Comments on Base Modelling

PR24 Draft Determination Representations – August 24

Contents

Summary of proposals

In this document, we propose a range of adjustments to Ofwat's Draft Determination base cost models. The following table looks at each one in isolation and evaluates them.

It is very important to note that these uplifts are **not** additive. They are all relative to the baseline for each individual modification. It would thus be wrong to sum all of the impacts together to reach a total impact figure.

In the case of the All Models changes, these represent alternatives. You would implement AMP dummies or starting from the start of AMP6 but not both together.

With the impact of adding in 2024 data, while the figure quoted is small and negative, the impact on various changes proposed can be much larger - and positive.

All of these impacts are totals for the appointed business. The changes at a price control level may be more significant.

£m, 2022/23 PB	Post FS & RPE impact on modelled total	Comment
All models:		
Data panel runs from start of AMP6: Water	120.5	The impact on Wholesale Water of using a eight year panel from 2016 to 2023
Use AMP6 & AMP7 dummies: Water	91.6	The impact on Wholesale Water of including separate dummies for both AMP6 costs and AMP7 costs
Data panel runs from start of AMP6: Water Recycling	58.6	The impact on Wholesale Water Recycling Network Plus of using a eight year panel from 2016 to 2023
Use AMP6 & AMP7 dummies: Water Recycling	68.3	The impact on Wholesale Water Recycling Network Plus of including separate dummies for both AMP6 costs and AMP7 costs
Include 2024 data	-1.0	Impact on all DD Wholesale and Retail models of adding 2024 data
Water models:		
Lack of rainfall (include Water Resource Plus APH)	32.7	The impact of adding APH for Water Resources Plus to each of the Water Resources Plus models
Include total APH in total cost models	45.6	The impact of adding Total APH to each of the Total Water cost models in place of the APH for Treated Water Distribution
De-emphasise PS/L models	33.1	The impact of giving the Pumping Station / Length models zero weight in both the Treateed Water Distribution models and in the Total Water models

£m, 2022/23 PB	Post FS & RPE impact on modelled total	Comment
Water Recycling Network Plus models:		
Reinstate models without rainfall variable	89.3	The impact on the Water Resource Network Plus models of reinstating the models which exclude the urban rainfall variable
Move consents to unmodelled	-42.4	The negative impact of taking consents from the modelled total is £42m. This is offset in unmodelled by including the £51m consent fees expected in our BP plus the additional £38m now expected as a result of EA actions. Net impact is thus +£46m
Bioresources models:		
Model as Botex	4.4	The impact on the Bioresouces unit cost models of excluding Bioresources growth from the models, transforming them from Botex Plus to Botex
Reinstate total cost models	14.3	The impact of reinstating the Total cost models alongside the unit cost models
Sludge growth modelled separately	Not evaluated	We did not have sufficient time during the Draft Determination Representations window to develop a model for Bioresources growth
Retail models:		
Include forward look	11.6	The impact of following the PR19 approach to Retail cost assessment. At PR19, Ofwat's catch up efficiency was the triangulation of the historic view used for the Wholesale cost assessment models and a forward view.
Use Ofwat bill sizes in PR24-DD-Base-costs-residential-retail-2.xlsx	-5.0	The impact of using the Ofwat Draft Determination average bill size forecast for us

All base models

We strongly support Ofwat's decision to include the 2024 data in the data panel used to derive the Final Determination models. Using the most recent data available for setting the Final Determination follows the approach taken by Ofwat at PR19 and indeed also by the CMA in its 2020 Redetermination. However, we see no justification for further tightening the catch up efficiency from Upper Quartile given the absence of any improvement in model quality when the additional year's data has been added.

We believe that using the most recent data is even more important at PR24 given the salience of the cost data in that year. In particular, 2023-24 was the year in which the impact of energy cost increases as a consequence of Russia's invasion of Ukraine were made manifest as companies' energy hedges unwound. It is only by including the 2024 data that the full position with regard to energy costs becomes clear.

In Appendix 1, we set out key model quality metrics for the DD Base cost models as published and when 2024 data are added to the data panel. These can be summarised as follows:

For the Wholesale models, extending the data panel to include 2024 data:

1. Sends the coefficient for the booster pumping stations per length of main (PS/L) variable insignificant in both the treated water distribution (TWD) models and in the Total Water Base cost models;
2. Moves the Sewage Collection models from passing the Reset test to failing it;
3. Bioresources Botex Plus Unit Cost models re2 and re3 deteriorate, moving from 2 star to 1 star, with R squared falling and the range of efficiency results increasing;
4. The Bioresources Botex Plus Total Cost models perform better than the Unit Cost models, although the coefficient for the percentage of load treated in Bands 1-3 in model re4 becomes insignificant when the 2024 data are added;
5. Across the board, the Botex versions of the Bioresources models perform better than the Botex Plus versions.

With the addition of 2024 data, the wholesale panel extends to 13 years and the retail panel to 11 years. As we set out below, we consider this to be excessive. We believe there should be a move to a shorter panel, if not now then definitely for PR29.

Overall, the Wholesale DD base cost models deteriorate at the margin when the 2024 data are added while still remaining perfectly viable models. We discuss the implications of points 1 - 5 below, but for now the point we would wish to stress is that given this marginal model quality deterioration, there is no justification for any further tightening of the catch up efficiency level from Upper Quartile at the Final Determination.

For the Retail models, the models' quality remains pretty much unchanged. One of the two Other cost models, re4, sees total number of households move from 1 star to 2 star; the Covid 19 dummy for 2020/21 moves from 0 stars to 1 star in Total cost models re5, re7 and re8. However, for all models, R squared barely moves with the added year. The efficiency ranges all continue to look sensible.

Data panel length and evidence of step changes in data

Given the long data panel and the marked exogenous changes in costs since 2020, we believe that Ofwat should either shorten the panel or employ AMP dummies to recognize marked changes in costs over time.

Currently, the data panel used to develop the base cost models runs from 2012 to 2023. At FD the panel will include 2024 as well. So, at present, the data panel is 12 years. At FD it will be 13 years. Ofwat has long argued that the data panel needs to be longer to ensure more robust models and to allow for a range of variables to be used within the models. There are however two arguments against "the longer the better" approach.

First, the longer the data panel, the less impact each additional year has within the panel. At FD, assuming Ofwat sticks with the current approach, the thirteenth year of data, 2023-24 will be given the same weight as the first year, 2011-12, a weight of 7.7 percent. By contrast, in a five year panel, the additional year has a 20 percent weight. Insofar as companies are becoming more efficient over time, the impact of recent improvement is heavily attenuated by the panel length.

Second, the longer the panel, the more likely it is that changes in the way data are collected and / or recorded may impact the effectiveness of the cost models. For example, the move around the end of AMP5 from UK GAAP to IFRS accounting standards led to a shift in Capital Maintenance levels.

We have looked at the impact of two alternative ways of addressing this issue. Both are robust and effective.

First, we look at the impact of starting the data panel in 2015-16. Such a panel will be nine years long by FD. That would be longer than the PR19 data panel at FD – that was eight years. This panel has the benefit of starting after the accounting change. As can be seen in appendix 3, the models remain robust, although the urban rainfall variable becomes insignificant in the Network Plus models.

Second, we keep the longer data panel but introduce AMP dummies for AMP6 and AMP7. This is rooted in the idea that each AMP has its own unique characteristics. It also recognizes the cost shocks that have hit the economy as a whole since 2020: first Covid, the energy cost shock that followed the Russian invasion of Ukraine. The coefficients and significance of the model coefficients are also shown in appendix 3. It can be seen that the models still appear robust.

We would strongly support Ofwat following one of these two approaches at FD. Our preferred approach would be to shorten the panel. We believe that the need to do so at PR29 will be overwhelming. Now would be a good time to make the move. Were Ofwat to conclude that it should maintain the full panel for now, then we would strongly support the inclusion of the AMP dummies as an alternative way of giving more weight to more recent data.

Water models

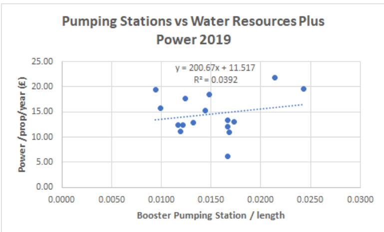
Booster PS/L argument

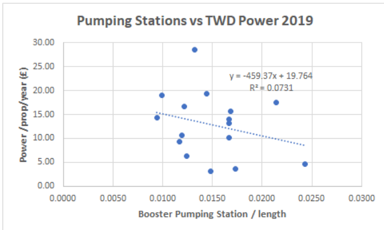
We wholeheartedly support Ofwat's reintroduction of Average Pumping Head (APH) into its Base cost models as a means for controlling for topography. We believe that Ofwat should go further at FD and include both APH for Water Resource Plus and Total APH within its suite of models. We also consider that the Booster Pumping Stations variable should be de-emphasized at FD as it becomes insignificant when the 2024 data are added to the data panel.

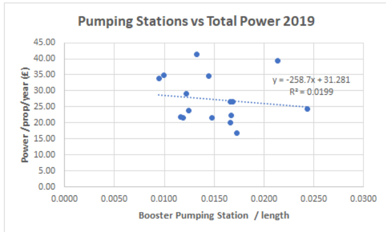
At PR19, Ofwat was not prepared to use APH within its base cost models on the grounds that its data quality was inadequate. Since then, Ofwat and the industry has worked hard to improve APH data quality in conjunction with work undertaken by Turner and Townsend and WRC. This work, which continues and has led companies to overhaul the way APH data are collected, collated and (importantly) used. Ofwat has year on year evidence of improvement in data quality.

Any historic data quality concerns about APH must be set against the bigger data concerns around booster pumping stations which Ofwat chose to use at PR19 to control for topography. When Ofwat attempted to improve the definition of this variable via a query in May 2019 the numbers submitted by companies changed considerably in comparison with the numbers they had submitted in their initial plans. Two companies reported uplifts of over 50 percent, three more reported uplifts of over 25 percent and others reported reductions. Anglian reported four separate numbers for this line across the four submission it made during the price review, reflecting the ambiguity in its definition.

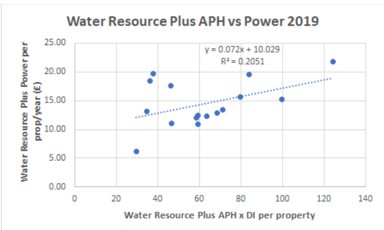
The charts below support our concerns about the reliability of the number of network booster pumping stations as a control variable for topography. Whether measured for Water Resources Plus, TWD or Wholesale Water, there is no correlation at all between booster pumping station numbers and power costs. [APH power per prop correlation v3.xlsx]

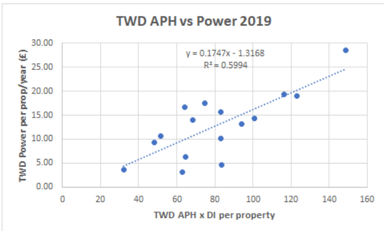


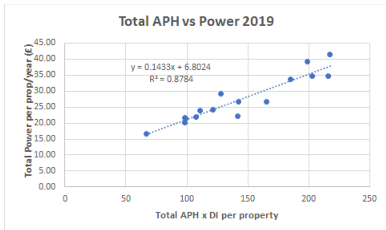




By comparison, the following charts demonstrate the correlation between APH and power costs. This relationship demonstrates the considerable superiority of this measure as a control variable for topography.







Our view on the superiority of APH is supported by the impact on the relative efficiency of Portsmouth Water when booster pumping stations is replaced with APH in Ofwat's models. Portsmouth Water appears super-efficient in Ofwat's models, with costs 17 percent lower than Ofwat's assessment and far ahead of the second ranked company. Using models with APH rather than booster pumping stations, Portsmouth Water's efficiency reduces to a more credible level.

At Draft Determination (DD), Ofwat used all of the Base cost Water models which it consulted on back in April 2023. So the Treated Water Distribution (TWD) model set and the Total Water cost model set both included models using Average Pumping Head (APH) and Pumping Stations per length of mains (PS/L). This Ofwat justified more on the grounds that the models worked than based on engineering rationale: Ofwat has accepted that APH is a much better measure of topography however the coefficients for both PS/L and APH were strongly significant.

The addition of the 2024 data changes the position. This is set out in Appendix 1. Whereas previously the coefficients for PS/L have been significant, now they are insignificant. The justification for maintaining the PS/L models is now undermined. We propose that Ofwat now drops the use of the PS/L models both within the TWD and the total cost models. Failing that, the case for adjusting the weights of the PS/L models to reflect their markedly poorer quality is undeniable. While our strong preference would be to give those models a zero weight, we think the maximum weights given to the PS/L models in TWD (re7, re 8 and re9) should be 5 percent with the weights assigned to the APH models increased accordingly. For the Total cost models (re13 – re18), we think the maximum PS/L weight should be 2.5 percent.

Our proposed weights in the TWD cost models are set out below:

	re7	re8	re9	re10	re11	re12
Preferred weights	0%	0%	0%	25%	25%	50%
Maximum weights	2.5%	2.5%	5%	30%	30%	60%

Our proposed weights in the Total Water cost models are set out below

	re13	re14	re15	re16	re17	re18	re19	re20	re21	re22	re23	re24
Preferred weights	0%	0%	0%	0%	0%	0%	12.5%	12.5%	12.5%	12.5%	25.0%	25.0%
Maximum weights	1.25%	1.25%	1.25%	1.25%	2.5%	2.5%	11.25%	11.25%	11.25%	11.25%	22.5%	22.5%

Lack of rainfall for Water inverse to urban rainfall argument

We believe there is a strong argument for including APH in both the Water Resource Plus and total cost models. The reasons are set out below.

Within the suite of Water Recycling Network Plus models used at DD, Ofwat has chosen to exclusively use the models including the reformulated urban rainfall variable and to drop models not using that variable. In doing so, Ofwat has accepted the argument that Water Recycling Collection costs are increased with higher levels of rainfall.

In the light of Ofwat's use of the urban rainfall variable within the Water Recycling base cost models, we feel that the inverse impact for Water services based on the lack of rainfall in dry areas of the country needs also to be recognized. For companies in dry parts of the country, it is necessary to access marginal water sources at higher incremental costs so as to provide water to customers. A very obvious way in which this manifests itself is the need to pump water out of the ground rather than relying on gravity fed upland water sources as is the case in wetter parts of the country.

The APH for Water Resources Plus (APH_WRP) would appropriately take account of the pumping requirements for raw water abstraction and transport within the Water models. Adding APH_WRP into the six Water Resources Plus cost models improves the quality of the models. As is set out in Appendix 4, the coefficients for APH_WRP are strongly significant in all models both with the existing data set and with 2024 added in. With APH_WRP and APH_TWD being used in the disaggregated models, there is no reason not to also use total APH in the total water models as well. The impact on model quality and on the modelled assessments are also set out in Appendix 4.

Ofwat's rationale for not using total APH in the Total cost models has been the lower data quality for Water Resources APH. As can be seen from our APR24 commentary, the quality of these data is improving rapidly. Overall, more than two thirds of total APH is derived from measured data, with APH for TWD at 84 percent. We are not alone. Of the companies who have made public their APR commentaries, Thames reports that 76 percent of Water Abstraction APH, 77 percent of Raw Water Distribution APH and 94 percent of Water Treatment APH is based on measured data, compared to 83 percent for Treated Water Distribution; while Affinity reports 92 percent of Water Abstraction APH, 100 percent of Raw Water Distribution APH and 83 percent of Water Treatment APH is based on measured data, with APH for Treated Water Distribution also at 100 percent.

Consequently we believe that this level of data quality merits APH_WRP being included in the Water Resource Plus models and the total APH being used in the Water Total cost models. It is notable that model quality improves with Total APH being used in place of TWD APH in the total cost models with 2024 cost data included: all of the six models show as three star with Total APH.

Wastewater models

We believe that Ofwat should reinstate the models which exclude the use of the urban rainfall variable. We also believe that the Sewage Treatment model using the percentage of load treated in Bands 1-3 should be given weight of no more than 25 percent.

We fully support Ofwat's use of the Weighted Average Treatment Size (WATS) variable in one of its two Water Recycling Treatment models (re5) and in one of its two Network Plus models (re7). The other Treatment model (re4) and the other Network Plus model (re6) use the percentage of load treated in Bands 1-3.

We note that the coefficient for percentage of load treated in Bands 1-3 in Treatment model re4 as published by Ofwat at DD is insignificant. We also note that this remains the same with the addition of the 2024 data (see Appendix 1).

While supporting Ofwat's default stance that independent models ought to be triangulated given the implausibility that such parsimonious models should be able to capture all aspects of cost derivation, we do not agree that this should be done always and everywhere on an equal basis. If one model is evidently poorer than another, either it should not be used at all or at most should be given a significantly lower weight in triangulation.

As Ofwat has only put forward two models for Sewage Treatment, excluding re4 would mean there would be no triangulation within the Sewage Treatment models. It is thus our contention that the Sewage Treatment model using the percentage of load treated in Bands 1-3 should be given a lower weight relative to the other Treatment model, re5. We consider that the weight for re4 should be no more than 25 percent.

We note that one of the Network Plus models fails the Reset test on the DD models as published and again with the addition of the 2024 data. We further note that reinstating the models which do not include urban rainfall leads to all of those versions passing the Reset test. We would strongly support the reinstatement of the models excluding urban rainfall amongst the Network Plus suite of models to improve model quality and triangulation.

Notwithstanding our previously stated concerns, we recognize the improvements made by Ofwat to the definition of the urban rainfall variable at Draft Determination. Looking forward towards PR29, we believe that if the models are to reflect the impact of rainfall on costs then Ofwat should take into account all the relevant factors.

First, while the absolute level of rainfall has an impact on costs, so too does the intensity of that rainfall. With climate change moving from a theorical to an actual issue, we are already seeing many more extreme weather events. The arrival of a month's rainfall in a few hours will inevitably have a significant impact on sewer networks.

Second, a compounding factor for an area with low population density is the fact that sewers tend to be smaller and thus can be more quickly inundated. This, in turn highlights a further issue with the variable as currently defined. The focus currently is on urban areas. For Anglian, with the largest and lowest density area and with the largest number of sewer networks, this is particularly pressing. We would wish to see the rainfall variable covering all of our sewer networks, especially as the more rural networks have the smallest diameter sewers and are thus most prone to the impact of high intensity rainfall.

Bioresources models

Ofwat's Bioresources models do not account for sludge growth. As such, the models should be redefined as Botex models and growth should be modelled separately. The total cost models should be reinstated to improve the quality of the triangulated assessment.

Clear evidence that models do not provide for increased growth

In Ofwat's PR24 Final Methodology Appendix 4 (Bioresources)[1], it states that its approach: *"funds growth enhancement costs through our econometric models rather than bespoke assessments;"* Unfortunately, this is not the case.

The Implicit Allowance (IA) for Bioresources Growth in the Ofwat Draft Determination (DD) base cost models is -£4million after the imposition of Frontier Shift (FS) and Real

[1] https://www.ofwat.gov.uk/wp-content/uploads/2022/12/PR24_final_methodology_Appendix_4_Bioresources.pdf

Price Effects (RPE). This was computed by comparing the assessment of the baseline Bioresources models as reported by Ofwat for the DDs with a variant on the baseline which excluded the Bioresources growth from the costs used to develop the model coefficients. To be clear, the assessment on a Botex basis (that is, purely base opex and Capital Maintenance) was £4m more than that for the Botex Plus baseline which included the growth costs.

Consequently, the £36.9 million Bioresources growth costs reported on CWW3.164 are not funded at all within the published DD Bioresources base cost models. After applying FS and RPE, the figure reduces to £35.2 million which is unfunded. If Ofwat persists in using the Botex Plus Bioresources models at Final Determination (FD), then the net impact is £39.2 million after taking account of the negative IA. If, on the other hand Ofwat were to use the Botex versions of the Bioresources models, then the impact would be £35.2 million.

The methodology followed to arrive at these conclusions are set out in Appendix 2.

Case for broader re-consideration of bioresource models

Adding in the 2024 data makes the UC models deteriorate - see Appendix 1. For Botex Plus, density in two models moves from 2 star to 1 star For the Botex models density moves from 3 star to 2 star.

The UC models used at DD are overly parsimonious. While we accept that they or something very similar will be used at FD, we would strongly support developing models which capture more variability in the data for PR29. In the meantime, we would strongly support the reintroduction of the Total Cost (TC) models to improve both model quality and triangulation.

This is because the model quality on the UC models is poorer than for the TC models: R squared, coefficient significance, Reset results, efficiency ranges and UQ level are all better in the TC models than in the UC models– see Appendix 1.

The Botex model quality is better than for Botex Plus for both UC & TC models. (See Appendix 1) For this reason, and so as to deal with the problem of negative IA for Bioresources Growth, we strongly support a move from Botex Plus to Botex models for Bioresources, with Bioresources Growth assessed separately as an enhancement cost

In short, our preferred position is that Ofwat should:

i) Look to further develop the UC models to improve model quality
ii) Triangulate between UC and TC models;
iii) Move from Botex Plus to Botex for Bioresources; and
iv) Assess Sludge Growth through either a deep dive or through a new model, if feasible

We appreciate that much of this agenda may have to wait for PR29. However, we would strongly urge to act on points iii) and iv) at DD so as to address the non-funding of sludge growth, given the negative IA for sludge growth.

Retail models

We believe the Retail models continue to behave well. Ofwat raises two issues in the Draft Determination. We respond to both below.

The Retail models appear to continue to perform adequately when the 2024 data are added. As can be seen in Appendix 1, the level of significance of coefficients either improves or stays the same for the cost drivers; the historic Upper Quartile moves marginally from 0.899 to 0.907 and the ranges of efficiencies remains at credible levels for all eight models.

Ofwat raises a valid point that the Retail cost assessment is based in part on companies' proposed bill increases as set out in their Business Plans. This feeds into the average household bill cost driver which is a key driver both for the Doubtful debt models and for the total cost models. The intuition behind the use of this variable is that the level of doubtful debts is driven by the absolute level of bills: the higher the bills, the more households will find difficulty in meeting those charges. Ofwat's concern is that while companies' retail forecasts are based on their own bill size forecasts, at its DD Ofwat has set what it considers companies' bills should be. As these numbers are generally lower than the companies' forecasts, to that extent the Retail models will be setting their assessments too high.

At present in Ofwat's Retail forecasting workbook, *PR24-DD-Base-Costs-Residential-Retail.xlsx*, Ofwat's approach to forecasting household bills is to increase the 2022/23 average bill size by 20 percent across AMP8. Our proposed approach to addressing this issue is to take the average household bill size variable and make the following adjustment. For each year in AMP8, multiply the existing average household bill size variable by Ofwat's DD bill size for that year divided by the company's Business Plan proposed bill size for that year.

An alternative, or possibly complementary approach would be to triangulate the historic catch up efficiency with the forecast catch up efficiency as was implemented at PR19.

Ofwat makes a subsidiary point that the approach taken at DD has led to some companies having assessments above the level of their own Business Plans. We would like to make two points regarding this observation. First, Ofwat's approach to setting base cost allowances since PR14 has allowed for the possibility that some companies will be sufficiently efficient such that their costs are below the assessed level. While unsurprisingly most focus in this regard is on Wholesale costs, it is equally valid for Retail. Second, at PR19, many if not most companies bid low in their Retail plans. It is not inconceivable that some companies may have done the same at PR24.

Appendix 1: Impact of adding 2024 data to DD base models

Within the following tables, 0, 1, 2 and 3 represent the level of statistical significance for the coefficients, being the number of stars shown on the STATA Results output.

Water Resource Plus models

	Using 2012 - 2023 data						Using 2012 - 2024 data					
	re1	re2	re3	re4	re5	re6	re1	re2	re3	re4	re5	re6
Properties	3	3	3	3	3	3	3	3	3	3	3	3
% water treated Bands3-6	3		3		3		3		3		3	
WAC		0		0		0		0		0		1
MLP	3	3					3	3				
MLP sq	3	3					3	2				
MP			3	2					3	3		
MP sq			3	2					3	2		
P/L					3	3					2	2
P/L sq					3	2					2	2
R sq	0.910	0.904	0.902	0.898	0.912	0.908	0.911	0.906	0.902	0.899	0.912	0.909
Reset	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Range	164%	162%	164%	163%	161%	159%	171%	166%	171%	168%	167%	163%

Treated Water Distribution models

	Using 2012 - 2023 data						Using 2012 - 2024 data					
	re7	re8	re9	re10	re11	re12	re7	re8	re9	re10	re11	re12
Length	3	3	3	3	3	3	3	3	3	3	3	3
PS/L	2	3	3				0	0	0			
APH				3	3	3				3	3	3
MLP	3			3			3			3		
MLP sq	3			3			3			3		
MP		3			3			3			3	
MP sq		3			3			3			3	
P/L			3			3			3			3
P/L sq			3			3			3			3
R sq	0.955	0.955	0.961	0.957	0.962	0.962	0.953	0.953	0.959	0.956	0.961	0.962
Reset	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Range	48%	56%	58%	60%	54%	48%	45%	50%	51%	50%	49%	42%

Total Base Cost Water models

	Using 2012 - 2023 data											
	re13	**re14**	**re15**	**re16**	**re17**	**re18**	**re19**	**re20**	**re21**	**re22**	**re23**	**re24**
Properties	3	3	3	3	3	3	3	3	3	3	3	3
% water treated Bands3-6	3		2		3		2		0		2	
WAC		2		2		2		0		0		1
MLP	3	3					3	3				
MLP sq	3	3					3	3				
MP			3	3					3	3		
MP sq			3	3					3	3		
P/L					3	3					3	3
P/L sq					3	3					3	3
PS/L	3	3	3	3	2	2						
APH							3	3	3	3	1	1
R sq	0.965	0.966	0.963	0.965	0.965	0.967	0.96	0.96	0.956	0.957	0.962	0.963
Reset	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Range	62%	66%	67%	68%	66%	63%	91%	90%	85%	85%	86%	85%

	Using 2012 - 2024 data											
	re13	**re14**	**re15**	**re16**	**re17**	**re18**	**re19**	**re20**	**re21**	**re22**	**re23**	**re24**
Properties	3	3	3	3	3	3	3	3	3	3	3	3
% water treated Bands3-6	3		2		3		3		1		3	
WAC		2		2		2		1		0		2
MLP	3	3					3	3				
MLP sq	3	3					3	3				
MP			3	3					3	3		
MP sq			3	3					3	3		
P/L					3	3					3	3
P/L sq					3	3					3	3
PS/L	0	0	0	1	0	0						
APH							2	2	2	2	0	0
R sq	0.963	0.965	0.962	0.964	0.965	0.967	0.96	0.96	0.956	0.957	0.962	0.963
Reset	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Range	75%	73%	68%	67%	78%	75%	98%	97%	92%	91%	94%	93%

Sewage Collection models

	Using 2012 - 2023 data			Using 2012 - 2024 data		
	re1	re2	re3	re1	re2	re3
Length	3	3	3	3	3	3
PC/L	2	3	3	3	3	3
Rainfall	3	3	3	3	3	3
MLP		3			3	
MP			3			3
P/L	3			3		
R sq	0.917	0.906	0.903	0.909	0.901	0.899
Reset	Pass	Pass	Pass	Fail	Fail	Fail
Range	25%	30%	27%	39%	31%	30%

Sewage Treatment models

	Using 2012 -2023 data		Using 2012-2024 data	
	re4	re5	re4	re5
Load	3	3	3	3
% NH3<3mg	3	3	3	3
% load treated in Bands1-3	0		0	
WATS		3		3
R sq	0.860	0.907	0.846	0.897
Reset	Pass	Pass	Pass	Pass
Range	78%	43%	87%	47%

Water Recycling Network Plus

	Using 2012 -2023 data		Using 2012 -2024 data	
	re6	re7	re6	re7
Load	3	3	3	3
% NH3<3mg	3	3	3	3
PC/L	3	3	3	3
Rainfall	2	2	2	1
% load treated in Bands1-3	2		2	
WATS		2		2
R sq	0.953	0.956	0.947	0.950
Reset	Pass	Fail	Pass	Fail
Range	18%	16%	28%	24%

Bioresources Unit Cost Botex Plus models

	Using 2012 - 2023 data				Using 2012 - 2024 data			
	re1	re2	re3	re4	re1	re2	re3	re4
% treated in Bands 1-3	3				3			
MLP		2				1		
MP			2				1	
STW/Properties				2				2
R sq	0.256	0.172	0.145	0.166	0.241	0.148	0.123	0.140
Reset	Pass	Fail	Fail	Pass	Pass	Fail	Fail	Pass
Range	77%	70%	73%	77%	81%	83%	87%	84%

Bioresources Total Cost Botex Plus models

	Using 2012 – 2023 data						Using 2012 – 2024 data					
	re1	re2	re3	re4	re5	re6	re1	re2	re3	re4	re5	re6
Sludge treated	3	3	3	3	3	3	3	3	3	3	3	3
% treated in Bands 1-3	0	0		1			0	0		0		
MLP	0				0		0				0	
MP		0				0		0				0
STW/Properties			0						0			
R sq	0.795	0.785	0.762	0.787	0.762	0.755	0.766	0.756	0.732	0.762	0.735	0.727
Reset	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Range	89%	83%	85%	87%	85%	87%	85%	86%	87%	82%	83%	86%

Bioresources Unit Cost Botex models

	Using 2012 - 2023 data				Using 2012 - 2024 data			
	re1	re2	re3	re4	re1	re2	re3	re4
% treated in Bands 1-3	3				3			
MLP		3				2		
MP			3				2	
STW/Properties				3				3
R sq	0.298	0.246	0.219	0.24	0.279	0.209	0.183	0.202
Reset	Pass	Fail	Fail	Pass	Pass	Fail	Fail	Pass
Range	76%	68%	72%	76%	82%	85%	89%	85%

Bioresources Total Cost Botex models

	Using 2012 – 2023 data						Using 2012 – 2024 data					
	re1	re2	re3	re4	re5	re6	re1	re2	re3	re4	re5	re6
Sludge treated	3	3	3	3	3	3	3	3	3	3	3	3
% treated in Bands 1-3	1	0		1			1	0		1		
MLP	1				0		0				0	
MP		0				0		0				0
STW/Prop			0						0			
R sq	0.795	0.780	0.762	0.776	0.761	0.752	0.767	0.754	0.731	0.754	0.733	0.724
Reset	Pass	Pass	Fail	Fail	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Range	67%	71%	74%	77%	69%	75%	66%	72%	76%	78%	72%	76%

Retail models

Bad debt models

	Using 2014 - 2023 data		Using 2014 - 2024 data	
	re1	re2	re1	re2
Household bill size	3	3	3	3
Households with propensity to default	3		3	
Covid19 dummy for 2019/20	3	3	3	3
Covid19 dummy for 2020/21	2	3	2	3
incomescore_interpolated		3		3
% dual households				
Total number of households				
R sq	0.664	0.668	0.667	0.667
Reset	0.165	0.179	0.262	0.287
Range	99%	80%	89%	83%

Other Cost Models

	Using 2014 - 2023 data		Using 2014 - 2024 data	
	re3	re4	re3	re4
Household bill size				
Households with propensity to default				
Covid19 dummy for 2019/20				
Covid19 dummy for 2020/21				
incomescore_interpolated				
% dual households	2	3	2	3
Total number of households		1		2
R sq	0.143	0.152	0.129	0.132
Reset	0.989	0.099	0.966	0.085
Range	74%	70%	76%	71%

Total cost models

	Using 2014 - 2023 data			
	re5	re6	re7	re8
Household bill size	3	3	3	3
Households with propensity to default	3		3	
Covid19 dummy for 2019/20	3	3	3	3
Covid19 dummy for 2020/21	0	1	0	0
incomescore_interpolated		1		1
% dual households				
Total number of households	3	3		
R sq	0.711	0.656	0.672	0.651
Reset	0.689	0.502	0.418	0.283
Range	46%	60%	53%	65%

Appendix 2: Bioresources Growth Implicit Allowance calculation methodology

The baseline analysis is set out in PR24-DD-Base-costs-wastewater-model-3-Bioresources.xlsx. The coefficients reported on the *model coeffs* tab were in turn calculated by running the Stata code for Bioresources base cost models provided on 11 July as part of the suite of documents and models for DD by Ofwat.

The modelled assessments generated on a pre RPE and Frontier Shift basis by this baseline analysis were as follows on the *Final Allowances* tab:

	Bioresources					
Company	2025-26	2026-27	2027-28	2028-29	2029-30	2025-30
ANH	84	84	84	86	89	**427**
HDD	2	2	2	2	2	**8**
NES	33	33	33	34	34	**167**
NWT	91	92	92	92	92	**459**
SRN	52	52	52	53	54	**263**
SVE	117	118	118	119	120	**592**
SWB	27	28	29	29	30	**144**
TMS	130	130	131	132	132	**655**
WSH	42	43	43	43	44	**215**
WSX	31	31	31	32	33	**158**
YKY	76	76	77	77	77	**383**
Total	**685**	**689**	**693**	**698**	**706**	**3,471**

After the application of both RPEs and Frontier Shift and the addition of unmodelled costs in PR24-DD-Base-costs-aggregator.xlsx, the overall baseline assessments are as follows on the *Wastewater – outputs* tab:

	Bioresources base allowances excluding third party services and pension deficit recovery costs					
Company	**2025-26**	**2026-27**	**2027-28**	**2028-29**	**2029-30**	**2025-30**
ANH	88	88	87	88	89	**440**
NES	35	35	35	35	35	**173**
NWT	97	96	96	96	96	**482**
SRN	53	53	53	53	54	**267**
SWB	29	30	30	31	31	**150**
TMS	129	128	128	129	129	**643**
WSH	42	42	42	42	42	**211**
WSX	32	32	32	32	32	**160**
YKY	76	76	75	75	75	**378**
SVE	38	74	98	76	11	**298**
HDD	1	1	1	1	1	**4**
Total	**621**	**655**	**678**	**657**	**595**	**3,206**

The impact of Frontier Shift and RPE falls on the modelled costs. As such, the difference between the baseline modelled assessment and that generated by the adjusted STATA code, which excludes Bioresources growth costs represents the IA for Bioresources Growth.

The pre and post Frontier Shift and RPE assessments both including and excluding Bioresources growth are set out below. All costs are shown in 2022/23 Price Base and are in £millions. A partial explanation for the counter-intuitive reduction between the Botex and Botex Plus versions of the modelled total for Anglian (as well as South West and Welsh) is that the catch up efficiency is less challenging (at 7%) for Botex than for Botex Plus (9%). But the bulk of the difference comes as a result of changes to the coefficients of the four models. The coefficients for the two sets of models are shown below.

Pre Prody and RPE

Company	Modelled baseline	Exc Growth	IA
ANH	427	432	-5
NES	167	166	1
NWT	459	451	9
SRN	263	259	4
SVH	600	592	8
SWB	144	148	-4
TMS	655	623	32
WSH	215	219	-4
WSX	158	158	0
YKY	383	381	2
Total	3,471	3,428	43
Catch up	0.9104	0.9299	

Post Prody & RPE

Company	Modelled baseline	Exc Growth	IA
ANH	412	417	-4
NES	161	160	1
NWT	443	435	8
SRN	253	250	4
SVH	579	571	8
SWB	139	143	-4
TMS	632	601	31
WSH	207	212	-4
WSX	153	152	0
YKY	369	367	2
Total	3,349	3,307	42

Botex Plus basis (including Growth costs)

Variable code	Full variable name	Bioresources unit cost models			
		re1	re2	re3	re4
		BR7	BR8	BR9	BR10
pctbands13	% of load treated in bands 1-3	0.0532	0.0000	0.0000	0.0000
lnWAD_MSOAtoLAD_population	ln (weighted average density - LAD from MSOA)	0.0000	-0.2460	0.0000	0.0000
lnWAD_MSOA_population	ln (weighted average density - MSOA)	0.0000	0.0000	-0.3416	0.0000
Lnswtwperpro	ln (number of sewerage treatment works per property)	0.0000	0.0000	0.0000	0.2044
_cons	Constant	-0.8613	1.1136	2.0387	1.0160

Botex basis (excluding Growth costs)

Variable code	Full variable name	Bioresources unit cost models			
		re1	re2	re3	re4
		BR7	BR8	BR9	BR10
pctbands13	% of load treated in bands 1-3	0.0602	0.0000	0.0000	0.0000
lnWAD_MSOAtoLAD_population	ln (weighted average density - LAD from MSOA)	0.0000	-0.2855	0.0000	0.0000
lnWAD_MSOA_population	ln (weighted average density - MSOA)	0.0000	0.0000	-0.3930	0.0000
Lnswtwperpro	ln (number of sewerage treatment works per property)	0.0000	0.0000	0.0000	0.2429
_cons	Constant	-0.9124	1.3732	2.4201	1.3070

Anglian has £36.9 million of pre Frontier Shift and RPE Bioresources Growth costs included in its Business Plan on Table CWW3.164. After the application of Frontier Shift and RPE on the basis set out in Ofwat's DD, this figure moves to £35.2 million as set out below.

DD Frontier Shift & RPE for capex: Bioresources

	FS	RPE	Net impact	Cum FS & RPE impact	CWW3.164	CWW3.164 after applying FS & RPE
2024	-1.00%	0.23%	-0.77%	-0.77%		
2025	-1.00%	0.46%	-0.54%	-1.31%		
2026	-1.00%	0.09%	-0.91%	-2.20%		
2027	-1.00%	0.12%	-0.88%	-3.06%	1.689	1.637
2028	-1.00%	0.09%	-0.91%	-3.94%	9.41	9.039
2029	-1.00%	0.18%	-0.82%	-4.73%	15.571	14.834
2030	-1.00%	0.21%	-0.79%	-5.49%	10.245	9.683
AMP8					36.915	35.194

Since PR14, the concept of the IA has used to justify total or partial coverage of specific costs which form part of a total assessment. Given in this particular case the IA is negative, there is clearly no funding provided in the models for Bioresources Growth. As such, Anglian requires some form of recognition of these costs which are not included in our base allowance. We suggest that the simplest way to do so would be to move from a Botex Plus to a Botex basis for Bioresources, and to model Bioresources growth separately.

Appendix 3: Stata output showing the significance of coefficients with data panel changes

1. Data panel from 2016 – 2024

Water Resources Plus

	re1 b/p	re2 b/p	re3 b/p	re4 b/p	re5 b/p	re6 b/p
Lnproperties	1.111*** {0.000}	1.098*** {0.000}	1.092*** {0.000}	1.080*** {0.000}	1.061*** {0.000}	1.048*** {0.000}
pctwatertreated36	0.008*** {0.006}		0.007* {0.058}		0.008** {0.022}	
lnWAD_MSOAtoLAD_population	-1.564*** {0.005}	-1.350* {0.054}				
lnWAD_MSOAtoLAD_population2	0.097*** {0.006}	0.081* {0.077}				
Lnwac		1.013 {0.105}		0.957 {0.160}		1.019 {0.110}
lnWAD_MSOA_population			-4.810*** {0.004}	-4.304* {0.066}		
lnWAD_MSOA_population2			0.289*** {0.004}	0.255* {0.074}		
Lnpropperlength					-6.910** {0.033}	-5.721 {0.136}
lnpropperlength2					0.747** {0.047}	0.601 {0.173}
lnlengthsofmain						
lnboosterperlength						
lnAPH_TWD						
_cons	-5.791*** {0.001}	-7.155*** {0.009}	8.317 {0.179}	5.732 {0.545}	4.611 {0.498}	1.494 {0.859}
depvar	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	153	153	153	153	153	153
vce	cluster	cluster	cluster	cluster	cluster	Cluster
R_squared	0.913	0.905	0.903	0.895	0.913	0.906
RESET_P_value	0.579	0.405	0.856	0.738	0.515	0.173

Treated Water Distribution

	re7 b/p	re8 b/p	re9 b/p	re10 b/p	re11 b/p	re12 b/p
lnproperties						
pctwatertreated36						
lnWAD_MSOAtoLAD_population	-3.214*** {0.000}			-3.303*** {0.000}		
lnWAD_MSOAtoLAD_population2	0.245*** {0.000}			0.252*** {0.000}		
lnwac						
lnWAD_MSOA_population		-6.967*** {0.000}			-7.392*** {0.000}	
lnWAD_MSOA_population2		0.471*** {0.000}			0.500*** {0.000}	
lnpropperlength			-17.318*** {0.000}			-17.864*** {0.000}
lnpropperlength2			2.140*** {0.000}			2.202*** {0.000}
lnlengthsofmain	1.074*** {0.000}	1.027*** {0.000}	1.055*** {0.000}	1.072*** {0.000}	1.021*** {0.000}	1.049*** {0.000}
lnboosterperlength	-0.026 {0.814}	0.014 {0.905}	0.077 {0.524}			
lnAPH_TWD				0.150** {0.021}	0.227*** {0.000}	0.163** {0.025}
_cons	4.417*** {0.006}	20.258*** {0.000}	29.511*** {0.000}	4.143*** {0.003}	20.860*** {0.000}	29.741*** {0.000}
depvar	lnrealbotexplustwd	lnrealbotexplustwd	lnrealbotexplustwd	lnrealbotexplustwd	lnrealbotexplustwd	lnrealbotexplustwd
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	153	153	153	153	153	153
vce	cluster	cluster	cluster	cluster	cluster	Cluster
R_squared	0.959	0.959	0.965	0.963	0.966	0.967
RESET_P_value	0.122	0.311	0.766	0.231	0.64	0.867

Total Water costs

	re13 b/p	re14 b/p	re15 b/p	re16 b/p	re17 b/p	re18 b/p
lnproperties	1.089*** {0.000}	1.077*** {0.000}	1.066*** {0.000}	1.054*** {0.000}	1.051*** {0.000}	1.040*** {0.000}
pctwatertreated36	0.004* {0.063}		0.003 {0.274}		0.004 {0.132}	
lnWAD_MSOAtoLAD_population	-2.231*** {0.000}	-2.060*** {0.000}				
lnWAD_MSOAtoLAD_population2	0.152*** {0.000}	0.139*** {0.000}				
						0.666 {0.108}
			-5.846*** {0.000}	-5.310*** {0.001}		
			0.365*** {0.000}	0.330*** {0.000}		
					-13.097*** {0.000}	-12.090*** {0.000}
lnpropperlength2					1.502*** {0.000}	1.379*** {0.000}
lnlengthsofmain						
lnboosterperlength	0.086 {0.576}	0.082 {0.612}	0.136 {0.397}	0.134 {0.444}	0.056 {0.661}	0.048 {0.732}
lnAPH_TWD						
_cons	-1.964 {0.283}	-3.068 {0.147}	13.895** {0.011}	11.324* {0.070}	18.805*** {0.000}	16.198*** {0.000}
depvar	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	153	153	153	153	153	153
vce	cluster	cluster	cluster	cluster	cluster	cluster
R_squared	0.965	0.965	0.963	0.962	0.965	0.965
RESET_P_value	0.231	0.11	0.44	0.258	0.297	0.15

	re19 b/p	re20 b/p	re21 b/p	re22 b/p	re23 b/p	re24 b/p
lnproperties	1.093*** {0.000}	1.081*** {0.000}	1.066*** {0.000}	1.053*** {0.000}	1.048*** {0.000}	1.038*** {0.000}
pctwatertreated36	0.004* {0.073}		0.002 {0.381}		0.004 {0.150}	
lnWAD_MSOAtoLAD_population	-2.438*** {0.000}	-2.247*** {0.000}				
lnWAD_MSOAtoLAD_population2	0.166*** {0.000}	0.151*** {0.000}				
lnwac		0.678 {0.123}		0.601 {0.224}		0.664 {0.129}
lnWAD_MSOA_population			-6.708*** {0.000}	-6.025*** {0.000}		
lnWAD_MSOA_population2			0.418*** {0.000}	0.374*** {0.000}		
lnpropperlength					-13.525*** {0.000}	-12.489*** {0.000}
lnpropperlength2					1.552*** {0.000}	1.426*** {0.000}
lnlengthsofmain						
lnboosterperlength						
lnAPH_TWD	0.122 {0.219}	0.092 {0.393}	0.14 {0.192}	0.105 {0.340}	0.074 {0.455}	0.045 {0.655}
_cons	-2.093 {0.254}	-3.156 {0.154}	16.245*** {0.003}	13.217** {0.038}	19.247*** {0.000}	16.700*** {0.000}
depvar	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	153	153	153	153	153	153
vce	cluster	cluster	cluster	cluster	cluster	cluster
R_squared	0.964	0.963	0.959	0.957	0.964	0.963
RESET_P_value	0.673	0.605	0.733	0.719	0.686	0.531

Water Recycling Network Plus

	re1 b/p	re2 b/p	re3 b/p	re4 b/p	re5 b/p	re6 b/p	re7 b/p
lnsewerlength	0.810*** {0.000}	0.893*** {0.000}	0.867*** {0.000}				
lnpumpingcapperlength	0.385** {0.021}	0.627*** {0.000}	0.579*** {0.000}			0.453*** {0.000}	0.364*** {0.000}
lndensity	1.272*** {0.000}						
lnurbanMSOArainfallperlength	0.013 {0.789}	0.101* {0.069}	0.096 {0.100}			0.007 {0.863}	0.026 {0.498}
lnWAD_MSOAtoLAD_population		0.286*** {0.000}					
lnWAD_MSOA_population			0.460*** {0.000}				
lnload				0.763*** {0.000}	0.807*** {0.000}	0.722*** {0.000}	0.683*** {0.000}
pctbands13				0.017 {0.559}		0.020*** {0.001}	
pctnh3below3mg				0.002 {0.258}	0.005* {0.061}	0.005*** {0.000}	0.007*** {0.000}
lnWATS					-0.221*** {0.000}		-0.100*** {0.000}
_cons	-8.696*** {0.000}	-6.740*** {0.000}	-8.018*** {0.000}	-4.757*** {0.001}	-3.194*** {0.006}	-3.856*** {0.000}	-2.250*** {0.000}
depvar	lnrealbotexplusswc	lnrealbotexplusswc	lnrealbotexplusswc	lnrealbotexplusswt	lnrealbotexplusswt	lnrealbotexpluswwnp	lnrealbotexpluswwnp
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	90	90	90	90	90	90	90
vce	cluster	cluster	cluster	cluster	cluster	cluster	cluster
R_squared	0.925	0.923	0.923	0.842	0.894	0.949	0.953
RESET_P_value	0.017	0.012	0.01	0.252	0.84	0.342	0.012

2. The addition of AMP dummies

Water Resource Plus

	re1 b/p	re2 b/p	re3 b/p	re4 b/p	re5 b/p	re6 b/p
lnproperties	1.092*** {0.000}	1.090*** {0.000}	1.086*** {0.000}	1.085*** {0.000}	1.046*** {0.000}	1.045*** {0.000}
pctwatertreated36	0.003 {0.126}		0.002 {0.344}		0.003 {0.122}	
lnWAD_MSOAtoLAD_population	-1.491** {0.017}	-1.462** {0.037}				
lnWAD_MSOAtoLAD_population2	0.091** {0.025}	0.089* {0.053}				
dummyAMP6	0.052 {0.278}	0.048 {0.259}	0.06 {0.216}	0.055 {0.209}	0.057 {0.225}	0.053 {0.217}
dummyAMP7	0.103 {0.210}	0.098 {0.163}	0.115 {0.163}	0.108 {0.128}	0.115 {0.158}	0.109 {0.120}
lnwac		0.25 {0.288}		0.205 {0.414}		0.265 {0.246}
lnWAD_MSOA_population			-5.447*** {0.008}	-5.470** {0.015}		
lnWAD_MSOA_population2			0.326*** {0.010}	0.327** {0.018}		
lnpropperlength					-6.752 {0.114}	-6.783 {0.124}
lnpropperlength2					0.718 {0.154}	0.72 {0.165}
lnlengthsofmain						
lnboosterperlength						
lnAPH_TWD						
_cons	-5.358*** {0.001}	-5.554*** {0.007}	11.468 {0.135}	11.455 {0.182}	5.062 {0.565}	5.022 {0.583}
depvar	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	221	221	221	221	221	221
Vce	cluster	cluster	cluster	cluster	cluster	cluster
R_squared	0.908	0.904	0.902	0.9	0.912	0.909
RESET_P_value	0.759	0.579	0.829	0.751	0.657	0.43

Treated Water Distribution

	re7 b/p	re8 b/p	re9 b/p	re10 b/p	re11 b/p	re12 b/p
lnproperties						
pctwatertreated36						
lnWAD_MSOAtoLAD_population	-2.786*** {0.000}			-3.079*** {0.000}		
lnWAD_MSOAtoLAD_population2	0.218*** {0.000}			0.236*** {0.000}		
dummyAMP6	0.044 {0.178}	0.036 {0.274}	0.038 {0.254}	0.042 {0.194}	0.034 {0.291}	0.037 {0.259}
dummyAMP7	0.096** {0.026}	0.083* {0.051}	0.077* {0.071}	0.091** {0.031}	0.080* {0.058}	0.073* {0.086}
lnwac						
lnWAD_MSOA_population		-6.036*** {0.000}			-6.923*** {0.000}	
lnWAD_MSOA_population2		0.415*** {0.000}			0.470*** {0.000}	
lnpropperlength			-15.923*** {0.000}			-17.137*** {0.000}
lnpropperlength2			1.985*** {0.000}			2.115*** {0.000}
lnlengthsofmain	1.063*** {0.000}	1.023*** {0.000}	1.056*** {0.000}	1.061*** {0.000}	1.016*** {0.000}	1.044*** {0.000}
lnboosterperlength	0.166 {0.230}	0.165 {0.212}	0.194 {0.148}			
lnAPH_TWD				0.244*** {0.001}	0.307*** {0.000}	0.232*** {0.003}
_cons	3.605** {0.024}	17.041*** {0.001}	26.812*** {0.000}	2.987* {0.060}	18.677*** {0.000}	27.909*** {0.000}
depvar	lnrealbotexplustwd	lnrealbotexplustwd	lnrealbotexplustwd	lnrealbotexplustwd	lnrealbotexplustwd	lnrealbotexplustwd
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	221	221	221	221	221	221
vce	cluster	cluster	cluster	cluster	cluster	cluster
R_squared	0.956	0.956	0.961	0.959	0.963	0.963
RESET_P_value	0.607	0.592	0.838	0.793	0.972	0.834

Total Water models

	re13 b/p	re14 b/p	re15 b/p	re16 b/p	re17 b/p	re18 b/p
lnproperties	1.074*** {0.000}	1.068*** {0.000}	1.062*** {0.000}	1.056*** {0.000}	1.045*** {0.000}	1.040*** {0.000}
pctwatertreated36	0.002 {0.164}		0.001 {0.478}		0.002 {0.215}	
lnWAD_MSOAtoLAD_population	-1.927*** {0.000}	-1.811*** {0.001}				
	0.133*** {0.000}	0.125*** {0.000}				
dummyAMP6	0.039 {0.249}	0.03 {0.376}	0.044 {0.207}	0.035 {0.324}	0.042 {0.208}	0.032 {0.346}
dummyAMP7	0.086 {0.137}	0.076 {0.160}	0.092 {0.112}	0.081 {0.133}	0.086 {0.130}	0.075 {0.161}
lnwac		0.26 {0.103}		0.213 {0.221}		0.262* {0.095}
lnWAD_MSOA_population			-5.522*** {0.000}	-5.201*** {0.001}		
lnWAD_MSOA_population2			0.346*** {0.000}	0.326*** {0.000}		
lnpropperlength					-11.921*** {0.000}	-11.375*** {0.000}
lnpropperlength2					1.369*** {0.000}	1.305*** {0.000}
lnlengthsofmain						
lnboosterperlength	0.230* {0.070}	0.251* {0.055}	0.241* {0.066}	0.266* {0.053}	0.155 {0.139}	0.174 {0.124}
lnAPH_TWD						
_cons	-2.2 {0.174}	-2.662 {0.104}	13.163** {0.025}	11.835** {0.046}	16.879*** {0.000}	15.616*** {0.001}
depvar	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	221	221	221	221	221	221
vce	cluster	cluster	cluster	cluster	cluster	cluster
R_squared	0.964	0.965	0.963	0.964	0.964	0.966
RESET_P_value	0.679	0.512	0.839	0.72	0.576	0.381

	re19 b/p	re20 b/p	re21 b/p	re22 b/p	re23 b/p	re24 b/p
lnproperties	1.077*** {0.000}	1.073*** {0.000}	1.061*** {0.000}	1.055*** {0.000}	1.037*** {0.000}	1.033*** {0.000}
pctwatertreated36	0.001 {0.535}		0 {0.985}		0.001 {0.501}	
lnWAD_MSOAtoLAD_population	-2.341*** {0.000}	-2.284*** {0.000}				
lnWAD_MSOAtoLAD_population2	0.159*** {0.000}	0.155*** {0.000}				
dummyAMP6	0.042 {0.195}	0.035 {0.280}	0.048 {0.149}	0.04 {0.230}	0.045 {0.161}	0.037 {0.257}
dummyAMP7	0.086 {0.128}	0.077 {0.135}	0.094* {0.096}	0.083 {0.106}	0.089 {0.113}	0.078 {0.127}
lnwac		0.163 {0.284}		0.117 {0.471}		0.188 {0.200}
lnWAD_MSOA_population			-6.936*** {0.000}	-6.722*** {0.000}		
lnWAD_MSOA_population2			0.431*** {0.000}	0.418*** {0.000}		
lnpropperlength					-13.037*** {0.000}	-12.787*** {0.000}
lnpropperlength2					1.492*** {0.000}	1.462*** {0.000}
lnlengthsofmain						
lnboosterperlength						
lnAPH_TWD	0.248** {0.020}	0.247** {0.020}	0.248** {0.020}	0.248** {0.019}	0.181 {0.127}	0.179 {0.130}
_cons	-2.583 {0.123}	-2.888 {0.104}	16.993*** {0.002}	16.039*** {0.003}	18.141*** {0.000}	17.487*** {0.000}
depvar	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	221	221	221	221	221	221
vce	cluster	cluster	cluster	cluster	cluster	cluster
R_squared	0.96	0.961	0.958	0.959	0.962	0.963
RESET_P_value	0.961	0.941	0.953	0.98	0.902	0.802

Water Recycling Network Plus

	re1 b/p	re2 b/p	re3 b/p	re4 b/p	re5 b/p	re6 b/p	re7 b/p
lnsewerlength	0.791*** {0.000}	0.846*** {0.000}	0.811*** {0.000}				
lnpumpingcapperlength	0.356** {0.026}	0.564*** {0.000}	0.516*** {0.001}			0.358*** {0.003}	0.278*** {0.009}
lndensity	1.237*** {0.000}						
lnurbanMSOArainfallperlength	0.093*** {0.008}	0.150*** {0.004}	0.147*** {0.005}			0.074*** {0.009}	0.078** {0.019}
dummyAMP6	-0.060* {0.077}	-0.046 {0.199}	-0.053 {0.144}	0.066* {0.096}	0.061 {0.106}	-0.015 {0.313}	-0.016 {0.248}
dummyAMP7	0.001 {0.983}	0.037 {0.561}	0.025 {0.689}	0.154** {0.012}	0.147** {0.012}	0.061 {0.207}	0.061 {0.199}
lnWAD_MSOAtoLAD_population		0.295*** {0.000}					
lnWAD_MSOA_population			0.495*** {0.000}				
lnload				0.812*** {0.000}	0.874*** {0.000}	0.762*** {0.000}	0.733*** {0.000}
pctbands13				0.042 {0.158}		0.025** {0.024}	
pctnh3below3mg				0.002 {0.131}	0.003** {0.041}	0.004*** {0.000}	0.005*** {0.000}
lnWATS					-0.224*** {0.000}		-0.091** {0.025}
_cons	-8.068*** {0.000}	-6.109*** {0.000}	-7.497*** {0.000}	-5.592*** {0.000}	-4.070*** {0.000}	-4.134*** {0.000}	-2.756*** {0.000}
depvar	lnrealbotexplusswc	lnrealbotexplusswc	lnrealbotexplusswc	lnrealbotexplusswt	lnrealbotexplusswt	lnrealbotexpluswwnp	lnrealbotexpluswwnp
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	130	130	130	130	130	130	130
vce	cluster	cluster	cluster	cluster	cluster	cluster	cluster
R_squared	0.912	0.907	0.903	0.866	0.907	0.95	0.953
RESET_P_value	0.09	0.33	0.273	0.041	0.594	0.315	0.041

Appendix 4: Use of APH in Water Resource Plus and Total cost models

Within this appendix, we show the impact on the quality of the models of using APH within both the Water Resource Plus and Total Water models. We also show that adding in the 2024 data does not materially damage model quality.

We also show the impact on the modelled element of the base cost assessment of including the additional elements of APH, over and above APH for Treated Water Distribution which Ofwat included in both the TWD and total Water models.

1. Comparison of Water Resource Plus models with and without APH

STATA Results file – Water Resource Plus for years 2012-23: Baseline (without APH)

	re1	re2	re3	re4	re5	re6
Lnproperties	1.095***	1.092***	1.070***	1.070***	1.043***	1.041***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
pctwatertreated36	0.005***		0.004***		0.005***	
	{0.000}		{0.002}		{0.000}	
lnWAD_MSOAtoLAD_popn	-1.741***	-1.661***				
	{0.001}	{0.006}				
lnWAD_MSOAtoLAD_popn2	0.111***	0.104***				
	{0.001}	{0.007}				
Lnwac		0.39		0.367		0.416
		{0.148}		{0.178}		{0.108}
lnWAD_MSOA_popn			-5.579***	-5.587**		
			{0.004}	{0.011}		
lnWAD_MSOA_popn2			0.341***	0.340**		
			{0.005}	{0.011}		
lnpropperlength					-8.915***	-8.645***
					{0.004}	{0.007}
lnpropperlength2					0.987***	0.952**
					{0.007}	{0.011}
_cons	-4.721***	-5.122***	11.679	11.584	9.283	8.595
	{0.001}	{0.004}	{0.108}	{0.164}	{0.151}	{0.200}
Depvar	Lnrealbotexwrp	Lnrealbotexwrp	Lnrealbotexwrp	lnrealbotexwrp	Lnrealbotexwrp	lnrealbotexwrp
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	204	204	204	204	204	204
Vce	cluster	cluster	Cluster	cluster	Cluster	cluster
R_squared	0.910	0.904	0.902	0.898	0.912	0.908
RESET_P_value	0.55	0.492	0.822	0.696	0.999	0.976

STATA Results file – Water Resource Plus for years 2012-23: including APH

In the following output, APH_WRP is the sum of APH for Water Resources, Raw Water Distribution and Treatment.

	re1	re2	re3	re4	re5	re6
Lnproperties	1.112***	1.112***	1.096***	1.097***	1.095***	1.094***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
pctwatertreated36	0.004***		0.004**		0.004***	
	{0.009}		{0.019}		{0.003}	
lnWAD_MSOAtoLAD_population	-1.614***	-1.564**				
	{0.003}	{0.012}				
lnWAD_MSOAtoLAD_population2	0.108***	0.104**				
	{0.003}	{0.011}				
lnAPH_WRP	0.307**	0.301***	0.350***	0.341***	0.368***	0.358***
	{0.012}	{0.004}	{0.005}	{0.002}	{0.002}	{0.001}
Lnwac		0.286		0.25		0.287
		{0.258}		{0.330}		{0.225}
lnWAD_MSOA_population			-5.179***	-5.269**		
			{0.009}	{0.019}		
lnWAD_MSOA_population2			0.324***	0.329**		
			{0.008}	{0.017}		
lnpropperlength					-11.808***	-11.563***
					{0.000}	{0.000}
lnpropperlength2					1.352***	1.321***
					{0.000}	{0.000}
_cons	-6.930***	-7.132***	7.831	8.18	12.788***	12.301**
	{0.001}	{0.003}	{0.316}	{0.359}	{0.004}	{0.013}
Depvar	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	Lnrealbotexwrp	lnrealbotexwrp
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	204	204	204	204	204	204
Vce	cluster	cluster	cluster	cluster	Cluster	cluster
R_squared	0.923	0.916	0.923	0.918	0.931	0.924
RESET_P_value	0.72	0.466	0.769	0.674	0.397	0.489

APH_WRP is strongly significant in all the Water Resource Plus models.

As can be seen by comparing the two Results outputs, the models in the version including APH_WRP all display higher R Squared results than the baseline models. In no case do coefficients which were significant in the baseline models become insignificant in the APH versions and in two cases, re5 and re6, the constants become significant in the APH versions where they were insignificant in the baseline version.

STATA Results file – Water Resource Plus for years 2012-24: Baseline (without APH)

	re1	re2	re3	re4	re5	re6
	b/p	b/p	b/p	b/p	b/p	b/p
Lnproperties	1.101***	1.096***	1.078***	1.075***	1.047***	1.043***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
pctwatertreated36	0.005***		0.005***		0.005***	
	{0.000}		{0.001}		{0.000}	
lnWAD_MSOAtoLAD_population	-1.745***	-1.647***				
	{0.001}	{0.008}				
lnWAD_MSOAtoLAD_population2	0.111***	0.103**				
	{0.002}	{0.011}				
Lnwac		0.462		0.441		0.491*
		{0.112}		{0.130}		{0.079}
lnWAD_MSOA_population			-5.639***	-5.587***		
			{0.004}	{0.010}		
lnWAD_MSOA_population2			0.344***	0.340**		
			{0.004}	{0.010}		
Lnpropperlength					-8.349**	-8.064**
					{0.015}	{0.024}
lnpropperlength2					0.922**	0.884**
					{0.023}	{0.034}
_cons	-4.814***	-5.331***	11.804	11.421	7.982	7.202
	{0.001}	{0.005}	{0.101}	{0.163}	{0.261}	{0.333}
Depvar	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp	lnrealbotexwrp
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	221	221	221	221	221	221
Vce	cluster	cluster	cluster	cluster	cluster	cluster
R_squared	0.911	0.906	0.902	0.899	0.912	0.909
RESET_P_value	0.61	0.47	0.892	0.734	0.987	0.925

STATA Results file – Water Resource Plus for years 2012-24: including APH

	re1	re2	re3	re4	re5	re6
Lnproperties	1.117***	1.113***	1.100***	1.098***	1.095***	1.091***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
pctwatertreated36	0.004***		0.004***		0.004***	
	{0.003}		{0.007}		{0.001}	
lnWAD_MSOAtoLAD_popn	-1.608***	-1.536**				
	{0.004}	{0.013}				
lnWAD_MSOAtoLAD_popn2	0.107***	0.101**				
	{0.004}	{0.013}				
lnAPH_WRP	0.281***	0.268***	0.322***	0.305***	0.339***	0.321***
	{0.004}	{0.001}	{0.002}	{0.000}	{0.001}	{0.000}
Lnwac		0.368		0.334		0.37
		{0.199}		{0.243}		{0.170}
lnWAD_MSOA_popn			-5.205***	-5.201**		
			{0.009}	{0.019}		
lnWAD_MSOA_popn2			0.325***	0.323**		
			{0.009}	{0.018}		
Lnpropperlength					-10.899***	-10.451***
					{0.000}	{0.000}
lnpropperlength2					1.243***	1.187***
					{0.000}	{0.000}
_cons	-6.884***	-7.194***	8.033	7.995	11.006**	10.062*
	{0.001}	{0.002}	{0.306}	{0.366}	{0.021}	{0.058}
Depvar	lnrealbotexwrp	Lnrealbotexwrp	lnrealbotexwrp	Lnrealbotexwrp	Lnrealbotexwrp	lnrealbotexwrp
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	221	221	221	221	221	221
Vce	cluster	Cluster	cluster	cluster	cluster	cluster
R_squared	0.921	0.916	0.921	0.916	0.929	0.923
RESET_P_value	0.751	0.51	0.791	0.693	0.389	0.473

Again, APH_WRP is strongly significant in all the Water Resource Plus models.

There is no significant change in the relative strength of the models when the 2024 data are added in. Weighted average complexity goes insignificant in re6 for the models with APH, but again for models re5 and re6, the constant moves from being insignificant to becoming significant when APH is added in.

2. Comparison of Water total cost models with and without APH

STATA Results file – Total Water models for years 2012-23: Baseline (with APH_TWD)

	re19	re20	re21	re22	re23	re24
	b/p	b/p	b/p	b/p	b/p	b/p
Lnproperties	1.083***	1.076***	1.052***	1.047***	1.035***	1.030***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
pctwatertreated36	0.002**		0.001		0.002**	
	{0.017}		{0.183}		{0.023}	
lnWAD_MSOAtoLAD_population	-2.612***	-2.487***				
	{0.000}	{0.000}				
lnWAD_MSOAtoLAD_population2	0.179***	0.170***				
	{0.000}	{0.000}				
Lnwac		0.249		0.223		0.283*
		{0.130}		{0.173}		{0.067}
lnWAD_MSOA_population			-7.318***	-7.035***		
			{0.000}	{0.000}		
lnWAD_MSOA_population2			0.460***	0.442***		
			{0.000}	{0.000}		
Lnpropperlength					-14.451***	-13.809***
					{0.000}	{0.000}
lnpropperlength2					1.667***	1.588***
					{0.000}	{0.000}
lnAPH_TWD	0.327***	0.324***	0.340***	0.336***	0.244*	0.236*
	{0.008}	{0.009}	{0.006}	{0.007}	{0.078}	{0.091}
_cons	-2.181	-2.707	17.847***	16.645***	20.655***	19.222***
	{0.185}	{0.111}	{0.001}	{0.001}	{0.000}	{0.000}
Depvar	lnrealbotexplusww	Lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	Lnrealbotexplusww	Lnrealbotexplusww
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	204	204	204	204	204	204
Vce	Cluster	cluster	cluster	cluster	cluster	Cluster
R_squared	0.960	0.960	0.956	0.957	0.962	0.963
RESET_P_value	0.655	0.662	0.751	0.826	0.831	0.772

STATA Results file – Total Water models for years 2012-23: models with total APH

	re19	re20	re21	re22	re23	re24
Lnproperties	1.100***	1.094***	1.074***	1.069***	1.075***	1.071***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
pctwatertreated36	0.002*		0.001		0.002**	
	{0.093}		{0.212}		{0.015}	
lnWAD_MSOAtoLAD_population	-2.395***	-2.297***				
	{0.000}	{0.000}				
lnWAD_MSOAtoLAD_population2	0.169***	0.161***				
	{0.000}	{0.000}				
Lnwac		0.19		0.153		0.221*
		{0.236}		{0.316}		{0.098}
lnWAD_MSOA_population			-6.752***	-6.572***		
			{0.000}	{0.000}		
lnWAD_MSOA_population2			0.432***	0.420***		
			{0.000}	{0.000}		
Lnpropperlength					-16.952***	-16.409***
					{0.000}	{0.000}
lnpropperlength2					1.976***	1.910***
					{0.000}	{0.000}
lnAPH_Total	0.459***	0.440***	0.525***	0.507***	0.482***	0.466***
	{0.001}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
_cons	-4.217	-4.515*	13.775*	13.115*	23.802***	22.684***
	{0.118}	{0.093}	{0.083}	{0.097}	{0.000}	{0.000}
Depvar	Lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	204	204	204	204	204	204
Vce	Cluster	cluster	cluster	cluster	cluster	cluster
R_squared	0.961	0.961	0.961	0.962	0.971	0.970
RESET_P_value	0.724	0.727	0.685	0.831	0.842	0.970

With the data panel to 2023, all of the models using the total APH have higher R squared results than the baseline models which use only the APH to Treated Water Distribution. In models re23 and re24, the level of significance of the APH variable improves in the total APH models. In the others, it is at the same level of significance in both sets of models.

STATA Results file – Total Water models for years 2012-24: Baseline (without APH)

	re19	re20	re21	re22	re23	re24
Lnproperties	1.086***	1.077***	1.055***	1.048***	1.037***	1.031***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
pctwatertreated36	0.002***		0.002*		0.003***	
	{0.002}		{0.081}		{0.007}	
lnWAD_MSOAtoLAD_population	-2.563***	-2.422***				
	{0.000}	{0.000}				
lnWAD_MSOAtoLAD_population2	0.176***	0.165***				
	{0.000}	{0.000}				
Lnwac		0.310*		0.287		0.339**
		{0.090}		{0.114}		{0.044}
lnWAD_MSOA_population			-7.155***	-6.842***		
			{0.000}	{0.000}		
lnWAD_MSOA_population2			0.450***	0.429***		
			{0.000}	{0.000}		
Lnpropperlength					-14.114***	-13.468***
					{0.000}	{0.000}
lnAPH_TWD	0.247**	0.249**	0.255**	0.257**	0.183	0.18
	{0.023}	{0.023}	{0.015}	{0.016}	{0.108}	{0.120}
_cons	-2.068	-2.697	17.500***	16.131***	20.147***	18.649***
	{0.248}	{0.139}	{0.002}	{0.003}	{0.000}	{0.000}
Depvar	lnrealbotexplusww	Lnrealbotexplusww	lnrealbotexplusww	lnrealbotexplusww	Lnrealbotexplusww	lnrealbotexplusww
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	221	221	221	221	221	221
Vce	cluster	cluster	cluster	cluster	Cluster	cluster
R_squared	0.960	0.960	0.956	0.957	0.962	0.963
RESET_P_value	0.609	0.585	0.724	0.779	0.882	0.745

STATA Results file – Total Water models for years 2012-24: models with total APH

	re19	re20	re21	re22	re23	re24
Lnproperties	1.099***	1.090***	1.071***	1.065***	1.070***	1.064***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
pctwatertreated36	0.002***		0.002*		0.002***	
	{0.008}		{0.064}		{0.001}	
lnWAD_MSOAtoLAD_population	-2.400***	-2.274***				
	{0.000}	{0.000}				
lnWAD_MSOAtoLAD_population2	0.168***	0.158***				
	{0.000}	{0.000}				
Lnwac		0.265		0.233		0.284*
		{0.154}		{0.196}		{0.061}
lnWAD_MSOA_popn			-6.698***	-6.449***		
			{0.000}	{0.000}		
lnWAD_MSOA_popn2			0.427***	0.410***		
			{0.000}	{0.000}		
Lnpropperlength					-16.119***	-15.479***
					{0.000}	{0.000}
lnpropperlength2					1.875***	1.797***
					{0.000}	{0.000}
lnAPH_Total	0.351***	0.332***	0.413***	0.392***	0.405***	0.383***
	{0.003}	{0.004}	{0.000}	{0.000}	{0.000}	{0.000}
_cons	-3.629	-4.062	14.212*	13.258*	22.529***	21.194***
	{0.164}	{0.114}	{0.071}	{0.086}	{0.000}	{0.000}
Depvar	lnrealbotexplusww	Lnrealbotexplusww	Lnrealbotexplusww	lnrealbotexplusww	Lnrealbotexplusww	lnrealbotexplusww
Estimation_method	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects	Random Effects
N	221	221	221	221	221	221
Vce	cluster	cluster	Cluster	cluster	Cluster	cluster
R_squared	0.961	0.961	0.961	0.961	0.970	0.970
RESET_P_value	0.766	0.76	0.683	0.827	0.864	0.983

When the 2024 data are added, all models perform better using total APH. All have higher R squared results with total APH and in all models, the level of significance for APH is higher when total APH is used compared to APH for only Treated Water Distribution. In models re20 and re23, the level of significance of weighted average complexity declines when total APH is used. In model re20, the constant becomes more significant, while in re22 and re23, the level of significance for the constant declines.

3. Impact on modelled total base assessment

In the following tables, the baseline modelled results (as published by Ofwat for Draft Determination) are compared with a variant with APH for Water Resource Plus in the Water Resource Plus models and total APH which is included in the total cost models in place of TWD APH which Ofwat used in its Draft Determination models.

In both the analysis up to 2023 and that including 2024, the Upper Quartile increases marginally when the additional elements of APH are added to the models. In the case of the data panel to 2023, the UQ moves from 0.995 to 0.998. For the data panel to 2024, the UQ moves from 0.974 to 0.979.

Modelled output, after imposing Frontier Shift and RPE in line with Ofwat DD assumptions, panel to 2023

	2012-23 data panel		
Company	**Baseline**	**WRP & Total APH**	**Delta**
ANH	1,689	1,768	78
HDD	127	121	-6
NES	1,343	1,323	-20
NWT	2,391	2,391	-1
SRN	792	843	51
SVE	2,752	2,853	101
SWB	802	778	-24
TMS	4,446	4,493	47
WSH	1,220	1,211	-9
WSX	492	540	47
YKY	1,620	1,592	-28
AFW	1,179	1,179	-1
BRL	381	392	11
PRT	181	172	-9
SES	186	191	5
SEW	770	761	-9
SSC	526	527	0
Total	**20,900**	**21,133**	**233**

Modelled output, after imposing Frontier Shift and RPE in line with Ofwat DD assumptions, panel to 2024

Company	Baseline	2012-24 WRP & Total APH	Delta
ANH	1,725	1,796	71
HDD	122	117	-5
NES	1,363	1,346	-17
NWT	2,392	2,396	4
SRN	784	828	44
SVE	2,709	2,802	93
SWB	819	801	-18
TMS	4,726	4,775	50
WSH	1,206	1,200	-5
WSX	480	522	41
YKY	1,615	1,593	-22
AFW	1,154	1,155	1
BRL	376	386	10
PRT	188	180	-8
SES	178	182	4
SEW	759	754	-5
SSC	519	521	2
Total	**21,115**	**21,355**	**241**