Economies of scale in water treatment

Southern Water

January 2024

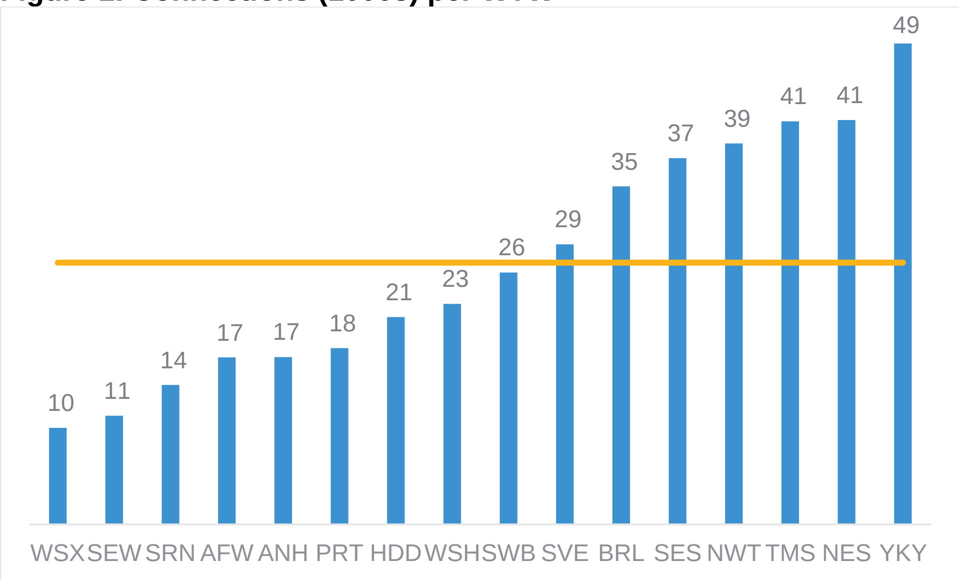
Summary and purpose

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. 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), the concentration of demand, and the fact that most facilities have already been built.

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.

Southern Water’s supply area is challenging. Like other companies in the South, it is operating relatively small and numerous WTWs, given borehole water sourcing and multiple smaller towns. Figure 1 shows that Southern Water has relatively small number of connections per WTW.

Figure 1: Connections (1000s) per WTW*



* Based on APR data of 2021-22.

In this note we provide evidence of economies of scale at water treatment. Specifically, we provide econometric evidence about the relationship between 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 ask Ofwat to take this evidence into account in its draft and final PR24 determinations, given the sufficient time still available in the price review. This note is **effectively** a cost adjustment claim (CAC) by Southern Water, we have set out the summary of this CAC in annex 2. We have not submitted it with our business plan because there was not time to develop our internal evidence to sufficiently pass the high bar Ofwat's sets for CACs. Having looked across business plans to understand where we can challenge ourselves further and where we can learn from approaches taken by others (as Ofwat expects companies to do), we have managed to develop better evidence, which we provide in this note.

We consider that the econometric evidence presented in this note, 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. 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.

In the remainder of this note we discuss:

- South East Water's CAC in relation to lack of economies of scale at water treatment;
- Information available in Ofwat's APRs on water treatment per WTW size band;
- The weighted average water treatment size (WATS-water) metric;
- Econometric evidence of economies of scale in water treatment; and
- Implications on cost adjustments.

South East Water's cost adjustment claim

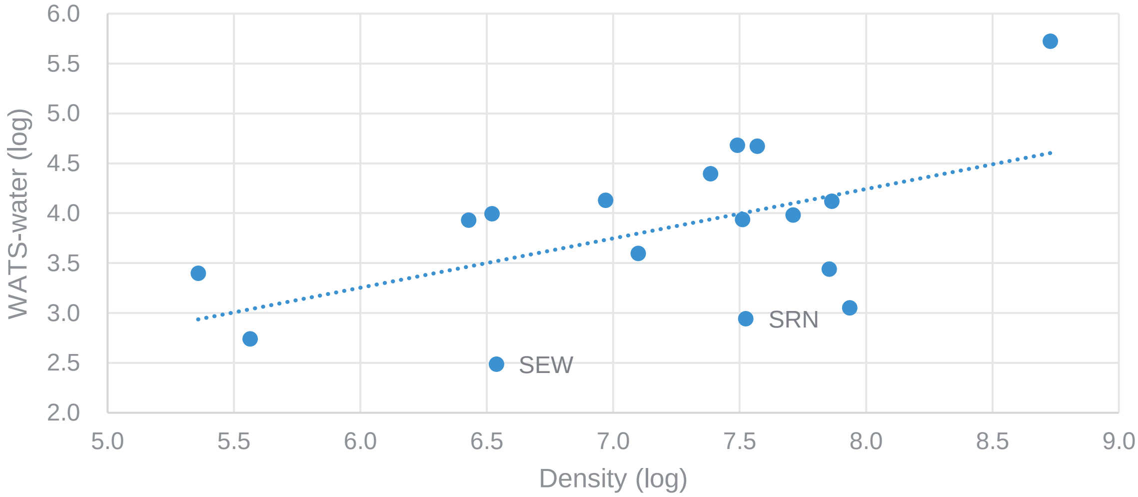
South East Water (SEW) submitted a CAC precisely on the issue above. SEW argues that due to factors beyond its control (e.g. its operating environment relies on many small boreholes with physical and environmental constraints on their consolidation) it must operate relatively small and numerous WTWs.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

[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.

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. Further, 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 2 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.

Figure 2: 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.[2]

Information on water treatment per size band in Ofwat's Annual Performance Reports (APRs)

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

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

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

As far as we know, 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 cost allowances for the sector.

Figure 3 summarises the information on proportion of DI per size band for the year 2020-21.

Figure 3: The proportion of water treated at each WTW size band*

Company	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8	Total
ANH	0.6%	1.9%	11.0%	17.8%	12.3%	22.0%	6.2%	28.1%	**100%**
HDD	1.1%	7.9%	-	-	25.8%	65.3%	-	-	**100%**
NES	0.4%	1.2%	2.9%	2.8%	4.3%	14.9%	31.5%	42.0%	**100%**
NWT	0.2%	0.6%	1.5%	5.5%	7.8%	7.9%	14.7%	61.8%	**100%**
SRN	1.3%	5.5%	14.6%	18.7%	25.9%	16.1%	17.8%	-	**100%**
SVE	0.7%	1.8%	6.4%	10.1%	11.7%	12.7%	13.9%	42.7%	**100%**
SWB	0.2%	1.0%	0.5%	14.4%	16.8%	19.7%	47.4%	-	**100%**
TMS	0.4%	0.8%	2.0%	5.5%	8.7%	5.9%	10.2%	66.5%	**100%**
WSH	0.1%	2.9%	3.0%	9.4%	12.2%	27.3%	17.0%	28.0%	**100%**
WSX	4.1%	3.3%	12.0%	35.1%	29.4%	-	16.1%	-	**100%**
YKY	0.4%	0.4%	3.2%	5.0%	25.8%	25.5%	16.0%	23.7%	**100%**
AFW	2.5%	3.9%	12.1%	10.1%	18.1%	10.1%	-	43.2%	**100%**
BRL	-	0.6%	2.6%	5.9%	15.2%	18.2%	31.9%	25.6%	**100%**
PRT	-	-	11.8%	30.1%	21.5%	19.2%	17.4%	-	**100%**
SES	-	-	-	2.7%	2.1%	44.4%	50.8%	-	**100%**
SEW	5.5%	10.6%	17.5%	33.1%	26.2%	7.1%	-	-	**100%**
Average	**1.1%**	**2.6%**	**6.3%**	**12.9%**	**16.5%**	**19.8%**	**18.2%**	**22.6%**	**100%**

* See Annex 1 for band definitions.

Some companies with larger water sources, such as United Utilities and Thames Water treat a high proportion of their water in very large treatment works. Other companies, such as Wessex, Southern and South East Water treat a high proportion of water in small to medium works.

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 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 variables in wastewater, arguing that such variables do not reflect the full range of WTW sizes. Instead, they arbitrarily assume a single boundary between lower costs and higher cost size bands, and reduce the eight-band information granularity to two bands only.

As we show in the next section, 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.

The weighted average treatment size (WATS-water) metric

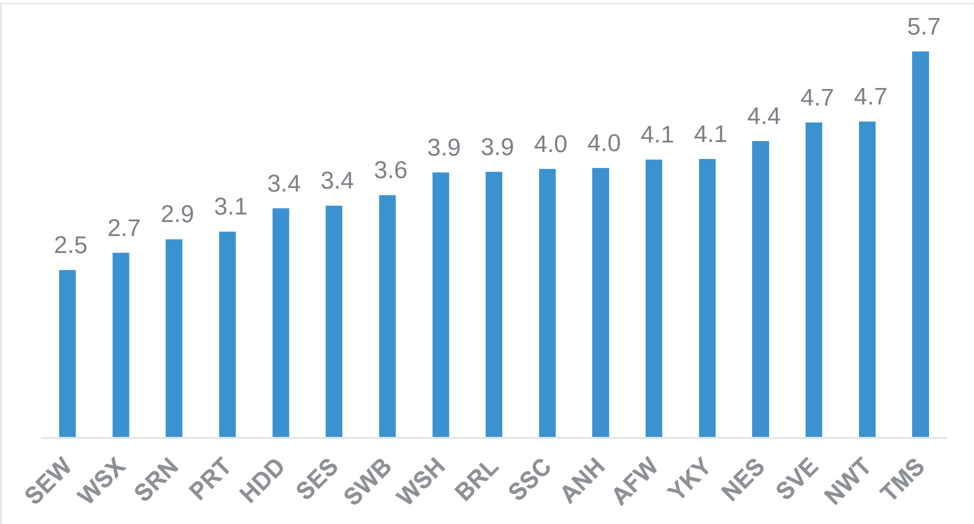
Based on the information from the APRs, we calculated a weighted average WTW size per company as follows:

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

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.

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. This is what WATS-water does.

Figure 4: The WATS-water variable*



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

Statistical evidence

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 5 compares WRP modelling results with and without the WATS-water. The results show that the WATS 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 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.

Figure 5: 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***	1.146***	1.146***	1.137***	1.144***	1.092***	1.096***
Water treated 3-6 (%)	0.005***		0.005***		0.005***		0.007***		0.006***		0.007***	
Treatment complexity (WAC)		0.437 (0.12)		0.414 (0.15)		0.459*		0.555 (0.10)		0.569*		0.585*
WAD LAD	-1.617***	-1.505**					-2.194***	-2.126***				
WAD LAD ^2	0.102***	0.094**					0.146***	0.141**				
WAD MSOA			-5.205**	-5.113**					-6.865***	-6.984**		
WAD MSOA ^2			0.318**	0.311**					0.427***	0.434**		
Properties/km					-8.043**	-7.586**					-11.192**	-11.040**
Properties/km ^2					0.894**	0.837**					1.279**	1.258**
WATS-water							-0.125*	-0.14 (0.17)	-0.163**	-0.185*	-0.134*	-0.15 (0.16)
R2	0.906	0.901	0.897	0.894	0.906	0.902	0.908	0.901	0.903	0.898	0.906	0.9
RESET (p-value)	0.504	0.411	0.786	0.653	0.436	0.282	0.654	0.371	0.698	0.297	0.37	0.123

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.

Implications on cost adjustments

Using the models above, we calculated indicative cost adjustment for the water network plus controls. These are presented in Figure 6. 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, Southern Water and Wessex Water, the results show a positive cost adjustment.

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.

Figure 6: Cost adjustment effect of the inclusion of water-WATS

Company	Cost adjustment*	% impact of network plus model
AFW	+22	1.9%
ANH	-10	-0.6%
BRL	-3	-0.7%
HDD	-1	-1.2%
NES	-5	-0.3%
NWT	-37	-1.5%
PRT	+1	0.7%
SES	0	0.0%
SEW	+32	4.0%
SRN	+28	3.3%
SSC	-3	-0.6%
SVE	-4	-0.1%
SWB	+1	0.1%
TMS	+96	2.1%
WSH	-4	-0.3%
WSX	+6	1.1%
YKY	+12	0.7%

* £m of 2022-23.

Conclusions

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. The density variables, however, 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 note 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 incorporation of the variable to Ofwat's PR24 econometric modelling specifications or asymmetric cost adjustments for materially affected companies. We believe that this analysis, t alongside the analysis conducted by South East Water is addressing a long-standing omission in the botex models. We ask Ofwat to take this analysis into account in its draft and final PR24 determinations, given the sufficient time still available in the price review. 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.

Annex 1 – Water Treatment Works' Size Bands

Table A1: 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.

Annex 2 – Cost Adjustment Claim

Water Economies of Scale

Name of claim	Regional labour costs
Business Plan Tables where botex claim is reported	CW18 (TBA)
Price control the claim relates to	WN+
Total gross value of claim for AMP8	WN+: £2186m
Total implicit value of claim for AMP8	WN+: £2158m
Total net value of claim for AMP8	WN+: £28m
Materiality for relevant price controls	WN+: £22m
DPC?	No

Cost Adjustment Claim Tests

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 (similar to the Weighted Average Treatment Size adjustment applied to the wastewater network plus econometric models).
Uniqueness	Southern Water's supply area is challenging. It operates relatively small and numerous water treatment works (WTWs), given bore-hole water sourcing and multiple smaller towns.
Management Control	The 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 of demand.
Materiality	The claim is material at 1.3% 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 the region. In our approach, we added an additional cost driver for average weighted size of works (Water-WATS) to the existing 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 £28m cost adjustment effect for Southern Water.
Cost Efficient	The cost of efficiently operating small water treatment works (WTW) is, inherently, proportionally more expensive compared with efficiently operating large WTW. SEW showed within their submitted CAC 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, both Southern Water and South East Water 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 is material for companies, like Southern Water, that have proportionally greater output from smaller water treatment works.
Need for Investment	Not Applicable
Best option for customers	Not Applicable
Customer Protection	Not Applicable