Estimating the cost of capital for implementation of price controls by UK Regulators, pG-151.
[105] KPMG (2025) Analysis of WACC in the PR24 Provisional Determination, paragraphs 12.5.9–12.5.11.
[106] Merton, R. C. (1974) 'On the pricing of corporate debt: The risk structure of interest rates' *The Journal of Finance*, pp449–470.
[107] Campello, M, Chen, L and Zhang, L (2008) 'Expected returns, yield spreads, and asset pricing tests', *The Review of Financial Studies*, pp1297–1338.
[108] KPMG (2025) Estimating the Cost of Capital for PR24, section 9.2.3.

F.41 In the Merton framework, the relation between debt and equity returns is expressed as an elasticity, $\frac{\partial E/E}{\partial D/D}$ and it is assumed that the elasticity is a function of the nominal risk-free rate, the firm's leverage, and the stock's volatility.

$$Elasticity = \alpha + \beta_{rf}\ RFR + \ \beta_{lev}\ leverage + \beta_{vol}\ volatility$$

F.42 KPMG ran such a regression for United Utilities and Severn Trent and then used the estimated regression coefficients to estimate expected elasticities and an implied cost of equity using the following relationship.

$$R_e = r_f + elasticity\,(R_d - \ r_f)$$

F.43 Where R_e is the cost of equity, r_f is the RFR, and $R_d - \ r_f$ is the debt risk premium. KPMG performs the analysis for United Utilities and Severn Trent and uses the iBoxx benchmark index plus a 40bps uplift to estimate the debt risk premium.[109] The cost of equity is estimated in nominal terms, using nominal 20-year gilt yields as the RFR. The cost of equity is then deflated into CPIH terms using a 20-year CPI swap rate.

F.44 Similar to MFMs, the inference analysis has been subject to ongoing debate between Ofwat and the Disputing Companies. Wo do not repeat all the submissions on this topic but focus on drawing out the key themes.

Relationship between debt and equity returns

F.45 KPMG submitted that, unlike the market return input into the CAPM, the yield on debt can be directly observed, and the yield is automatically forward-looking. While the promised yield is not the same as the expected yield, there is a clear way to adjust observed yields to subtract the default risk premium.[110]

F.46 In response to the Disputing Companies' statements of case, Mason, Robertson and Wright noted the general challenge of accurately measuring the expected return on debt. Specifically, the pricing of risk of default is a long-standing empirical puzzle in finance, since the observed credit spreads are hard to explain in terms of observed frequency of default and plausible default risk premia.[111]

F.47 We consider that there are similar empirical challenges with the inference analysis which are present in all debt-to-equity premia cross-checks discussed in chapter 7 (Allowed return) of the CMA PR24 FD. There is uncertainty around the appropriate way to isolate the underlying debt risk premium from the observed cost of debt. We do not consider that this renders any attempt at comparing debt and equity returns useless, but it is an important caveat to this type of analysis.

[109] KPMG (2025) Estimating the Cost of Capital for PR24, section 16.1.21, Table 74.
[110] KPMG (2025) Estimating the Cost of Capital for PR24, section 9.3.7.
[111] Mason, R, Robertson, D and Wright, S (2025) A report on allowed return issues in disputing companies' statements of case, paragraph 5.37.

F.48 Specifically in the context of inference analysis, in the CMA PR24 PD, we expressed some reservations about the applicability of the Merton framework to regulated firms, noting the following characteristics of regulated water companies.

(a) **Regulatory mechanisms and protections**: there are various regulatory mechanisms and protections, including the Special Administration Regime, substantial effect determinations and interim determinations, which may alter the underlying relationship between debt and equity values compared to non-regulated firms.

(b) **Limited default risk**: the essential service nature and regulatory protections (already noted above) mean UK regulated water companies have very low probability of default, despite sustaining high degrees of leverage. This may violate the Merton model's assumptions about meaningful default risk.

F.49 In response to the CMA PR24 PD, Southern stated that regulatory protections do not undermine the applicability of Merton's framework to water companies in the same way as the CAPM and to the extent regulatory protections impact on the cost of equity, they are captured in the beta in the CAPM and in the elasticity under Merton's framework. Southern added that Merton's framework applies at any level of default. For a company with a low cost of debt resulting from low default risk, this simply translates into a correspondingly lower inferred cost of equity.[112]

F.50 We consider Southern's observations to be valid. However, we still consider that the regulated nature of the industry may have some impact on the applicability of Merton's framework in practice. The relationship between the different claims on the firm's assets, in particular at times of financial distress, might be more complex for a regulated utility compared to a firm operating in a competitive market, subject to standard insolvency rules.

Statistical significance of regression coefficients

F.51 KPMG stated that the independent variables jointly explain the variation of elasticity and are jointly significant at a 5% significance level. KPMG stated that the use of F-statistics is appropriate in this context as it assesses the overall statistical significance of the regression model based on the collective impact of all independent variables.[113]

F.52 In response to the Disputing Companies' statements of case, Mason, Robertson and Wright noted that the independent variables are not individually statistically significant, and that market leverage and risk-free rate specifically have high standard errors.[114]

[112] Southern (2025) Response to CMA PR24 PD, paragraph 7.111.
[113] KPMG (2025) Estimating the Cost of Capital for PR24, section 16.1.19.
[114] Mason, R, Robertson, D and Wright, S (2025) A report on allowed return issues in disputing companies' statements of case, paragraph 5.43.2.

F.53 Greater statistical significance of regression coefficients increases the confidence with which we can rely on the estimated coefficients to make inferences. Given that KPMG estimates a fixed effects model, it is potentially not surprising that the resulting estimates are very 'noisy', ie characterised by relatively high standard errors. We do not consider that this completely invalidates the analysis (given that the coefficients are at least jointly statistically significant) but it does mean the estimates are highly uncertain.

F.54 In response to the CMA PR24 PD, KPMG submitted that the 95% confidence interval for expected elasticity was positive and relatively narrow.[115] We do not necessarily agree – the 95% confidence intervals show that the expected elasticity could be anywhere between 4 and 8 or between 2 and 6 for United Unities and Severn Trent respectively over the 2013-2025 period.[116]

Differences between elasticities and beta estimates for Severn Trent and United Utilities

F.55 KPMG stated that the differences in elasticity between two comparable companies has no bearing on the differences in their equity betas. KPMG noted that as elasticity and beta are measuring different types of risk their values and differences between companies are not directly comparable. As a result, variations in elasticity between companies will not necessarily align with differences in beta.[117]

F.56 MRW noted that they were not arguing that elasticities and betas should be identical or even align closely. However, Mason, Robertson and Wright submitted that given the significant difference between Severn Trent and United Utilities elasticities they would expect some testing to assess the statistical soundness of using results Severn Trent and United Utilities.[118]

F.57 While it is only proposed as a cross-check, given that we only have two firms in the sample, with quite different implications for the implied cost of equity depending on whether Severn Trent or United Utilities is considered, it is difficult to place much reliance on this analysis.

F.58 In response to the CMA PR24 PD, KPMG submitted that averaging the two elasticities reduced firm-specific noise and improved statistical reliability. KPMG further noted that the inferred cost of equity for the two firms, both individually and on average imply a materially higher cost of equity than estimates in the CMA PR24 PD. [119]

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115 KPMG (2025) Analysis of WACC in the PR24 Provisional Determination, paragraph 12.3.23.
116 KPMG (2025) Estimating the Cost of Capital for PR24, Figures 38 and 39, p208.
117 KPMG (2025) Estimating the Cost of Capital for PR24, sections 16.2.11–16.2.12.
118 Mason, R, Robertson, D and Wright, S (2025) A report on allowed return issues in disputing companies' statements of case, paragraph 5.51.
119 KPMG (2025) Analysis of WACC in the PR24 Provisional Determination, paragraphs 12.3.25–12.3.26.

Index versus company specific bond data

F.59 KPMG's analysis uses the iBoxx A/BBB index, plus a 40bps adjustment, as the cost of debt to derive the debt risk premium.

F.60 Mason, Robertson and Wright noted that Campello, Chen and Zhang derive firm-specific bond excess returns. Mason, Robertson and Wright noted that the firm-specific approach was not available to KPMG due to data limitations but noted that data limitations lead to analytical limitations.[120]

F.61 Ofwat stated that in January 2025 the yield on two United Utilities and Severn Trent bonds were 6.04% compared with the average iBoxx A/BBB yield of 6.06%. Ofwat noted that assuming a zero wedge above the iBoxx A/BBB reduces KPMG's cost of equity estimate to 4.94% CPIH-real.[121]

F.62 In the CMA PR24 PD, we agreed with Mason, Robertson and Wright that the use of the iBoxx A/BBB index rather than firm-specific bond data was a limitation. Given that KPMG used company-specific bond data to estimate market leverage, it is not clear why it could not have derived company-specific debt premia for Severn Trent and United Utilities.

F.63 In response to this point, KPMG submitted that the purpose of the inference analysis is to cross-check the notional company's cost of equity, using the observed relationship between debt and equity returns. Accordingly, the appropriate input is the notional company's cost of new debt. KPMG also submitted that in any event Ofwat overstated the sensitivity of KPMG's results to the choice of the cost of debt benchmark. Finally, KPMG produced updated analysis using company-specific bond data to show that inference analysis supports a higher cost of equity than estimated at CMA PR24 PD, applying tenor-adjustments to the underlying bond data.[122]

F.64 Consistent with our approach in our simple unlevered cost of equity cross-check and our cost of debt analysis we do not agree with KPMG's tenor adjustments to underlying bond data. Ofwat's calculation shows the sensitivity of the implied cost of equity to the debt risk premium assumption. This is an important caveat to the KPMG analysis.

F.65 We also continue to be of the view that KPMG's analysis inappropriately mixes and matches actual company-specific data with notional data, by applying a firm-specific elasticity of equity to a generic rather than a company-specific debt premium.

[120] Mason, R, Robertson, D and Wright, S (2025) A report on allowed return issues in disputing companies' statements of case, paragraph 5.45. See Campello, M, Chen, L and Zhang, L (2008) 'Expected returns, yield spreads, and asset pricing tests', *The Review of Financial Studies*, pp1297–1338.
[121] Ofwat (2025) Response to common issues on risk and return, paragraph 5.153.
[122] KPMG (2025) Analysis of WACC in the PR24 Provisional Determination, paragraphs 12.3.27–12.3.30.

Conclusions

F.66 Due to the limitations noted above we do not currently consider that inference analysis provides additional information on the choice of the cost of equity point estimate, over and above the simple debt-to-equity cross-checks.

Appendix G: PCDs for certain new allowances

G.1 This Appendix outlines details of the PCDs we have decided to apply to certain new base and enhancement allowances.

South East – Bewl

G.2 We have decided to adopt the PCD proposal for this allowance that has been jointly agreed between South East and Ofwat.[123] Our PCD is summarised as follows, and we instruct Ofwat to take the necessary steps to implement our PCD, liaising with South East as needed:

(a) a PCD for this scheme is to be incorporated into Ofwat's Water Resilience and Security PCD1 within PCDW16a;

(b) the Bewl scheme is to be incorporated with a scheme specific PCD incentive rate and its own Ml/d benefit generated;

(c) the scheme involves installation of a parallel treatment stream to increase WTW capacity up to [✂] Ml/d;

(d) the non-delivery unit is '£m per Ml/d';

(e) the non-delivery payment rates should be based on the allowance post adjustment and frontier shift per unit benefit expected;

(f) the benefit expected can be defined as the increase to treatment capacity of Ml/d, taking the site Peak Week Production Capacity from [✂] Ml/d to [✂] Ml/d;

(g) PCD outputs are forecasted to a completion date of March 2031. 'Ml/d of additional treatment capacity' is set to '[✂]' in all years between 2023/24 to 2029/30. From 2030/31 onwards the output is to change to '[✂]'; and

(h) Ofwat and South East are to update delivery plan tables and any other matters needed to implement the agreed proposal.

Wessex – Disinfection

G.3 We have decided to adopt the PCD proposal for this allowance that has been jointly agreed between Wessex and Ofwat. Our PCD is summarised as follows, and we instruct Ofwat to take the necessary steps to implement our PCD, liaising with Wessex as needed:

(a) the eight UV disinfection schemes are to be subject to the water quality PCD;[124]

[123] This proposal is set out in South East and Ofwat (2025) joint response to South East and Ofwat RFI01.
[124] Ofwat PR24 FD Price Control Deliverables Appendix, section 7.2.2 (p177).

(b) non-delivery payment rates are to be based on the allowance post adjustment and frontier shift provided for scheme;

(c) delivery years for each scheme are as set out in the jointly agreed proposal, which we understand mirror the DWI delivery dates for each scheme;

(d) Ofwat and South East are to update delivery plan tables and any other matters needed to implement the agreed proposal.

South East – Lead

G.4 There are two lead-related South East PCDs for us to consider:

(a) a PCD for lead pipe replacement activities; and

(b) a PCD for other lead related activities.

Lead pipe replacement PCD

G.5 South East proposed a PCD for lead pipe replacement, which it said was consistent with the approach that Ofwat used in its PR24 FD.[125] In response, Ofwat said that South East's proposed PCD was suitable, assuming that:

(a) the unit rates were aligned with the CMA's allowances; and

(b) South East's definitions for supply pipe replacement were consistent with Ofwat's definitions, as set out in Ofwat's response.[126]

G.6 We note that the unit rates in South East's proposal are consistent with the CMA's allowances and that South East has confirmed that its definitions for supply pipe replacement are consistent with Ofwat's definitions.[127] [128]

G.7 Our PCD is summarised as follows, and we instruct Ofwat to take the necessary steps to implement our PCD, liaising with South East as needed:

(a) South East to deliver 3,200 lead pipe replacements in AMP8;

(b) cumulative delivery targets for lead pipe replacements are as set out in Appendix A of South East's revised lead pipe replacement strategy;[129]

(c) non-delivery payment rates are to be based on the unit rates as set out in Appendix A of South East's revised lead pipe replacement strategy;[130] and

[125] South East (2026) PR24 Redetermination Update on RFI08 Question 2 – Revising South East Water's Lead Strategy (and its Annex A (Revised Lead Strategy Overview: January 2026), p9, section 4.3).
[126] Ofwat (2026) Ofwat's comments on South East's Revised Lead Approach pp2 and 4.
[127] South East said that for completeness it also includes nursery schools in the schools category of the definition for supply pipe replacement, and uses 'service pipe' and 'supply pipe' interchangeably in its lead strategy documentation.
[128] South East response to South East RFI11, paragraph 1, p1.
[129] South East (2026) PR24 Redetermination Update on RFI08 Question 2 – Revising South East Water's Lead Strategy, Annex A (Revised Lead Strategy Overview: January 2026), pp11–12 (Appendix A).
[130] South East (2026) PR24 Redetermination Update on RFI08 Question 2 – Revising South East Water's Lead Strategy, Annex A (Revised Lead Strategy Overview: January 2026), pp11–12 (Appendix A).

(d) Ofwat and South East are to update delivery plan tables and any other matters needed to implement the agreed proposal.

Other lead related activities PCD

G.8 In its comments on South East's revised lead approach, Ofwat proposed a second PCD for other lead related activities.[131] Ofwat suggested that any allowances given outside of lead pipe replacement are incorporated in the Water Quality PCD and that non-delivery payments would apply in the instance of South East not meeting the completion date of its DWI 'AMP8 Lead Strategy' undertaking.[132]

G.9 We asked South East if it agreed with Ofwat that the CMA should include a second PCD for other lead related activities. South East said in reply that it agreed to a second PCD on the basis that the other lead related activities include a trial.[133]

G.10 Our PCD for other lead related activities is summarised as follows, and we instruct Ofwat to take the necessary steps to implement our PCD, liaising with South East as needed:

(a) non-delivery payments will apply in the instance of South East not meeting the completion date for its DWI 'AMP8 revised lead strategy' undertaking;

(b) the non-delivery payment rate amounts to £8.034 million and will be added to cell G17 in the 'SEW – WQ' sheet in Ofwat's water quality PCD workbook;[134]

(c) the completion date is 30 April 2031, which is consistent with the delivery date already included in cell H17 of the 'SEW – WQ' sheet in Ofwat's water quality PCD workbook;[135] and

(d) Ofwat and South East are to update delivery plan tables and any other matters needed to implement the agreed proposal.

Anglian – Boundary Boxes

G.11 We have decided to impose a PCD for this allowance. Anglian and Ofwat did not reach agreement on the text of the PCD.

G.12 Ofwat said that it supported the CMA's provisional decision not to allow the claim. However, if the CMA accepted the claim Ofwat agreed that a PCD would be essential. Ofwat said that it could not provide the CMA with PCD text, formulae or payment rates.[136]

[131] Ofwat (2026) South East Water Revised Lead Approach – Ofwat's comments, pp2 and 3.
[132] Ofwat (2026) South East Water Revised Lead Approach – Ofwat's commentsp3.
[133] South East response to South East RFI11, paragraph 2, p1.
[134] As set out in the 'PR24PCD108-WQ-PCD v5 SEW Lead Update_draft ' excel workbook appended to South East response to South East RFI11, 'SEW - WQ Proposed' tab.
[135] As set out in the 'PR24PCD108-WQ-PCD v5 SEW Lead Update_draft ' excel workbook appended to South East response to South East RFI11, 'SEW - WQ Proposed' tab
[136] Ofwat response to Anglian and Ofwat RFI01, pp1–2.

G.13 Anglian provided draft text for the PCD and said that it had sought to follow the format and Ofwat approach to PCDs.[137] In a further submission Ofwat commented on the Anglian proposed PCD.[138]

G.14 Based on the Anglian and Ofwat submissions, our PCD is summarised as follows, and we instruct Ofwat to take the necessary steps to implement our PCD, liaising with Anglian as needed. The purpose of the PCD is to ensure that if Anglian replaces fewer than the expected number of boundary boxes it will return money to customers.

Deliverable

G.15 For the purposes of this PCD, a boundary box is defined as a buried chamber that includes the external valve ('stop tap') that controls the flow of water to a property and the port for a meter that measures water flow. Boundary boxes are replaced only when they have failed. A boundary box is considered to have failed and be in need of replacement when it is irreparably unable to serve its function. The normal prompts for replacement are:

(a) a customer report of a fault (eg because the stop tap is broken and therefore the property cannot be isolated from the mains water supply); or

(b) the discovery of a water leak within the boundary box.[139]

G.16 The following assets are out of scope of this PCD:

(a) other chambers that house stop taps and meters (eg wall-mounted chambers);

(b) broken boundary boxes discovered in the course of meter replacement or meter upgrading;

(c) repairs to boundary boxes (eg replacement of a lid or a faulty stop tap); and

(d) any boundary boxes replaced proactively (ie without evidence of any problem).[140]

G.17 The total number of boundary boxes the company will replace in AMP8 is forecast at 239,331. Anglian said that 18,289 of these will relate to meter replacement.[141] Therefore the forecast for the number of boundary boxes unrelated to meter replacement is 221,042.

[137] Anglian response to Anglian and Ofwat RFI01 and its supporting annex Boundary Box PCD definition and parameters, p1.
[138] Ofwat response to Anglian Water's PCD proposal, pp1–3.
[139] Anglian response to Anglian and Ofwat RFI01, supporting annex Boundary Box PCD definition and parameters, p1.
[140] Anglian response to Anglian and Ofwat RFI01, supporting annex Boundary Box PCD definition and parameters, pp1–2.
[141] Anglian SoC, paragraph 279. See also Anglian response to Anglian RFI12.

Delivery profile

G.18 The PCD target of 221,042 is defined in terms of the total number of boundary boxes replaced over AMP8.[142]

Measuring and reporting

G.19 Anglian will report progress against deliverables as per the common reporting requirements set out in section 2.2 of the Ofwat PR24 FD Price Control Deliverables Appendix.[143]

G.20 In addition, for each boundary box replaced Anglian will report the ground type surrounding the boundary box: unmade ground, carriageway or footpath.[144]

Other conditions

G.21 As set out above, only failed boundary boxes which have been replaced reactively are in scope. If a boundary box that has been replaced within AMP8 period fails again within the period, the second replacement will be out of scope (ie it cannot be counted twice).[145]

Assurance

G.22 Common assurance requirements apply as per section 2.3 of the Ofwat PR24 FD Price Control Deliverables Appendix.[146]

G.23 In addition, the company will provide independent third-party assurance that only the boundary boxes that fall within the scope of this PCD as defined above have been included.[147]

Payments

G.24 Non-delivery payments will apply if Anglian companies does not replace 221,042 boundary boxes that meet the definitions above. Payments will apply in line with the following formula:[148]

Non-delivery PCD payment = £577 × (221,042 – PCD performance).

G.25 The PCD performance is the total number of boundary box replacements completed in AMP8 that meet the definitions above.

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[142] Anglian response to Anglian and Ofwat RFI01, supporting annex Boundary Box PCD definition and parameters, pp1–2. Ofwat agreed with this proposal: Ofwat (2026) Ofwat response to Anglian Water's PCD proposal, p2.
[143] Anglian response to Anglian and Ofwat RFI01, supporting annex Boundary Box PCD definition and parameters, p2. Ofwat agreed with this proposal: Ofwat (2026) Ofwat response to Anglian Water's PCD proposal, p2.
[144] Ofwat (2026) Ofwat response to Anglian Water's PCD proposal, p2.
[145] Anglian response to Anglian and Ofwat RFI01, supporting annex Boundary Box PCD definition and parameters, p3.
[146] Ofwat PR24 FD Price Control Deliverables Appendix, pp12–13; Anglian response to Anglian and Ofwat RFI01, supporting annex Boundary Box PCD definition and parameters, pp1–2. Ofwat agreed with this proposal: Ofwat (2026) Ofwat response to Anglian Water's PCD proposal, p2.
[147] Anglian response to Anglian and Ofwat RFI01, supporting annex Boundary Box PCD definition and parameters, p3.
[148] Anglian response to Anglian and Ofwat RFI01, supporting annex Boundary Box PCD definition and parameters, p3. Unit rate of £577 is as set out under the section 'Anglian boundary boxes' in chapter 4 (Base costs).

G.26 There will be no additional payment to Anglian in this PCD.

Glossary

Term	Definition
AAD	Advanced anaerobic digestion.
Act	The Water Industry Act 1991.
Adjusted interest cover ratio (AICR)	The adjusted interest cover ratio measures the scope to make interest payments after meeting costs that have been expensed and RCV run-off. This is a financial ratio used for the assessment of financeability.
Affinity (or 'AFW')	Affinity Water Limited (also referred to as 'AFW' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
Aggregate sharing mechanism (ASM)	A mechanism that reduces the financial impact on customers and companies of very high or very low performance beyond certain thresholds through the use of cost-sharing. There are two ASMs: (a) a 'totex ASM' which is applied to costs at the end of the full five-year period at a threshold of ±200bps of **RoRE**; and (b) an 'outcomes ASM' which is applied to net outcomes delivery incentives (ODIs) payments on an annual basis. The outcomes ASM has two thresholds, at ±300bps of **RoRE** and ±500bps of **RoRE**.
Akaike Information Criterion (AIC)	Akaike Information Criterion is a tool used to compare different statistical models and helps to identify the model that explains the data most effectively while using the fewest number of variables.
Allowed return (on capital)	The allowed return on capital is multiplied by the **RCV** to provide a revenue allowance for efficient financing costs. It is set in real (**CPIH**) terms, with respect to the **notional capital structure**.
AMI	Advanced monitoring infrastructure.
AMP	Asset Management Period, a five-year regulatory period used by **Ofwat** to set price controls for water companies.
AMP5	The period between 2010 and 2015, during which PR09 applied.

Term	Definition
AMP6	The period between 2015 and 2020, during which PR14 applied.
AMP7	The period between 2020 and 2025, during which PR19 applied.
AMP8	The period between 2025 and 2030, during which PR24 applies.
AMR	Automated Meter Reading, a technology that enables the automatic collection of consumption data from utility meters.
Anglian (or 'ANH')	Anglian Water Services Limited (also referred to as 'ANH' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
APH	Average pumping head.
Appointee	The Appointee is a water company responsible for delivering the regulated wholesale and retail activities which are necessary for the water company to fulfil the function and duties of a **WoC** or **WaSC** under the **Act**.
APR	Annual performance report.
Aqua	Aqua Consultants
ASHE	Annual Survey of Hours and Earnings, a source of information on the structure and distribution of earnings in the UK.
ASRAP	Anglian's PR24 Asset Systems Resilience Appraisal, produced in 2023.
Base Costs	Routine costs that companies incur to provide a base level of service.
Basis point (or 'bp') / basis points (or 'bps')	A basis point is a unit of measurement equal to one hundredth of a percentage point (ie 0.01%). It is commonly used as a unit to describe differences in the yield of financial instruments.
Bayesian Information Criterion (BIC)	Bayesian Information Criterion is a tool used to compare different statistical models and helps to identify the model that explains the data most effectively while using the fewest number of variables
BCEW	Business Customer Experience in Wales.
BCIS	Building Cost Information Service provides construction cost data and analytical tools to support budgeting, cost estimation, and project planning.

Term	Definition
Bespoke performance commitment	Performance commitments that do not apply to all water companies. Some companies may have the same bespoke performance commitments as other companies.
Beta	Beta within the **CAPM** framework reflects an asset's (or a portfolio of assets') exposure to systematic (or common) risks relative to the broader market.
Bioresources	Bioresources refers to activities associated with wastewater sludge transport, treatment, recycling and disposal.
Blind year	The last year of a price control period (eg, 2024/25 for PR19) where actual performance data is not yet available when setting the next price control (PR24).
Blind Year Reconciliation FD	Ofwat (2025) Final determination on the 2024/25 blind year reconciliations **Blind year** reconciliation refers to the process of adjusting water companies' performance metrics to align with actual outcomes rather than forecasts.
Brennan CAPM	The Brennan (1971) capital asset pricing framework
Bristol Water	South West Water Limited trading as Bristol Water (also referred to as 'BRL' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
Business customer and retailer measure of experience (BR-MeX)	Performance commitment designed to improve outcomes for business customers in England. See '**Measures of experience**'.
CAC	Cost Adjustment Claim.
CAD	Conventional anaerobic digestion.
Capex	Capital expenditure, commonly known as capex, are funds used by a company to acquire, upgrade, and maintain physical assets such as property, buildings, an industrial plant, technology or equipment.

Term	Definition
CAPM	The Capital Asset Pricing Model describes the relationship between systematic risk and expected return for assets, particularly equities.
Caps and collars	Limits on outperformance and underperformance for an **ODI**, respectively.
Catch-up challenge	Efficiency savings required by the less efficient companies in the sector to catch-up to the more efficient companies.
CCP	Cost change process – the cost change process involves the adjustment of price controls for certain critical areas to allow companies to access additional revenue if necessary.
CCW	The Consumer Council for Water, known as CCW, is the independent representative of household and business water consumers in England and Wales.
CED	Consumption expenditure deflator.
CES	The customer experience survey ie a survey of a water company's household customers – performance on which (alongside CSS) informs a company's performance on **C-MeX**.
CMA	The Competition and Markets Authority.
CMA PR24 Approach Document	CMA (2025) Water PR24 Redetermination References: Approach and Prioritisation.
CMA PR24 PD	**CMA** (2025) PR24 Provisional Determinations.
CMA PR24 PD Summary	**CMA** (2025) Water PR24 References Provisional Determinations, Summary.
CMA PR24 PD Volume 1	**CMA** (2025) Water PR24 References Provisional Determinations Volume 1: Introduction, Background, Approach and prioritisation, Base costs – Chapters 1–4
CMA PR24 PD Volume 2	**CMA** (2025) Water PR24 References Provisional Determinations Volume 2: Enhancement costs – Chapter 5

Term	Definition
CMA PR24 PD Volume 3	**CMA** (2025) Water PR24 References Provisional Determinations Volume 3: Outcomes – Chapter 6
CMA PR24 PD Volume 4	**CMA** (2025) Water PR24 References Provisional Determinations Volume 4: Allowed Return, Risk & Return, Provisional Determinations, Next steps - Chapters 7–10
CMA PR24 PD Volume 5	**CMA** (2025) Water PR24 References Provisional Determinations Volume 5: Appendices A–F and Glossary
CNB	Catchment nutrient balancing.
COMAH regulations	Control of Major Accident Hazards Regulations 2015.
Common performance commitment	Performance commitments that apply to all companies which provide the services to which the common performance commitment relates (see **performance commitment**).
Consumer objective	Refers to the duty set out in the **Act**, section 2(2A)(a) and has the meaning set out in the **Act**, sections 2(2B)–2(2D).
Contingent allowance	An expenditure allowance that is contingent on an action.
COPI	Construction Output Price Index.
Cost sharing	Cost sharing refers to **Ofwat**'s policy treatment of overspend or underspend against the efficient cost allowances set for water companies: (a) the cost sharing rate on overspend captures the share of overspend that the company needs to bear (versus what may be borne by customers); and (b) the cost sharing rate on underspend captures the share of underspend that the company gets to keep.
CPI	Consumer Price Index.
CPIH	Consumer Price Index Including Owner Occupiers' Housing Costs.
CRI	Compliance risk index.

Term	Definition
CRT	Canal and River Trust.
CSS	The customer service survey – ie a survey of customers who have contacted a water company – performance on which (alongside **CES**) informs a company's performance on **C-MeX** and is represented by a score out of 100 calculated from the average scores of two satisfaction surveys.
Customer measure of experience (C-MeX)	Common performance commitment designed to improve outcomes for residential customers in England and Wales. See 'Measures of experience'.
CY	A Convenience Yield is often described as a discount on the yield investors are prepared to accept because of several characteristics of government bonds, such as their money-like nature, superior liquidity, superior collateral value, and excess demand from institutional investors driven by regulatory requirements.
Deadbands	Deadbands are a specified range around a performance commitment level where no financial incentives apply.
Defra	Department for Environment, Food & Rural Affairs.
Defra White Paper	Defra (2026) A New Vision for Water.
DESNZ	Department for Energy Security and Net Zero
Developer services measure of experience (D-MeX)	Performance commitment designed to improve outcomes for developer services customers in England and Wales. See 'Measures of experience'.
Direct Procurement for Customers (DPC)	Direct procurement for customers is an alternative approach, through competitive tendering, for water companies to deliver large scale, discrete programmes of work by means of a third party, which potentially may include the design, construction, financing, ownership, operation and maintenance of an asset.
Disputing Companies	Anglian, Northumbrian, Southern, South East and Wessex collectively.
DMS	Dimson, Marsh and Staunton

Term	Definition
DSEAR	Dangerous Substances and Explosives Atmospheres Regulations 2002.
DWI	The Drinking Water Inspectorate is the independent regulator of drinking water supplies in England and Wales, ensuring that water companies supply safe drinking water that is acceptable to customers and meets the standards set down in law.
DWMP	Drainage and wastewater management plan.
Dŵr Cymru (or "WSH')	Dŵr Cymru Cyfyngedig (also referred to as 'WSH' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
EA	Environment Agency, one body, responsible for environmental regulation in England and Wales, and the principal adviser to the government on the environment.
EDM	Event Duration Monitors, a means by which water companies record the frequency and duration of spills.
Efficiency Duty	Refers to the duty set out in the **Act**, section 2(3)(a).
Enhanced ODI	Performance payments that apply to outperformance only and are designed to incentivise further performance improvements from well-performing companies.
Enhancement costs	Costs required to enhance the capacity or quality of service beyond the base level.
Environmental Performance Assessment (EPA)	An assessment introduced by the Environment Agency in 2011 as a non-statutory tool for comparing performance between **WaSCs** operating wholly or mainly in England.
EOS	Emergency overflow sites.
ERP	The Equity risk premium is the excess return that investing in the stock market provides over a risk-free rate.
FFO	Funds from Operations
Financing Duty	Refers to the duty set out in the **Act**, section 2(2A)(c).
Frontier shift	Frontier shift is the rate of efficiency improvements that even the most efficient companies in the industry can achieve from

Term	Definition
	improvements in working practices and the introduction of new technology.
Functions Duty	Refers to the duty set out in the **Act**, section 2(2A)(b).
Funds from Operations/Net debt (FFO/Net Debt)	**FFO** divided by net debt measures companies' debt burden in relation to operational income. This is a financial ratio used for the assessment of financeability. It is also a key ratio for rating agencies, although each rating agency may make specific adjustments to **FFO** and/or net debt for its calculations.
FY	Financial Year.
Gated Allowance	An expenditure or contingent allowance provided to the company in **Ofwat**'s **PR24 FD**, where the company needs to pass through a series of gates to access additional funding.
Gearing	Gearing measures the percentage of a company's **RCV** that is financed by debt. It is measured by assessing net debt (total debt less cash & cash equivalents) divided by **RCV**.
GFC	The 2008 global financial crisis.
GIIA	The Global Infrastructure Investment Association
GLS	Generalised Least Squares
GMR	Gaussian Mixture Regression.
GO	Gross output measures aggregate output by one or more companies. The inputs used to make GO are capital, labour and intermediate inputs, including energy, materials and services.
Growth Duty	Refers to the duty set out in the Deregulation Act 2015, section 108.
GSS	Guaranteed Standards Scheme. Customers are entitled to guaranteed minimum standards of service, as laid down by down by the UK and Welsh Governments. These rights are known as the guaranteed standards scheme.
Hafren Dyfrdwy (or 'HDD')	Hafren Dyfrdwy Cyfyngedig (also referred to as 'HDD' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).

Term	Definition
Heathrow H7	The H7 Heathrow Airport Licence modification appeals made to the CMA in 2023 (and determined by the CMA in 2024).
HMT	His Majesty's Treasury.
HSE	Health and Safety Executive.
iBoxx indices	Bond indices compiled by IHS Markit and commonly used as a regulatory benchmark for the cost of debt. The 'benchmark index' is the average of the iBoxx A and BBB non-financial 10+ indices.
IED	The Industrial Emissions Directive.
ILD	Index-linked debt.
ILG	Index-linked gilt.
IRE	Infrastructure renewals expenditure.
IWC	Independent Commission on the Water Sector Regulatory System chaired by Sir John Cunliffe, also known as the Independent Water Commission.
IWC Final Report	**IWC** (2025) Final Report, published in July 2025
K factor	Each year water companies can increase their charges by inflation, as measured by **CPIH**, plus or minus a percentage determined by Ofwat (or by the **CMA** for the **Disputing Companies**). This percentage is known as the K factor.
LAD	Local Authority District
Least absolute shrinkage and selection operator (LASSO)	An econometric/machine learning technique which selects explanatory variables that best predict the outcome variable of interest.
Licence Duty	Refers to the duty set out in the **Act**, section 2(2A)(d).
Likelihood Ratio (LR)	A likelihood ratio test is a statistical test that compares how well two models fit the data by evaluating whether the more complex

Term	Definition
	model provides a significantly better likelihood than the simpler model.
LTVS	Long Term Viability Statement
MARs	Market-to-asset ratio(s). Ratio of enterprise value of a listed water company to its **RCV**.
MCERTS	Monitoring Certification Scheme, monitoring emissions to air, land and water.
Measures of experience (MeXes)	Performance commitments that measure the experience of residential customers (**C-MeX**), developer services customers (**D-MeX**), business customers in Wales (**BCEW**) and business customers in England (**BR-MeX**).
MFM	Multi-factor models.
Monte Carlo	A simulation that involves taking multiple draws from the estimated distribution (eg expenditure or performance outcomes) and, for each draw, computing the resulting **RoRE** outcome.
MPE	Materials, Plant and Equipment.
MSE	Mean Squared Error is a statistical metric that quantifies the average squared difference between predicted values and actual observed values.
MSOA	Middle-layer Super Output Area, a statistical geography unit in England and Wales used by **Ofwat** in computing density measures.
NAO	National Audit Office.
NARM	Network Asset Risk Metric
NIC	National Infrastructure Commission.
Northumbrian (or 'NES')	Northumbrian Water Limited (also referred to as 'NES' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
Notified item	Has the meaning set out in Condition B of **WoC** and **WaSC** licences (each of which is listed in **Ofwat**'s register).

Term	Definition
Notional capital structure	**Ofwat** sets an allowed return and tests financeability using an assumed capital structure for the notional company. **Ofwat** makes assumptions for notional **gearing**, share of index-linked debt, type of index-linked debt, dividend yield and equity issuance costs.
NPg	Northern Powergrid.
NPV	Net present value.
OBR	Office for Budget Responsibility.
Ofwat	**Ofwat** is the Office of the Water Services Regulation Authority, the economic regulator of water sector in England and Wales.
Ofwat PR24 FD Price Control Deliverables Appendix	**Ofwat** (2025) PR24 final determinations: Price control deliverables appendix
Ofwat's Response	**Ofwat**'s response to the **Disputing Companies**' statements of case.
OLS	Ordinary Least Squares.
ONS	Office for National Statistics.
Opex	Operating expenditure. Operating expenses are the costs a company incurs for running its day-to-day operations.
Outcome Delivery Incentive (ODI)	Outcome delivery incentives provide financial payments to water companies from customers for performing beyond committed levels of service (outperformance payments) or from companies to customers for performing below their committed levels (underperformance payments). Incentive payments are determined by multiplying a company's performance relative to its performance commitment level (ie **PCL**) by an incentive rate.
Outcomes ASM	Outcomes Aggregate Sharing Mechanism
Outturn adjustment mechanism (OAM)	A new mechanism introduced in **Ofwat**'s **PR24 FD** that adjusts the impact of outturn reconciliations for all companies equally in terms of the proportion of regulated equity to keep the reconciliation of the median average of companies within a range of -50bps to

Term	Definition
	+50bps **RoRE**. The mechanism applies to common performance commitments.
Overriding objective	The overriding objective to carry out redeterminations fairly, efficiently and at proportionate cost within the statutory timeframes, as set out in the Rules (Rule 4.1).
P-removal	Phosphorus removal.
P10	P10 is the level at which there is only an estimated 10% chance that the outcome performance level would be worse.
P90	P90 is the level at which there is only an estimated 10% chance that the outcome performance level would be higher.
PAYG	Pay As You Go is the proportion of total allowed expenditure that is recovered in each year of the price review period. Non-PAYG total allowed expenditure is added to the **RCV**.
PCA	Principal component analysis
PCD	A price control deliverable; this sets out the key outputs or outcomes that are expected from the provision of certain expenditure allowances and are used to ensure that customers receive the performance and outputs they have funded.
PDC	Provisional determination on costs
Pennon	Pennon Group plc, owner of Bristol Water, South West Water and **Sutton and East Surrey Water**
Performance commitment	Performance commitments are measures of performance that Ofwat uses when seeking to hold companies to account to deliver for customers and the environment.
Performance Commitment Level (PCL)	Performance commitment levels are the committed levels of performance set by Ofwat for each performance commitment.
PFAS	Perfluoroalkyl and polyfluoroalkyl substances.
PMICR	Post-Maintenance Interest Coverage Ratio. A financial metric used primarily by rating agencies and regulators to assess the financial

Term	Definition
	health of regulated companies. It measures a company's ability to service its debt using cash generated after accounting for capital maintenance.
Portsmouth Water (or 'PRT')	Portsmouth Water Limited (also referred to as 'PRT' within eg the 'Company acronyms' in Ofwat's PR24 glossary).
PPML	Pseudo-Poisson Maximum Likelihood model, developed by Santos Silva and Tenreyro (2006).
PR04	**Ofwat**'s periodic price review for 2004, covering the price control period from 2005–2010 and corresponding to AMP4.
PR09	**Ofwat**'s periodic price review for 2009, covering the price control period from 2010–2015 and corresponding to **AMP5**.
PR14	**Ofwat**'s periodic price review for 2014, covering the price control period from 2015–2020 and corresponding to **AMP6**.
PR19	**Ofwat**'s periodic price review for 2019, covering the price control period from 2020–2025 and corresponding to **AMP7**.
PR19 Final Report	The CMA's Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations Final Report, as issued in 2021.
PR24	**Ofwat**'s periodic price review for 2024, covering the price control period from 2025–2030 and corresponding to **AMP8**.
PR24 DD	**Ofwat**'s PR24 Draft Determinations (July 2024).
PR24 FD	**Ofwat**'s PR24 Final Determinations.
Price reviews (or periodic reviews)	**Ofwat** is required to carry out 5-yearly price reviews (sometimes referred to as periodic reviews) which limit the revenue allowed to water companies (as a result the charges levied by those companies) from their regulated activities.
QAA	Quality and Ambition Assessment.
R&D	Research and development.
RAM	Ofgem's Regulatory Adjustments Mechanisms

Term	Definition
RAPID	Regulators' Alliance for Progressing Infrastructure Development, a type of gated process introduced by **Ofwat**, the **EA** and the **DWI** to accelerate the development of new strategic water resource infrastructure.
RCV run-off	Non-PAYG totex is added annually to the **RCV**. This totex is then recovered through customer bills over a number of years. The rate at which it is recovered is determined by RCV run-off rates.
Real terms	Real terms can be used for figures such as bills, **totex** and revenues. Real terms figures do not reflect the impact of inflation. They are measured in the prices of an initial or base year. For PR24, real terms figures are in 2022/23 **CPIH** prices.
References	On 18 March 2025, **Ofwat**, as required by section 12(3)(a) of the **Act**, referred five disputed determinations to the CMA.
Regulatory Capital Value (RCV)	Regulatory Capital Value is a component used by **Ofwat** to calculate price limits. It represents a measure of the capital base of a company and reflects the allowed expenditure to be recovered from future customers. Expenditure not recovered in the current period through PAYG is added to RCV and recovered in future periods through **RCV run-off**. The RCV is inflated each year to maintain the RCV at current prices.
Resilience Objective	Refers to the duty set out in the **Act**, section 2(2A)(e) and has the meaning set out in the **Act**, sections 2(2DA)–2(2DB).
Return on regulatory equity (RoRE)	RoRE is a post-tax measure of return that is calculated with reference to the level of equity in the **notional capital structure**. RoRE is often calculated and presented as a variation from the allowed return on equity based on performance against price review incentives.
RFR	The Risk Free Rate is the theoretical rate of return on an investment with zero risk. It is the benchmark to measure other investments that include an element of risk.
RMA	Retail margin adjustment. An adjustment required if there is a double-counting compensation for retail risk embedded in the appointee-level allowed return as well as the retail margin.
RMSE	Root mean square error: the square root of the mean squared error

Term	Definition
RPEs	Real price effects.
RPI	Retail prices index.
S&P	Standard & Poor's (the credit rating agency).
SACP	Standalone Credit Profile, used in the context of ratings assessments by S&P.
Severn Trent (or 'SVE')	Severn Trent Water Limited (also referred to as 'SVE' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
SIC	Standard Industrial Classification, a list of the **ONS** codes used to classify business establishments and other standard units by the type of economic activity in which they engage.
SMR	Sustainable materials reinstatement.
SoC / SoCs	Statement of case / statements of case.
South East (or 'SEW')	South East Water Limited (also referred to as 'SEW' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
South Staffordshire Water (or 'SSC')	South Staffordshire Water plc (also referred to as South Staffs Water in **Ofwat**'s **PR24 FD** and 'SSC' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
South West Water (or 'SWB')	South West Water Limited (also referred to as 'SWB' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
Southern (or 'SRN')	Southern Water Services Limited (also referred to as 'SRN' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
SPS	The UK government's strategic policy statement which sets out the UK government's priorities for **Ofwat**'s regulation of the water sector in England.
SR	Service reservoir.
STC	Sewage treatment collection.
STW	Sewage treatment works.
Sustainability Duty	Refers to the duty set out in the **Act**, section 2(3)(e).

Term	Definition
Sutton and East Surrey Water (or 'SES')	Sutton and East Surrey Water plc (also referred to as SES Water in **Ofwat**'s **PR24 FD** and 'SES' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
SWC	Sewage Water Collection
SWT	Sewage Water Treatment
TFP	Total Factor Productivity, a rate which is a proxy for technological progress, based on the change in the volume of outputs produced per volume of inputs (ie growth in output not attributable to changes in capital or labour inputs).
Thames Investor Group	An ad hoc group of over 100 financial institutions that are creditors of **Thames Water**, which has made submissions to the CMA as part of the redeterminations.
Thames Water (or 'TMS')	Thames Water Utilities Limited also referred to as 'TMS' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
TI	Time Incentive (eg used in relation to TI **PCD**s).
TMA	Traffic Management Act 2004.
Total expenditure (Totex)	Total expenditure is capital expenditure and operating expenditure.
Total Market Return or TMR	The TMR is the total return that investors require for investing in a diversified basket of equities. It is the sum of the **RFR** and the equity risk premium (**ERP**), which is the part of this return that compensates investors for the additional risk associated with investing in equities, rather than in risk-free assets.
Totex ASM	Totex Aggregate Sharing Mechanism
True-up	A true-up provides some protection to water companies by transferring risk from companies to customers. This can be an ex-post true-up where an adjustment is made after the event, comparing the actual outturn costs to what was originally forecast or an index. An ex-ante true-up is a pre-determined adjustment to a price control allowance based on a forecast.
TWD	Treated water distribution.

Term	Definition
UKCSI	The UK Customer Satisfaction Index is a measure of customer satisfaction published twice a year by The Institute of Customer Service. It measures performance in 13 different sectors and is used to measure the improvement or decline of performance in different sectors.
UKRN	UK Regulators Network.
United Utilities (or ‘UUW’)	United Utilities Water Limited also referred to as ‘UUW’ within eg the ‘Company acronyms’ in **Ofwat**’s PR24 glossary).
Updated November 2025 PCDs Guidance	**Ofwat** (2026) Price control deliverables guidance, updating an earlier version published in November 2025
UQ	Upper Quartile.
VA	Value added is equivalent to gross output minus the value of intermediate inputs required to produce the final output. VA inputs are therefore labour and capital only. This means that productivity changes resulting from variations in the use of intermediate inputs should not be captured in VA measures.
VIF	Variance Inflation Factors
WACC	Weighted Average Cost of Capital. The cost of equity component of the WACC reflects returns required by equity investors, while the cost of debt component compensates for efficiently incurred costs of existing and new debt. The two costs are weighted in proportion to the debt and equity in a capital structure to give an overall WACC.
WaSC	Water and sewerage company.
Water Industry National Environment Programme (WINEP)/(NEP)	Sets out the requirements expected of companies to meet their environmental outcomes in England. (NEP is the equivalent for Wales).
WATS	Weighted average treatment size – a variable used in econometric modelling to account for the different sizes of water treatment works.

Term	Definition
Wessex (or 'WSX')	Wessex Water Services Limited (also referred to as 'WSX' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
WHO	World Health Organisation.
WICS	Water Industry Commission for Scotland.
WINEP	Water Industry National Environment Programme.
WISER	Water Industry Strategic Environmental Requirements
WoC	Water only company.
Working Paper	CMA (2025) Water PR24 Redetermination References: Base Costs Modelling – Working Paper.
WRc	Water Research Centre Group, the firm of engineering consultants assisting the CMA on technical engineering matters in this determination.
WRMP	Water Resources Management Plan.
WRP	Water resources plus.
WTW	Water treatment works.
WW	Wholesale water.
WWTW	Wastewater treatment works.
Yorkshire Water (or 'YKY')	Yorkshire Water Services Limited (also referred to as 'YKY' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).