SRN-DDR-0014: Water Treatment Economies of Scale Cost Adjustment Claim

Cost Adjustment Claim

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Version 1.0

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Cost Adjustment Claim: Economies of Scale

Name of claim	Regional labour costs
Business Plan Tables where botex claim is reported	CW18
Price control the claim relates to	WN+
Total gross value of claim for AMP8	WN+: £932m
Total implicit value of claim for AMP8	WN+: £908m
Total net value of claim for AMP8	WN+: £24m
Materiality for relevant price controls	WN+: £22m
DPC?	No

What is the claim for?

An efficiently operated small water treatment works (WTW) will have higher costs per unit of output compared with an efficiently operated large WTW. This is supported by our analysis of the relationship between water treatment costs and companies' average WTWs size, as we demonstrate in section 1.6, econometric evidence. An adjustment is necessary to account for these economies of scale and ensure a sufficient cost allowance is provided to those companies with proportionally greater output from smaller water treatment works.

Ofwat has recognised that economies of scale is an important factor to take into account in wastewater treatment and has used various cost drivers, such as the 'weighted average wastewater treatment size', to account for it in econometric models. Ofwat has to date failed to apply the same logic to capture economies of scale in water treatment. This claim applies a similar Weighted Average Treatment Size to capture economies of scale in water treatment.

Southern Water's supply area is challenging. It operates 16 water resource zones across 6 non-contiguous areas, with relatively small and numerous WTWs, given borehole water sourcing and multiple smaller towns which results in a relatively small number of connections per WTW.

Our claim is for a modelling adjustment to provide a sufficient cost allowance for operating in a region with a proportionally greater output from smaller water treatment works, which is not mitigated by the population density factor included in Ofwat's econometric models. We believe without such recognition of water treatment economies of scale, cost allowances derived through the models would not correctly remunerate efficient costs, and hence would be unreasonable.

This claim was originally raised as further evidence in December 2023 and submitted as a report in January 2024. The claim further develops the South East Water cost adjustment claim and provides robust evidence for a water economies of scale factor similar to the wastewater weighted average treatment size factor. Following feedback from Ofwat, we were informed that this would not be considered for the draft determination but should be submitted in our draft determination response for consideration at final determination. Our claim is material, well evidenced and particularly applicable to Southern Water due to its unique operational circumstances. We believe that this is important additional evidence that should be considered for the final determination.

Test	Brief summary of evidence to support claim
Need for cost adjustment	An efficiently operated small water treatment works (WTW) will have higher costs per unit of output compared with an efficiently operated large WTW. An adjustment is necessary to account for these economies of scale and ensure a sufficient cost allowance is provided to those companies with proportionally greater output from smaller water treatment works. Ofwat has recognised this issue in wastewater treatment and has captured economies of scale at wastewater treatment in its econometric models through various cost drivers, including a 'weighted average wastewater treatment size'. Ofwat has to date failed to apply the same logic to capture economies of scale in water treatment. This claim applies a similar Weighted Average Treatment Size to capture economies of scale in water treatment.
Uniqueness	Southern Water's supply area is challenging. It operates across 6 non-contiguous zones with relatively small and numerous water treatment works (WTWs), given bore-hole water sourcing and multiple smaller towns. Most companies (12) have either 1 or 2 contiguous zones. Southern has the most (6).
Management Control	The economies of scale are largely beyond management control. This is because the size (and therefore number) of WTWs depends on factors such as the size of water resources (small underground borehole sources are common in the South) and the location of demand (multiple small towns).
Materiality	The claim is material at 1.1% for WN+ of totex allowances.
Adjustment to allowances	Our claim covers the additional funding required to accommodate the diseconomies of scale of smaller treatment works in our region. In our approach, we added an additional cost driver for average weighted size of works (Water-WATS) to the existing Ofwat specifications of the Water Resource Plus (WRP) models. The results showed that the Water-WATS worked well in Ofwat's WRP models. Its sign is negative, as expected, and its statistical significance is generally good. Other model diagnostics such as the R-squared and the RESET test remain practically the same. The range of efficiency scores, which is noticeably high in WRP models, reduces from about 1.6 to about 1.28. The inclusion of the Water-WATS variable resulted in a £24m cost adjustment effect for Southern Water.
Cost Efficient	The value of the CAC is derived from robust econometric models (which are based on Ofwat consultation models) and includes catch-up and frontier shift efficiency challenges.
Need for Investment	Not Applicable
Best option for customers	Not Applicable
Customer Protection	Not Applicable

1. Need for Adjustment

Southern Water's base costs are affected by diseconomies of scale at water treatment works not captured in the econometric models.

The cost of efficiently operating small water treatment works (WTW) is, inherently, proportionally more expensive compared with efficiently operating large WTW. This is supported by our analysis of the relationship between water treatment costs and companies' average WTWs size, as we demonstrate in section 1.6, econometric evidence. Southern Water's supply area is challenging for two reasons. First, we operate relatively small and more numerous water treatment works as a result of reliance on bore-hole water sourcing and demand concentrated in multiple smaller towns. Second, we operate 6 non-contiguous areas (as shown in Figure 1) compared to the majority of companies operating in 1 or 2 areas and therefore have less scope to consolidate into fewer, larger works. Southern Water is, therefore, impacted by the failure of the models to capture the diseconomies of scale at water treatment works.

Figure 1: Southern Water area of operation

Below we set out the relevant information to justify the need for an adjustment, which is the key assessment gate for this claim. The relevant information includes:

- Evidence that Southern Water faces unique circumstances.
- Econometric evidence for the adjustment.

1.1. Southern Water's unique circumstances

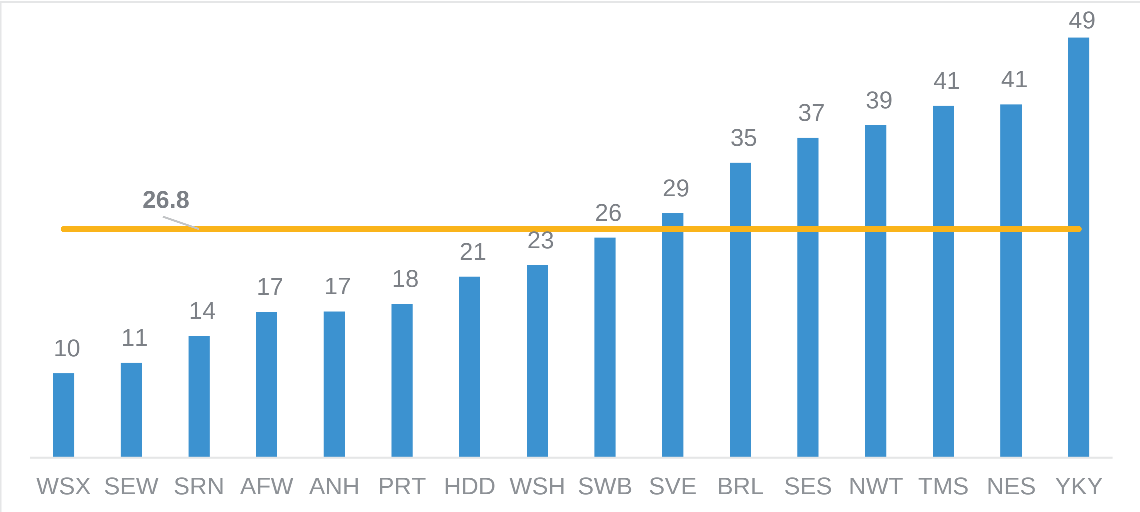
From an engineering point of view, there are economies of scale in water and wastewater treatment, just as there are with other infrastructure utilities. An efficiently operated small water treatment works (WTW) will have higher costs per unit of output compared with an efficiently operated large WTW as a result of costs increasing proportionally less than output. For example, the capital maintenance of 10 small pumps is significantly more expensive than the maintenance cost of one large pump, 10 times the size.

Indeed, larger water treatment works benefit from economies of scale, with reduced operational costs such as labour, capital maintenance, water quality testing, telemetry and materials. Conversely, smaller sites are inherently more inefficient, with higher maintenance and labour costs per unit of water produced. Material costs are proportionally higher at smaller sites, with smaller assets more expensive than larger assets per volume of water produced, and maintenance or replacement of smaller assets similarly less efficient, with little difference in the time and resource to replace smaller assets.

Labour costs are also more expensive across a large number of small sites, with staff required to travel to multiple sites to undertake scheduled work. These site visits are less efficient as some maintenance tasks on smaller sites are less frequent and not required on each visit. Multiple disciplines, e.g., mechanical, electrical and Instrumentation, Control and Automation (ICA) are all needed to undertake maintenance, which results in additional staff visits and travel time. Additionally, more remote sites often have less reliable power infrastructure, increasing the number of required unplanned visits to the sites to restart assets and processes after power blips. Therefore, maintenance, labour and materials are all proportionally higher for smaller sites than larger treatment works. At Southern Water, our management accounting processes assign such costs to larger treatment hubs and therefore detailed accounting costs for small sites is not available.

Recognising the above, Ofwat has attempted to capture economies of scale at treatment in its econometric models. In wastewater models, it has done so using variables such as 'the proportion of load treated in size bands 1-3', 'the proportion of load treated at works of over 100k population' and the 'weighted average treatment size' (WATS). In water models, it has done so using the density variable, which is not as directly related to the actual size of a company's treatment works as the variables used for wastewater. Figure 2 shows that Southern Water has relatively small number of connections per WTW.

Figure 2: Connections (1000s) per WTW*



* Based on APR data of 2021-22.

In this claim we provide evidence of economies of scale at water treatment. Specifically, we provide econometric evidence about the relationship between water treatment costs and companies' average WTWs size. We do this by using a similar variable to that already used in the wastewater models, the WATS. To distinguish, we will call it WATS-water.[1]

We consider that the econometric evidence presented in this claim, alongside the engineering rationale and the equivalence to Ofwat's approach in wastewater, supports a cost adjustment for materially affected companies, such as South East Water and Southern Water. Indeed, as Figure 3 shows, Southern Water and South East Water are two outliers in capturing economies of scale through the density variable that Ofwat

[1] A potentially better abbreviation for the WATS variables, should they become part and parcel in Ofwat's cost assessment framework, is WATS for water and WWTS for wastewater.

uses in its water econometric models. Without such recognition of water treatment economies of scale, we believe that cost allowances derived through the models would not correctly remunerate efficient costs, and hence would be unreasonable.

We are proposing a symmetrical sector-wide cost adjustment. As with other sector-wide adjustments proposed by Ofwat at draft determination, such as mains replacement and meter replacement, the adjustments are applied to all companies and, by their very nature, are not unique to a specific company. This is a similar sector-wide adjustment which is not relevant or unique to one company alone. We believe that the water treatment economies of scale should ideally be included in the water econometric models, but in the absence of such a factor, we believe a sector-wide cost adjustment is appropriate.

Ofwat has recognised this issue in wastewater treatment and has captured economies of scale at wastewater treatment in its econometric models through various cost drivers, including a 'weighted average wastewater treatment size'. Ofwat has to date failed to apply the same logic to capture economies of scale in water treatment.

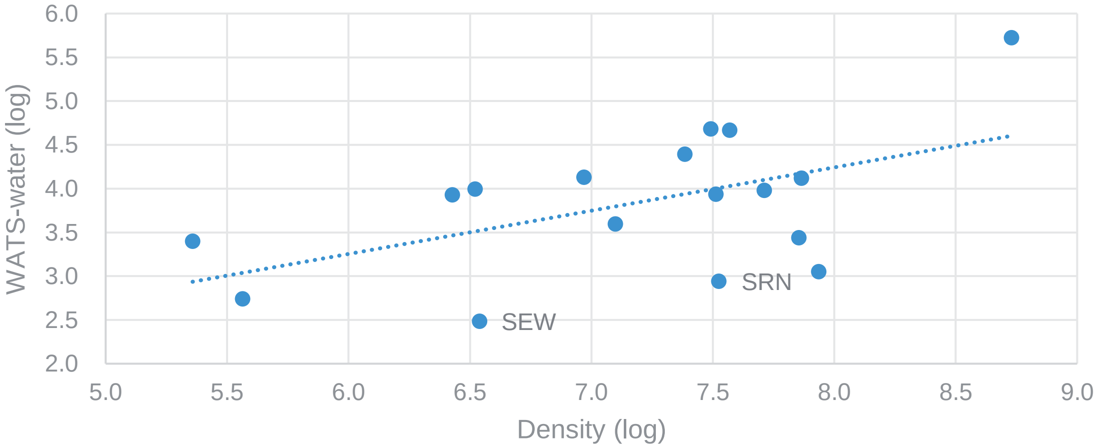
1.2. South East Water's cost adjustment claim

South East Water (SEW) submitted a CAC precisely on the issue above. SEW argues that due to factors beyond its control (e.g., its operating environment relies on many small boreholes with physical and environmental constraints on their consolidation) it must operate relatively small and numerous WTWs. This increases the level of its (efficiently incurred) costs compared with companies that can operate large WTWs.

SEW shows that the density variable in Ofwat's models is not well correlated with the average size of companies' WTWs. This means that the density variable on its own does not replace the need to have a more accurate measure of economies of scale. Furthermore, SEW materially deviates from the correlation line between density and average size of WTWs. This means that the implications of using the density variable without also using a variable to capture economies of scale more accurately may be relatively material for SEW.

Figure 3 shows the correlation between Ofwat's population density variable (in logs) and our measure of economies of scale, WATS-water. It shows that Southern Water, just like SEW, is materially distant from the linear correlation line. This means that the implications of using the density variable without also using a variable to capture economies of scale more accurately is material for companies, like Southern Water, that have proportionally greater output from smaller water treatment works.

Figure 3: The correlation between Weighted Average Density (WAD-LAD) and WATS-water



SEW's consultants, Oxera, use internal data from SEW to estimate a relationship between WTW size and treatment unit cost and concludes that the models underfund SEW by £27m. Oxera calculate symmetrical adjustments across the sector, which show a very material impact on Southern Water, at circa +£58m vs Ofwat's botex model outputs.[2]

1.3. Evidence on water treatment size band

In their Annual Performance Reports (APRs), companies report to Ofwat information on water treatment for eight different WTW size band.[3] Two pieces of information are reported:

- the number of WTWs per size band; and
- the proportion of total distribution input (DI) treated at each size band.

As far as we are aware, this information is not currently being used by Ofwat in its assessment of water companies' treatment costs. If this information provides useful and credible insight on the relationship between WTWs' size and the cost of treatment, making use of it can improve the setting of efficient cost allowances for the sector, without adding any additional regulatory burden or data requirements.

Figure 4 summarises the information on proportion of DI treated per size band for the period from 2011-12 to 2022-23. As demonstrated in Figure 4, Southern Water as far fewer water treatment works in size bands 7 and no treatment works in band 8 compared with industry average and most other companies. The higher the band the larger the WTWs. Figure 8 in the appendix shows a similar pattern for the year 2023-24.

Table 1: The proportion of water treated at each WTW size band for the period 2011-12 to 2022-23*

Company	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8
ANH	2.6%	7.0%	12.6%	15.5%	17.9%	10.7%	13.1%	20.5%
NES	0.5%	2.2%	2.9%	3.2%	6.2%	12.8%	41.2%	31.0%
NWT	0.2%	0.5%	1.8%	4.9%	6.4%	8.9%	15.6%	61.8%
SRN	**3.2%**	**7.0%**	**15.3%**	**24.1%**	**21.8%**	**18.2%**	**10.5%**	**0.0%**
SWB	0.8%	0.9%	6.8%	13.6%	29.8%	31.2%	16.7%	0.0%
TMS	0.6%	0.8%	2.5%	5.2%	8.2%	5.7%	9.9%	67.1%
WSH	0.2%	3.3%	3.1%	9.9%	12.4%	27.8%	15.5%	27.8%
WSX	5.8%	6.0%	20.1%	30.7%	18.5%	9.7%	8.3%	0.0%
YKY	0.2%	0.6%	2.3%	5.8%	14.5%	32.4%	20.7%	23.5%
AFW	3.6%	6.8%	11.5%	12.1%	19.1%	6.1%	15.4%	25.4%
BRL	0.0%	1.0%	2.8%	6.6%	15.3%	19.0%	23.6%	31.7%
PRT	0.6%	1.2%	8.7%	23.4%	27.1%	13.4%	25.7%	0.0%
SES	0.0%	0.0%	0.2%	2.6%	3.6%	43.3%	50.2%	0.0%
SEW	5.3%	10.3%	17.0%	35.1%	24.4%	8.1%	0.0%	0.0%
SSC	2.4%	4.7%	14.7%	17.9%	12.7%	3.6%	30.9%	13.3%
SVE	1.4%	3.1%	8.1%	11.0%	11.1%	11.9%	13.2%	40.3%

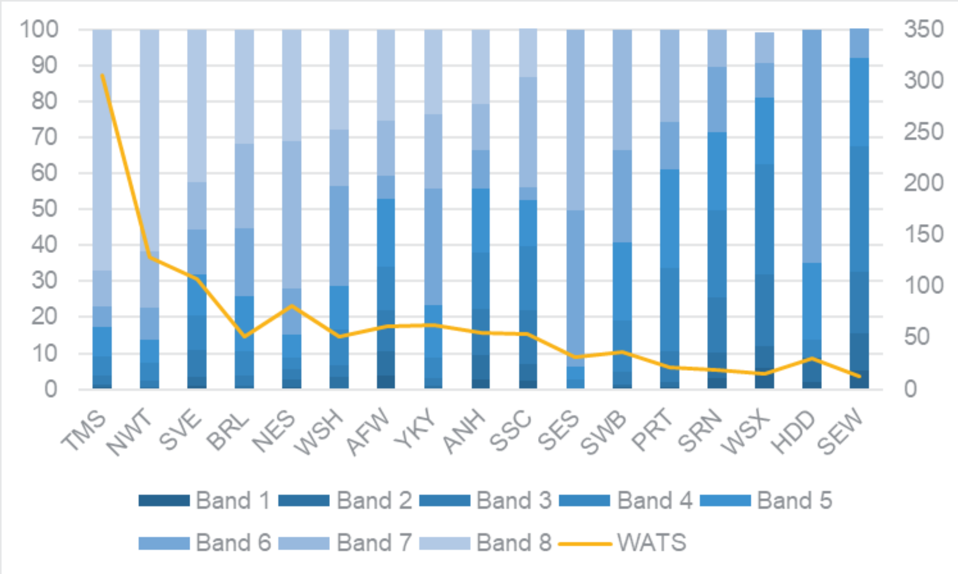
[2] An assessment of South East Water's cost adjustment claims, Oxera, 29 September 2023, pages 75-76.
[3] See Appendix 1 for definitions of size band.

Company	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8
HDD	1.9%	6.8%	0.0%	5.2%	21.1%	65.0%	0.0%	0.0%
Average	**1.7%**	**3.7%**	**7.7%**	**13.3%**	**15.9%**	**19.3%**	**18.3%**	**20.1%**

* See Appendix 1 for band definitions. Source: APR data

Some companies with larger water sources, such as United Utilities and Thames Water treat a high proportion (over 60%) of their water in very large treatment works (Band 8). Other companies, such as Wessex, Southern and South East Water treat a high proportion of water in small to medium works. The following figure 5 illustrates this.

Figure 4: Proportion of water treated by band vs water WATS value, average 2011-12 to 2022-23.*



* See Appendix 1 for band definitions. Source: APR data

Ofwat considered using the information above for PR24 to account for scale economies in water treatment. For its April 2023 consultation, CEPA, its consultants, tested variables that measure the percentage of DI treated at small WTWs (e.g., at bands 1-3) or at large WTWs (e.g. at bands 6-8). However, none of these variables yielded robust and intuitive results. Hence, CEPA recommended to Ofwat not to use them in its econometric models.

The variables tested by CEPA are similar to the variables used in wastewater models (e.g. 'the proportion of load treated in size bands 1-3'). Southern Water and other companies critiqued this type of variable in wastewater. Such variables reduce the eight-band information available in the reported data tables to two bands only. In doing so they discard useful information that explains the relationship between size band and costs in a granular way (consistent with economic intuition), and instead assume that there are only two relevant size bands. n doing so, they discard valid information that explains more granularity about the cost base.

As we show in Section 1.6, we can calculate and use a variable that summarises and retains the full range of information on water treatment by size that is available to us.

1.4. Management Control

These economies of scale are largely beyond management control, as the size (and therefore number) of WTWs depends on factors such as the size of water resources (small underground borehole sources are common in the south) and the concentration and distribution of demand. Southern Water's supply area is challenging. Like other companies in the South, it is operating relatively small and numerous WTWs as a result of our geological conditions and spatial distribution of our population. We abstract water from a large number of boreholes and serve multiple smaller towns. This results in a relatively small number of connections per WTW, as shown in Figure 2.

Our existing water treatment works were built many years ago, impacting our legacy economies of scale. Any management control to rationalise our numerous works to larger works would be on a long timescale to avoid stranding assets.

More importantly, there is limited potential management control available to mitigate the impact of economies of scale through the consolidation to larger sites. Any consolidation is limited by the water resources available in the region. Due to our geology and geography, we do not have access to large rivers which would allow surface water abstraction and investment in new consolidated large treatment works. Instead, we have chalk aquifers which require small boreholes and which, due to hydrological constraints, must be spread across our region. It is also worth noting that the water resources we do currently obtain from surface water rivers are subject to tightening water abstraction licences in the future, further limiting consolidation.

In addition to the water source constraints, Southern Water operates in six non-contiguous areas which limits consolidation, particularly the rationalisation of sites to very large treatment works such as that operated by United Utilities and Thames Water.

1.5. Materiality

Ofwat sets a materiality threshold for Cost Adjustment Claims below which it considers claims to be immaterial. We have calculated materiality thresholds for the Water Network Plus price control, based on our AMP8 efficient totex.

Table 2: Materiality Thresholds

Price control	Expected AMP8 totex	Materiality threshold (%)	Materiality amount (£m)
WN+	£2186m	1%	£22m

The table below summarises the materiality of the claim. We found that the water network plus part of the claim passed the threshold at 1.1% of the expected threshold.

Table 3: Materiality test

Price control	Threshold (£m)	Net value of the claim (£m)	Claim as % of totex	Status
WN+	£22m	£24m	1.1%	Pass

1.6. Econometric evidence for the adjustment

Based on the information from the APRs, we calculated a weighted average WTW size per company as follows:

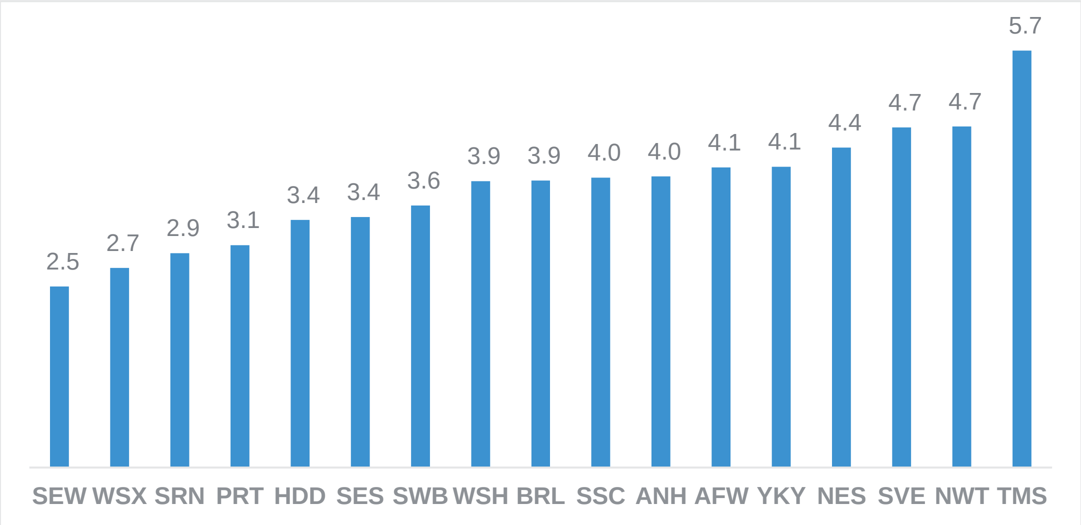
$$WATS_{water\,j,t} = \sum_{i=1}^{8} \frac{(volume\ of\ water\ treated\ in\ band\ i)_{j,t}}{(Number\ of\ WTWs\ in\ band\ i)_{j,t}} * (\%\ volume\ treated\ in\ band\ i)_{j,t}$$

In this formula, *j* denotes a company, *i* denotes a WTW size band, and t is a year.

This variable is similar to the WATS variable Ofwat has used in wastewater treatment models in its consultation. We take the natural logarithm of the variable before putting it into the econometric specification.

The variable is an improvement on alternative simpler variables, such as the unweighted average volume of water treated per WTW. The unweighted variable effectively assumes a fixed weight of 1/8 for each size band in the formula above. However, if a company treats a large proportion of its water at the smallest band or the highest size band, we will want to reflect that in the metric, as this would have implications on costs. Figure 6 shows the WATS-water variable for each company.

Figure 5: The WATS-water variable*



Note:* In logs, average across the entire period, 2011-12 to 2022-23

We tested WATS-water in Ofwat consultation's water resources plus (WRP) models. These models include water treatment costs. Our approach was similar to the approach taken by CEPA, namely we added the WATS as an additional cost driver to the existing specifications of the WRP models.

Figure 7 compares WRP modelling results with and without the WATS-water. The results show that the WATS-water variable works well in Ofwat's WRP models. Its sign is negative, as expected, and its statistical significance is generally good. Other model diagnostics such as the R-squared and the RESET test are marginally better than the models without WATS-water as a cost driver. More importantly, rhe range of efficiency scores, which is noticeably high in WRP models, reduces from about 1.6 to about 1.28. This indicates that the outcome of the new model is an improved allocation of funding amongst the companies in the sector through a more appropriate specification of the model.

Figure 6: Modelling results with WATS-water

	Ofwat's consultation models (ie no WATS-water)						+ WATS-water					
	WRP1	WRP2	WRP3	WRP4	WRP5	WRP6	WRP1	WRP2	WRP3	WRP4	WRP5	WRP6
Properties	1.084***	1.079***	1.060***	1.057***	1.030***	1.025***	1.145***	1.145***	1.137***	1.144***	1.092***	1.095***
Water treated 3-6 (%)	0.005***		0.005***		0.005***		0.006***		0.006***		0.007***	
Treatment complexity (WAC)		0.437 (0.12)		0.414 (0.15)		0.459*		0.549 (0.10)		0.565*		0.580*
WAD LAD	-1.617***	-1.505**					-2.178***	-2.102***				
WAD LAD ^2	0.102***	0.094**					0.145***	0.139**				
WAD MSOA			-5.205**	-5.113**					-6.834***	-6.937**		
WAD MSOA ^2			0.318**	0.311**					0.425***	0.431**		
Properties/km					-8.043**	-7.586**					-11.073**	-10.874**
Properties/km ^2					0.894**	0.837**					1.264**	1.238**
WATS-water							-0.122 (0.11)	-0.136 (0.20)	-0.160**	-0.182*	-0.130*	-0.148 (0.18)
R2	0.906	0.901	0.897	0.894	0.906	0.902	0.908	0.9	0.902	0.897	0.906	0.9
RESET (p-value)	0.504	0.411	0.786	0.653	0.436	0.282	0.652	0.355	0.666	0.263	0.367	0.118

Note: *** indicates 1% significance level; ** indicates 5% significance level; * indicates 10% significance level. Absence of stars indicates a lower level of statistical significance. Results are based on a 'random effects' estimation using panel data from 2011-12 to 2022-23.

1.7. Adjustment to allowances

Using the models above, we calculated indicative cost adjustment for the water network plus controls. These are presented in Figure 8. The adjustments are indicative as, in practice, they would depend on the specific approach to forecasting the cost drivers and the efficiency challenge used.

Overall, the results are in line with expectation for the majority of companies. For example, for companies with clear lack of economies of scale, such as SEW and Southern Water, the results show a positive cost adjustment which is significant in terms of % impact.

It is worth noting that including the WATS-water variable slightly increases the scale (properties) variable coefficient. This is likely due to the positive correlation of WATS-water with the scale variable. As a result, a small number of companies with a high WATS-water and a high number of properties will have a positive cost adjustment, because the positive impact of the scale variable is larger than the negative impact of WATS-water.

Table 4: Cost adjustment effect of the inclusion of water-WATS

Company	Cost adjustment (£m, 2022-23 prices)	% impact
AFW	13	1.0%
ANH	-17	-0.9%
BRL	-3	-0.7%
HDD	- 2	-1.5%
NES	- 5	-0.3%
NWT	-39	-1.4%
PRT	1	0.7%
SES	0	0.0%

Company	Cost adjustment (£m, 2022-23 prices)	% impact
SEW	29	3.3%
SRN	24	2.6%
SSC	-6	-1.0%
SVE	-5	-0.2%
SWB	1	0.1%
TMS	98	2.0%
WSH	-3	-0.3%
WSX	6	1.0%
YKY	10	0.6%

When making efficiency comparisons across companies it is crucial to capture differences in operating environments that lead to differences in efficient cost. Companies access to scale economies in water and wastewater treatment is one difference, largely dictated by the operating environment, which must be controlled for in efficiency comparisons.

In wastewater treatment, the variable that measures companies access to scale economies has evolved and – we believe – has improved since PR19 due to the introduction of the WATS. The same has not happened in water, where population density is still being used to capture access to scale economies. As Figure 3 shows, the density variables are poorly corelated with average WTW size and are not fit for purpose.

Evidencing the effect of an exogenous variable on cost is often not easy. Lack of data, or imperfect data combined with a small sample, often make it hard to present results with the statistical robustness that meets the high bar that Ofwat has set. Nonetheless, the engineering and economic rationale for scale economies at treatment are strong.

SEW presented a useful cost adjustment claim with a credible approach to quantify the required adjustment. In this claim we seek to strengthen SEW's claim by providing an alternative approach. Our approach sought to evolve the economies of scale variable in water in the same way that it has evolved in wastewater.

We consider that the evidence we are providing is sufficiently compelling to justify a cost adjustment, at least for the materially affected companies. For Southern Water, this equates to a cost adjustment of £27.940m. It would be reasonable to provide an adjustment to companies where (i) the impact is clearly material, and (ii) there is clear evidence of diseconomies of scale at water treatment works. This is clearly the case for Southern Water and South East Water (as evidenced in Figures 2, 3, 4 and 7), which have both submitted a cost adjustment claim on this matter.

This analysis, alongside the analysis conducted by South East Water is addressing an important omission in the botex models. We believe that without recognition of water treatment economies of scale, cost allowances derived through the models would not correctly remunerate efficient costs, and hence would be unreasonable.

1.8. Draft determination response

At Draft Determination, Ofwat rejected South East Water's claim on water treatment economies of scale. In its response, Ofwat stated that it tested the proportion of distribution input treated in different size bands and combinations of size bands in the base cost models. However, Ofwat found that "the estimated coefficients often had the counterintuitive sign and were statistically insignificant." As demonstrated in prior sections, we have derived a variable to represent economies of scale in water treatment that works in the base cost models.

In section 1.6, we derive a variable which is continuous and does not rely on discretely defined categories. With regard to the principle of parsimony in building econometric models, only some of these categories can be used in any specification which implies discarding pertinent information. The WATS-water variable avoids this problem by utilising all relevant information. We find that in the base costs models, the variable performs well and offers improvements relative to the model without this direct measure of economies of scale.

Other variables, such as population density, do not account for the impact of the water treatment economies of scale variable. Our analysis has shown a poor correlation between population density and the WATS-Water variable in logarithm scale (see Figure 9 below). This is the correct technique as the base models use variables in logarithm scale.

Table 5: Correlation between population density and WATS-Water

	lnWATS
lnWAD_MSOAtoLAD_population	0.560015714
lnWAD_MSOA_population	0.527824784
lnpropperlength	0.475130794

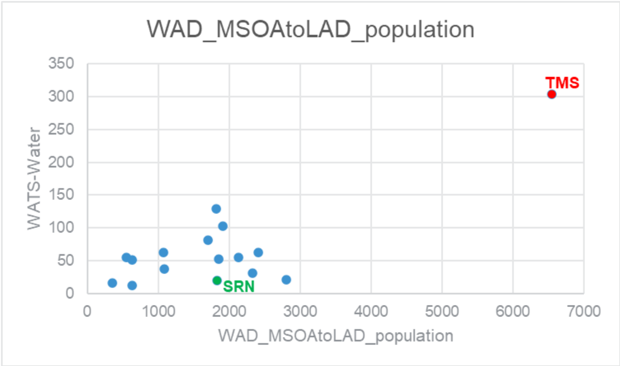
The correlation further reduces when you remove Thames Water which is an extreme outlier, skewing the correlation.

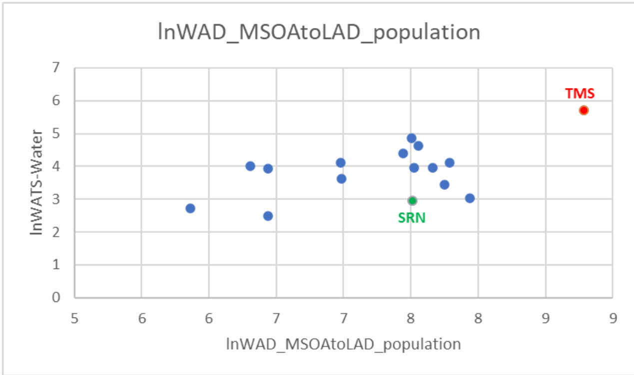
Table 6: Correlation between population density and WATS-Water without TMS

	lnWATS
lnWAD_MSOAtoLAD_population	0.383671458
lnWAD_MSOA_population	0.26414097
lnpropperlength	0.238061626

The poor correlation between density and economies of scale in water treatment is further illustrated in the scatterplots below (Figure 11), in logarithmic and in the original scale of the variables. For illustration purposes, we plot the WATS-water variable against one measure of density – WAD_MSOA to LAD_population, but the same pattern also applies to the other alternative measures of density. The scatterplots illustrate why water treatment economies of scale is poorly correlated with density. Whilst Thames Water has the highest population density and a small number of very large sites, other companies in the South East (like Southern Water) have moderate density but many small sites by virtue of geology which limits management ability to consolidate sites. The scatterplots also show Thames as an extreme outlier and remains an outlier even when both variables are transformed in logarithmic scale. This clearly demonstrates that population density does not account for water treatment economies of scale for Southern Water and other similar companies with moderate population density and a high number of small sites.

Figure 7: Scatterplots of population density and WATS-Water





2. Cost Efficient

We consider that the value of the claim is efficient given the strength of the models on which it is based (which are based on Ofwat consultation models); the strong underlying rationale; and that we further applied efficiency challenges to the results of the models.

This is the same way that Ofwat would conclude that any variable included in its models has an appropriate and efficient impact on companies, namely, through the engineering rationale and the statistical performance of the variable/model.

The actual value of the adjustment may vary depending on Ofwat's final choice of models and efficiency assumptions.

3. Need for Investment (where appropriate)

Not Applicable

4. Best Option for Customers (where appropriate)

Not Applicable

5. Customer Protection (where appropriate)

Not Applicable

Appendix 1 – Water Treatment Works' Size Bands

Table 7: Water Treatment Works' size bands in Ofwat's Regulatory Accounting Guidelines

Size band	Maximum Production Capacity Ml/d
Band 1	< 2
Band 2	≥ 2 and < 4
Band 3	≥4 and < 8
Band 4	≥8 and < 16
Band 5	≥16 and < 32
Band 6	≥32 and < 64
Band 7	≥64 and < 128
Band 8	≥ 128

Source: Ofwat's RAG 4.10 – Guideline for the table definitions in the annual performance report. Page 101.

Table 8: Proportion of water treated at each WTW size band for the year 2023-24

Company	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8	Total
ANH	1%	2%	11%	18%	12%	22%	6%	28%	**100%**
HDD	1%	8%	-	-	26%	65%	-	-	**100%**
NES	0%	1%	3%	3%	4%	15%	32%	42%	**100%**
NWT	0%	1%	2%	6%	8%	8%	15%	62%	**100%**
SRN	1%	6%	15%	19%	26%	16%	18%	-	**100%**
SVE	1%	2%	6%	10%	12%	13%	14%	43%	**100%**
SWB	0%	1%	1%	14%	17%	20%	47%	-	**100%**
TMS	0%	1%	2%	6%	9%	6%	10%	67%	**100%**
WSH	0%	3%	3%	9%	12%	27%	17%	28%	**100%**
WSX	4%	3%	12%	35%	29%	-	16%	-	**100%**
YKY	0%	0%	3%	5%	26%	26%	16%	24%	**100%**
AFW	3%	4%	12%	10%	18%	10%	-	43%	**100%**
BRL	-	1%	3%	6%	15%	18%	32%	26%	**100%**
PRT	-	-	12%	30%	22%	19%	17%	-	**100%**
SES	-	-	-	3%	2%	44%	51%	-	**100%**
SEW	6%	11%	18%	33%	26%	7%	-	-	**100%**
Average	**1%**	**3%**	**6%**	**13%**	**17%**	**20%**	**18%**	**23%**	**100%**

Source: Annual Performance Reports