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DRAFT WATER RESOURCES MANAGEMENT PLAN 2019

ADDENDUM TO CONSULTATION STATEMENT OF RESPONSE

April 2019

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1 INTRODUCTION

1.1 Purpose

This document is an addendum to our draft Water Resources Management Plan 2019 (dWRMP19) Consultation Statement of Response which we published in September 2018. It should be read alongside our initial Consultation Statement of Response.

1.2 Background

We updated our dWRMP19 and then invited statutory consultees, our customers and other interested stakeholders to comment on it. The consultation on our dWRMP19 took place over a twelve week period between Monday 5th March and Sunday 27th May 2018. The dWRMP19 was, and continues to be, available for review on our website https://www.eswater.co.uk/your-home/environment/water-res-man-plan.aspx

Consultees were asked to send their written representations on our dWRMP19 to the Secretary of State for Environment Food and Rural Affairs, which were then forwarded to Essex & Suffolk Water at the end of the consultation period.

We then prepared and published our dWRMP19 Consultation Statement of Response which detailed:

(a) the consideration that we gave to the consultation responses;
(b) any changes that we made to the dWRMP19 as a result of consideration of those consultation responses and the reasons for doing so; and
(c) where no change was made to the dWRMP19 as a result of consideration of any consultation response, the reason for this.

Defra subsequently wrote to us on 8th February 2019 and requested additional information to support our initial dWRMP19 Consultation Statement of Response. This information is presented in Section 2 below.

2 ADDENDUM TO CONSULTATION STATEMENT OF RESPONSE

This section presents the additional information requested by Defra on 8 February 2019, namely information:

- **Point 1:** in relation to the proposed Abberton to Hanningfield Pipeline (now known as the Abberton to Langford Pipeline);
- **Point 2:** to demonstrate compliance with Directions 3(d), 3(e), and 3(f) in its final plan; and
- **Point 3:** to demonstrate compliance with the Northumbrian Water (Essex and Suffolk) Water Resources Management Plan Direction 2014 3 – 2(d).

2.1 Point 1: Provide an assessment of non-drought related resilience issues and options and improve the assessment of deployable output

Defra commented as follows:

"We are aware that the company is proposing developing supply-side resilience options including the proposal to construct a pipeline between Abberton and Hanningfield reservoirs and upgrade to Layer water treatment. The company should set out the benefits of these options in its plan, including impacts on outage, deployable output and levels of service and the consequences to the supply-demand balance of this investment. This will help reassure stakeholders of the need for the investment".

To fulfil the above requirement, we have included the following information (pages 5 to 21) in Appendix 10 (new appendix) of our revised draft Water Resources Management Plan. Additionally, we have made reference to the new appendix in Section 10.1.2 (Final Water Resources Strategy – Essex).

ABBERTON TO HANNINGFIELD PIPELINE

Summary

The raising of Abberton reservoir has given the Essex Water Resource Zone (WRZ) a significant surplus of raw water supplies over demand until the 2060s. However changes to the quality of Abberton water as a result of the raising and the dry periods of 2016 -2019, coupled with the hot summer of 2018, has raised the risk of likelihood of severe restrictions on water use, and the associated civil and economic consequences of these restrictions, from low to medium. Construction of the link again reduces the likelihood to low.

The proposal to build a pipeline, effectively linking the raw water sources of the two reservoirs, is to build resilience into the Essex WRZ and not to increase deployable output and the supply demand balance. The conditions experienced in these two periods were predominantly due to exceptional outage events, associated with changed water quality not our asset failures, aggravated by changes to rainfall patterns resulting in 3 years of dry autumn/winters delaying reservoir recharge.

To resolve any future combination of these outages events in a more severe form than those experienced to options were identified.

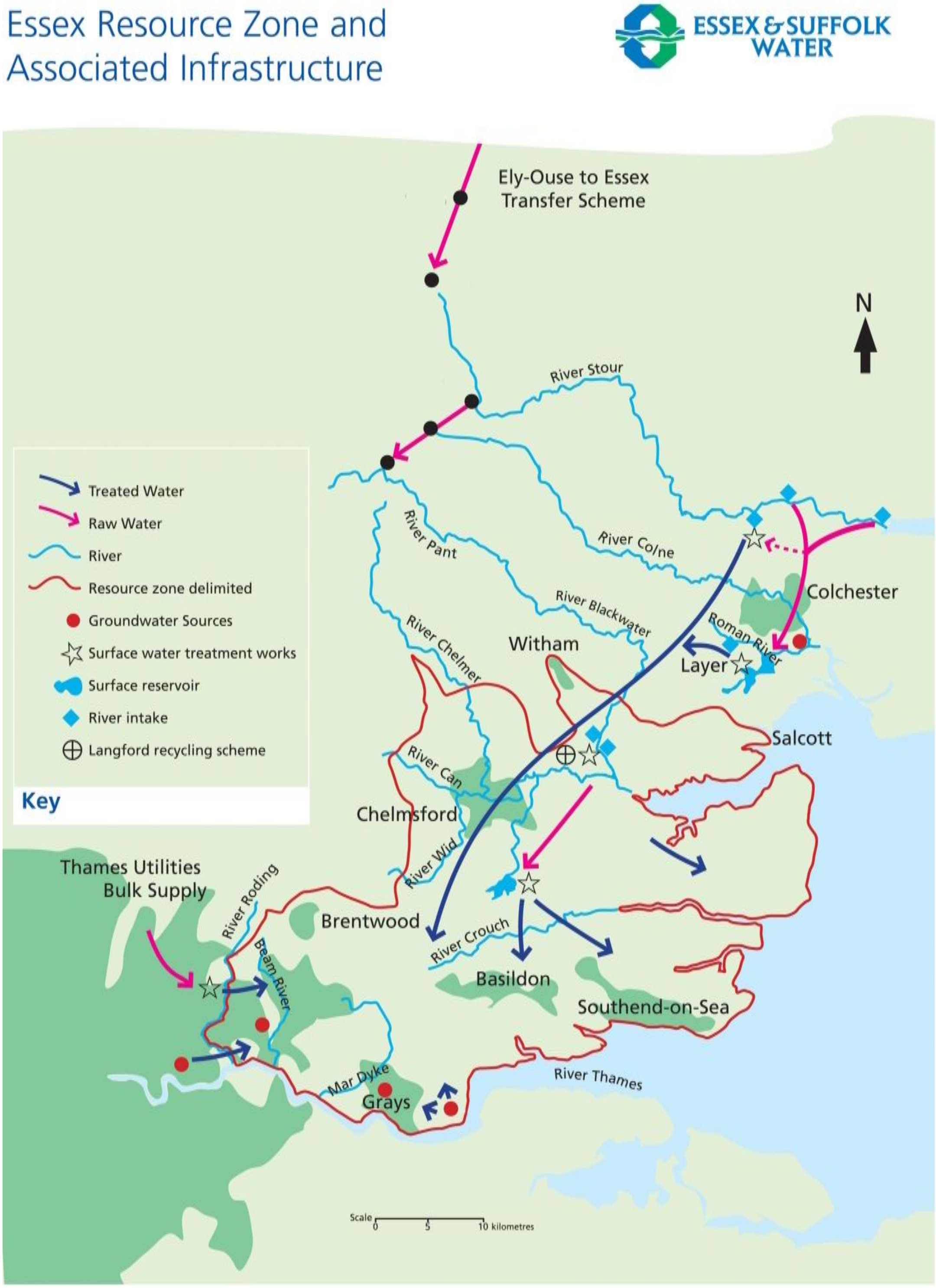
The two options are to increase treatment capacity at our Layer Water Treatment Works (WTW), including an additional 20Ml/d WTW extension, plus triplication of 14.1km of strategic mains to deliver the additional water, at a combined cost of >£60m or the construction of 15km of raw water mains to link Abberton supplies to Hanningfield WTW. The Abberton pipeline costing £20.2m is considerably the cheapest option and has the added benefit of deferring option 1 by a considerable period as demand grows.

Background

The Essex Water Resource Zone (WRZ) serves a population of nearly 1.66m people in the East and South of Essex and three of the London Boroughs. This population is forecast to increase to 1.98m by 2045, an increase of almost 20%. The main bulk of the population resides within the London Boroughs with the greater Southend-on-Sea area being the next most populous.

The Essex WRZ is highly integrated with the water from each of the five Water Treatment Works (WTW) able to compensate for lower distribution input from another WTW. This level of integration stems from the 1971 merger of the Southend Waterworks Company with the South Essex Waterworks company. The Southend Water works company, from its WTW at Langford fed water east into Southend. The South Essex company from its Langham WTW on the river Stour on the Essex/Suffolk border, and its Layer WTW fed from Abberton reservoir both piped water from the North of Essex to its customers in the South of the county and the London Boroughs. In the mid-1950s both companies jointly developed Hanningfield reservoir and WTW to feed the growing demand in both areas. This effectively integrated both company systems prior to the companies merging in 1971. In 1963, the South Essex Company built the Chigwell WTW, taking water from the, now, Thames Water, Lea Valley reservoirs to further meet the growing demand of the London Boroughs. The final major development was the 2014 opening of the raising of Abberton reservoir which increased its capacity from 25,500Ml to 41,500Ml.

Fig. 1



Vulnerability of Essex WRZ in 2016 and 2018/19

The Essex WRZ has five Water Treatment Works (WTW) producing over 98% of the potable supplies. Two small well sources make up the remainder. The WTW have two distinct methods of treating water. Layer, Langham and Chigwell are Slow Sand Filter (SSF) works where water is primarily filtered and then slowly passes through large beds of fine grade sand where bacteriological processes established on the sand bed aid purification of the water. The other two WTWs are Langford and Hanningfield which use physico/chemical treatment, including pre-ozonation, coagulation, primary filtration, ozonation and Granular Activated Carbon filtration. These physico/chemical works handle algal blooms in their source water far more effectively than the current SSF works. This can be seen by the recorded outage at each works in Figure 2.
The outage tabulated in Fig.2 is calculated as per the WRMP guidance methodology using actual WTW data 2012 – 2016. The full contribution from the 2016 exceptional algal events therefore only contributes 20% to the WRMP Layer outage figure.

Fig. 2

Table 3.15: Summary of Essex outage data

Water Resource Zone		Raw Water Source	Planned	Unplanned - Algae	Unplanned - Nitrates	Unplanned - Pollution of Source	Unplanned - Power Failure	Unplanned - System Failure	Unplanned - Turbidity	Grand Total
Total Ml										
	Chigwell	Reservoir	552	4,775				1,516		6,843
	Langford	River	3,862	1,232	1,215	1,357	57	330	1,912	9,965
Essex	Langham	River	5,145	4,303	92	1,855		2,030	502	13,927
	Layer	Reservoir	3,996	17,351				219	13,442	35,007
	Total		**13,555**	**27,661**	**1,308**	**3,212**	**57**	**4,096**	**15,856**	**65,743**
Total Days										
	Chigwell	Reservoir	14	229				64		307
	Langford	River	112	68	95	167	2	35	71	550
Essex	Langham	River	282	219	12	115		109	36	773
	Layer	Reservoir	104	456				9	240	809
	Total		**512**	**972**	**107**	**282**	**2**	**217**	**347**	**2,439**
(Average Ml/d)										
	Chigwell	Reservoir	0.30	2.62	-	-	-	0.83	-	3.75
	Langford	River	2.12	0.68	0.67	0.74	0.03	0.18	1.05	5.46
Essex	Langham	River	2.82	2.36	0.05	1.02	-	1.11	0.28	7.63
	Layer	Reservoir	2.19	9.51	-	-	-	0.12	7.37	19.18
	Total		**7**	**15**	**1**	**2**	**0**	**2**	**9**	**36**
(Average Days / Year)										
	Chigwell	Reservoir	2.80	45.80	-	-	-	12.80	-	61.40
	Langford	River	22.40	13.60	19.00	33.40	0.40	7.00	14.20	110.00
Essex	Langham	River	56.40	43.80	2.40	23.00	-	21.80	7.20	154.60
	Layer	Reservoir	20.80	91.20	-	-	-	1.80	48.00	161.80
	Total		**102**	**194**	**21**	**56**	**0**	**43**	**69**	**488**

As can be seen, the highest outage is from Layer WTW, fed from Abberton reservoir. Raising the reservoir has drastically altered the quality of the water within the reservoir, making it more difficult to treat in the existing WTW. This accounts for our proposal to add a "front end" Dissolved Air Flotation (DAF) stage at Layer during AMP7. Increased algal blooms, due to either more exposed soils in contact with the water or the new surface area or depth or all three, has accounted for most of the outage. Whilst Layer's maximum works output is 145Ml/d for 7 consecutive days the annual average reliable Distribution Input is around 120 – 130Ml/d prior to installation of a DAF plant. During years such as 2016, for periods when there are severe algal blooms, it is considerably less. A DAF plant would also deal with sedimentation issues causing turbidity outages. Again, increased turbidity is a consequence of reservoir raising which caused new ground to be flooded but also removed all of the 4m depth of concrete skirting that had circled the original reservoir.

Balancing Essex supplies to Essex demands

Following the raising of Abberton reservoir, completed in 2014, Essex has a significant surplus of raw water supplies against current and future demand. This has allowed us to trade raw water back to Thames Water and to be in discussion with both Anglian Water and Affinity Water about trading water with them for resilience of their jointly owned Ardleigh WTW.

With the raising of Abberton its capacity at 41,500Ml is now much greater than that of Hanningfield at 25,500Ml whereas previously they were of equal capacity. To maximise the deployable output of the system both reservoirs need to be drawn down at equal percentages, meaning the flows from Abberton should, on average, be 50% greater than those from Hanningfield.

However, raw water algal events in 2016 and the extreme dry, hot summer of 2018 have shown that treatment capability at our Layer and Chigwell WTWs has led to Hanningfield WTW having to output consistently high volumes. This has resulted in Hanningfield reservoir being drawn down below historic minimum levels, whilst at the same time Abberton reservoir, with much higher capacity (41,500Ml vs 25,500ML), has for most of the time been comfortably above its pre-raised full level.

Events of 2016

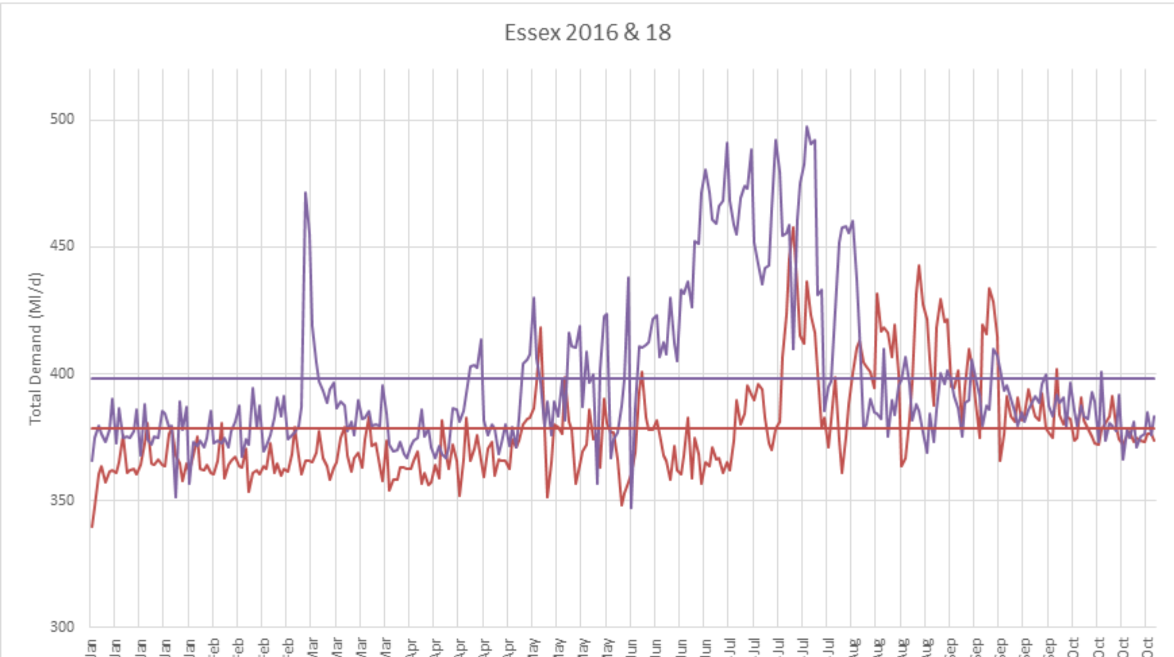
In the summer of 2016, from August almost through to Christmas, all of our reservoir sources suffered severe algal blooms. Whilst in eutrophic lowland waters algal blooms are common and expected, having all three sources so affected and, for such duration, is uncommon. Other companies with similar waters also reported similar problems. Abberton was worst affected both in type of algae, total biomass and duration of severe blooms. Chigwell experiencing blooms at this time of year is unusual, normally this source suffers more in early spring from diatom blooms. Hanningfield had severe blooms but the ability to disrupt the water in the reservoir using the installed air curtains reduced the duration and better treatment allowed higher outputs to be produced. Abberton's algal blooms, predominated by diatoms that require silica salts to exist, were undoubtedly exacerbated by the reservoir raising. The newly flooded virgin soils would have been a new and abundant source of silica.

The autumn remained dry through to mid-December reducing the volumes able to be pumped to Hanningfield reservoir. This combined with Hanningfield WTW having to run at a constant high load to compensate for the other WTWs saw the reservoir declining by 4% per week. The Environment Agency's Ely Ouse to Essex Transfer Schemes (EOETS) which, should water be available in the Ely Ouse, transfers water into the Essex rivers to aid in refilling Abberton and Hanningfield reservoirs, was unavailable during 2016. This was due to serious problems with the power supplies and pumps following a major refurbishment. The combined consequences of these events on the drawdown of Hanningfield reservoir can be seen in Figure 7 with the reservoir being below its historic minimum for six weeks. At the same time, Abberton reservoir (figure 4) remained above its pre raised top water level. A wet December, marked improvement in algal content at Abberton allowing a higher output from Layer WTW and some transfer from the EOETS allowed recovery of Hanningfield reservoir.

<u>Events of 2018/19</u>

The autumn of 2017 and the first 2 months of 2018 had been significantly dry. Beast from the East, depositing useful amounts of snow, was followed by above average wet conditions through to the end of May. This allowed full refill of both reservoirs by the end of May. From June onwards our Essex area along with most of England then entered one of the driest and hottest summers on record. Figure 3 below demonstrates the increase to demand over this period, peaking at 30% above normal and averaging 20% above normal between January and October.

Fig. 3



Layer WTW performed well over this period producing its expected 130Ml/d on average. Hanningfield was required to produce more water than in a normal year to meet the increased demand, as Hanningfield WTW is where the headroom in our deployable output resides. This resulted in Hanningfield reservoir beginning to draw down rapidly from July. Although the weather broke from its high temperatures in August the period from August 2018 to end of January 2019 saw rainfall, and hence river flows, significantly below the long term average for this period. Layer WTW performing as required up until September, then entered a period of low output continuing through to end February 2019. These low outputs were a combination of lengthy repairs needed to the chlorine contact tanks due to two separate inspections showing repairs to their integrity was needed, possibly caused by the ground being so dry during the summer the underground concrete structures were stressed. The nature of SSFs also added to the low output. When a SSF has run for approximately 20 weeks, it must be drained down, an approximate 10cm of sand skimmed off the bed and then "ripened" by running the bed to waste until the bacteriological fauna has built up sufficiently to reduce coliform and E. Coli within the filtered water to a predetermined level. In warm water conditions this can take three weeks or more. Only two beds can be ripened simultaneously. Additionally after five or so skims the whole bed then requires reinstatement. Having fulfilled its role through the summer we would expect lower output from Layer during the late summer/autumn, however the number of beds requiring skimming at similar times, due to the high summer demand, allied to the contact tanks meant its output was much lower in this period than historically. The only place this demand, and the continuing higher than normal demand due to the dry conditions, could be met was from Hanningfield. Figure 8 shows the rapid decline of the reservoir through to the end of September, with Figure 9 demonstrating the slow rate of refill, compared to long term average due to high output and low river flows. Transfers from the EOETS through to the beginning of February have aided refill. Currently, full refill for summer 2019 is expected by the end of May 2019, but could sooner if rainfall and river flows allow.

Fig. 4
Note week 40 = 1st October for each year

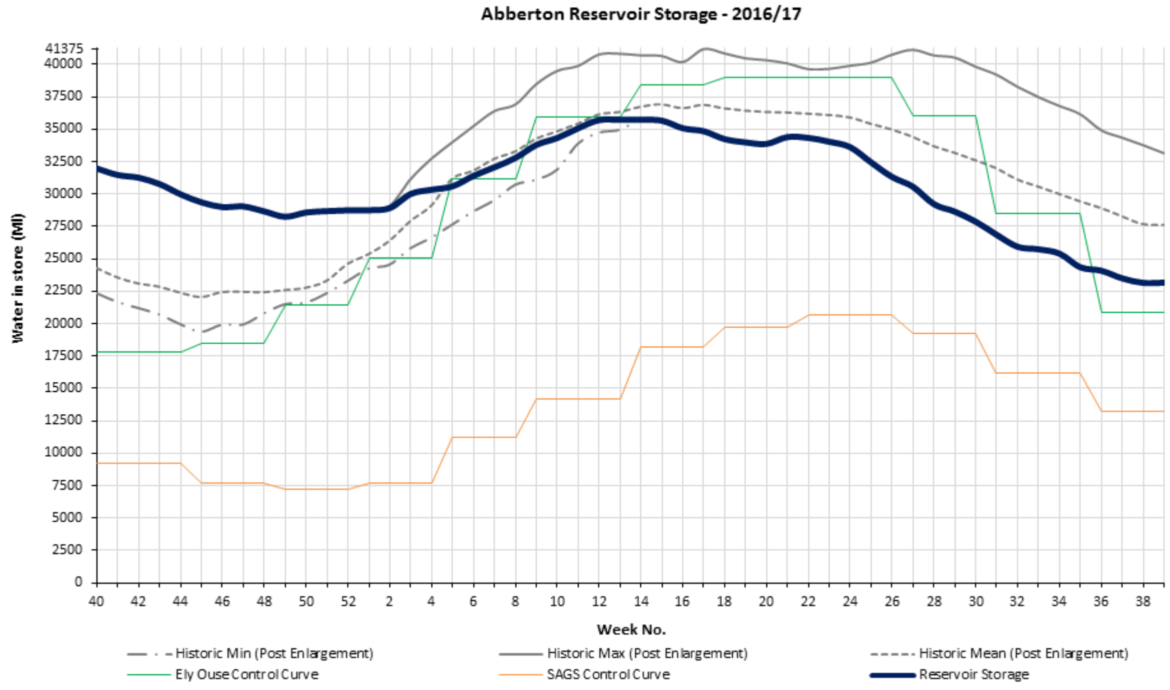


Fig. 5

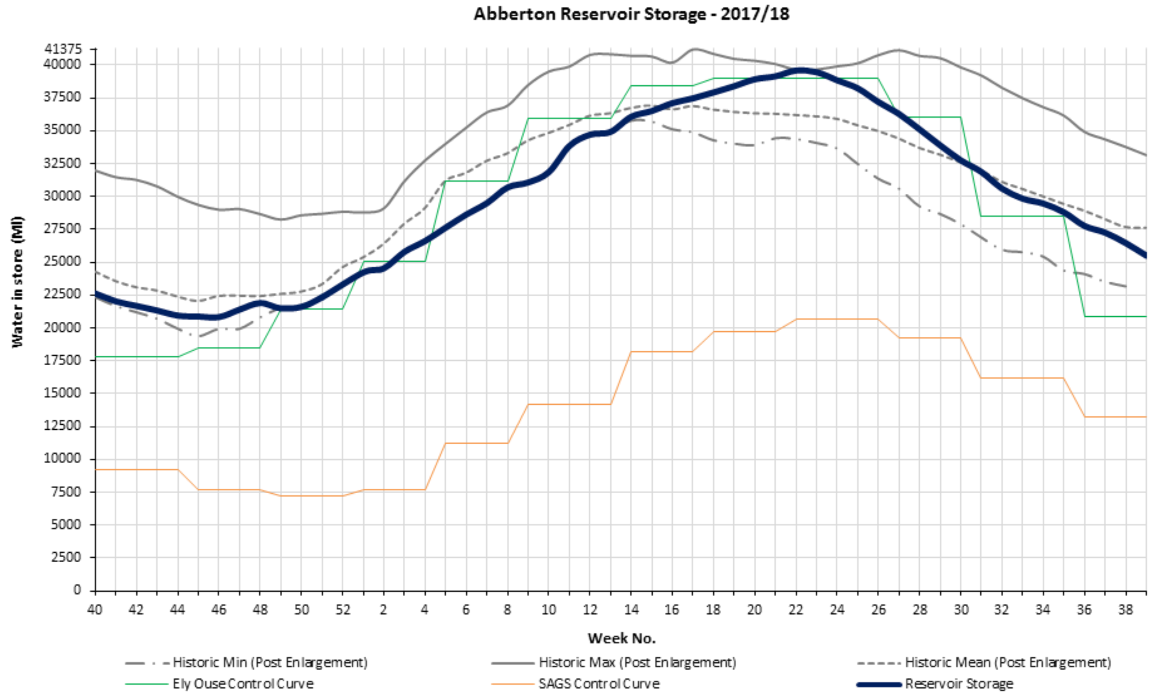
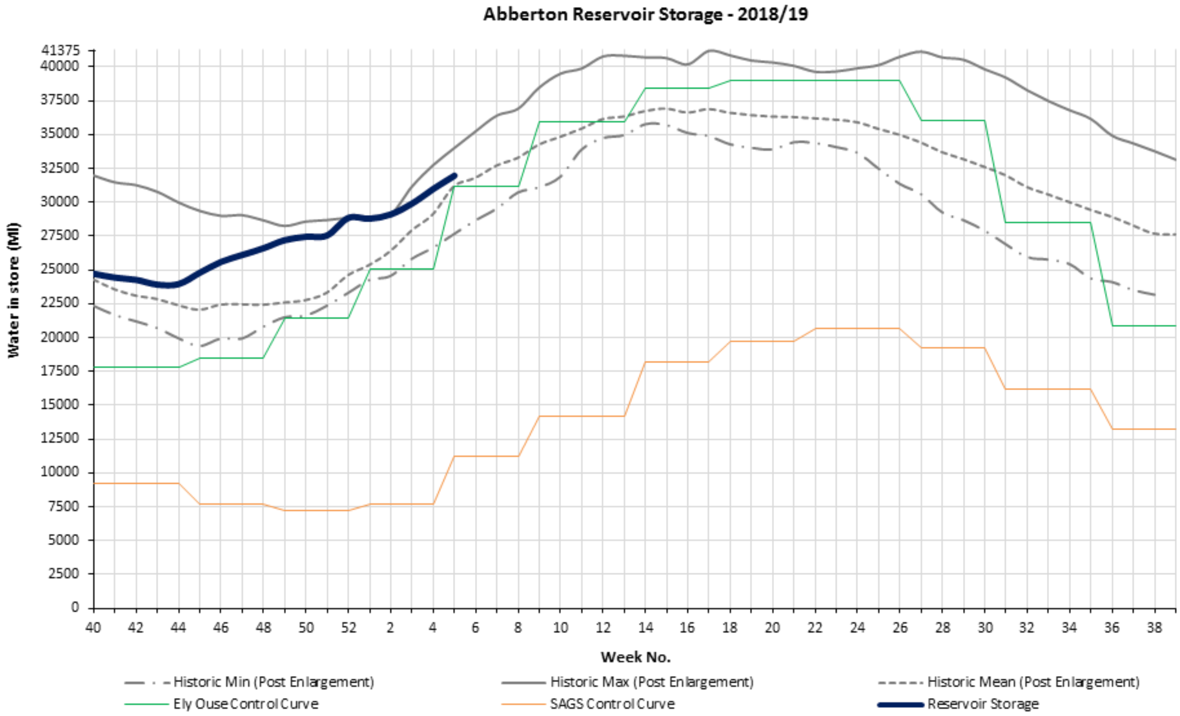
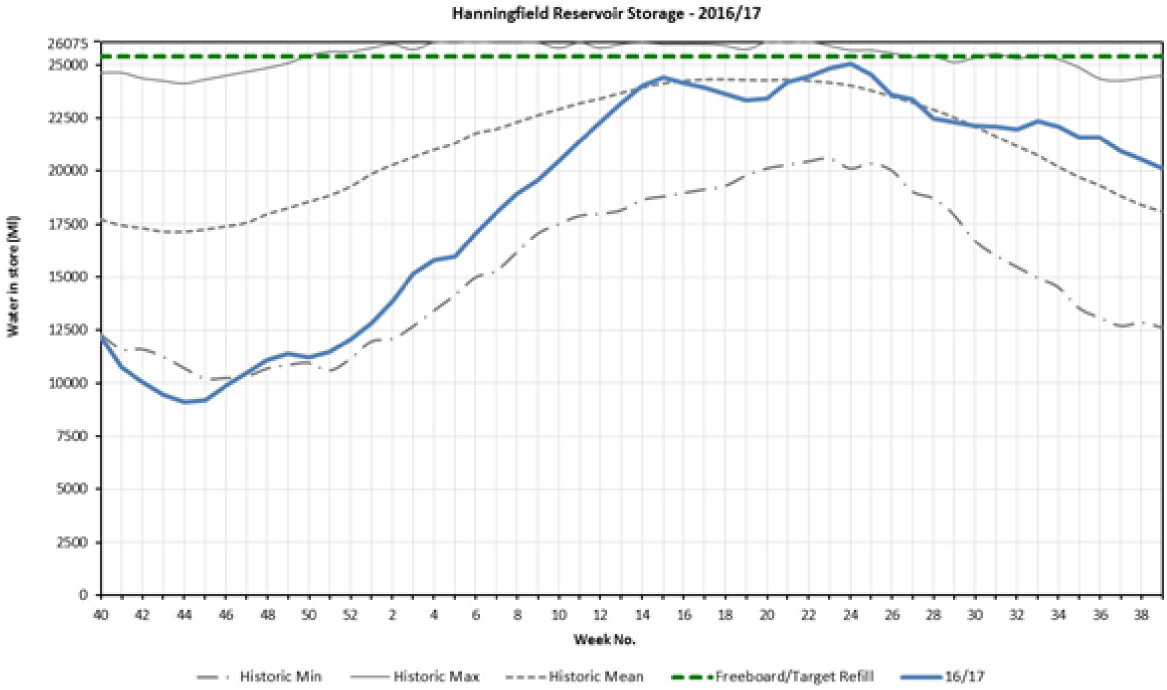


Fig. 6



Abberton Reservoir Storage - 2018/19
Water in store (Ml)
41375
40000
37500
35000
32500
30000
27500
25000
22500
20000
17500
15000
12500
10000
7500
5000
2500
0
40 42 44 46 48 50 52 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38
Week No.
Historic Min (Post Enlargement)
Historic Max (Post Enlargement)
Historic Mean (Post Enlargement)
Ely Ouse Control Curve
SAGS Control Curve
Reservoir Storage

Fig. 7



Hanningfield Reservoir Storage - 2016/17
Water in store (Ml)
26075
25000
22500
20000
17500
15000
12500
10000
7500
5000
2500
0
40 42 44 46 48 50 52 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38
Week No.
Historic Min
Historic Max
Historic Mean
Freeboard/Target Refill
16/17

Fig. 8
Note, new historic minimum following 2016/17

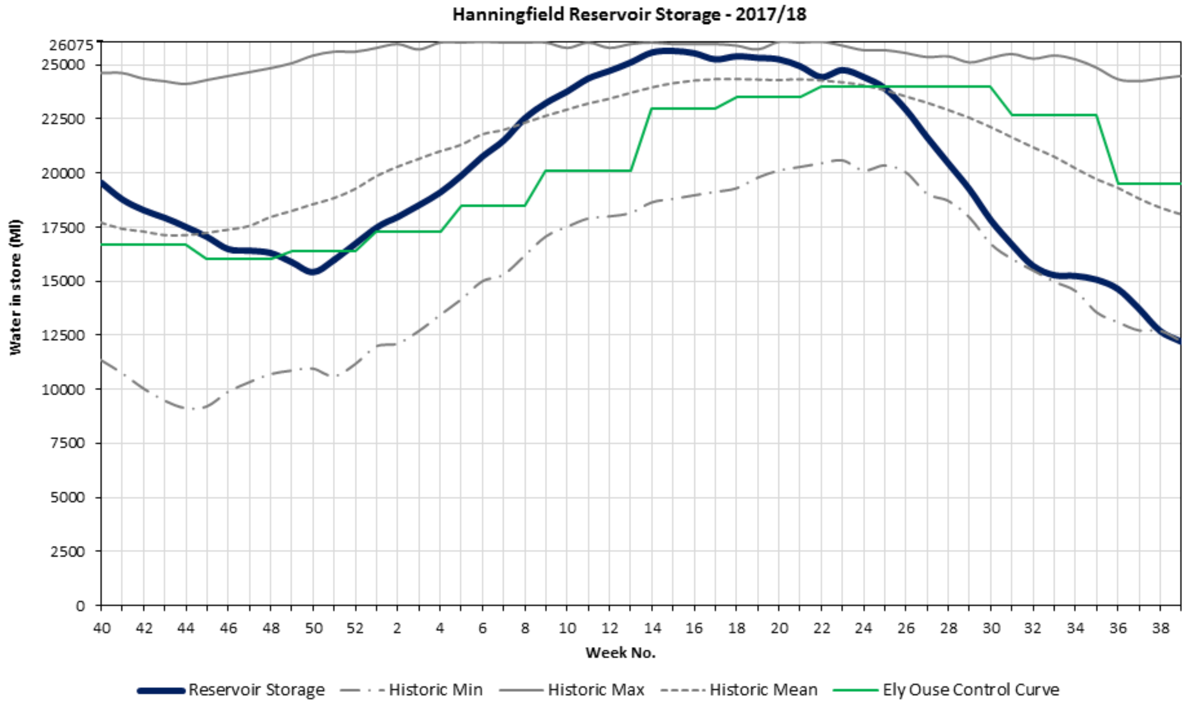
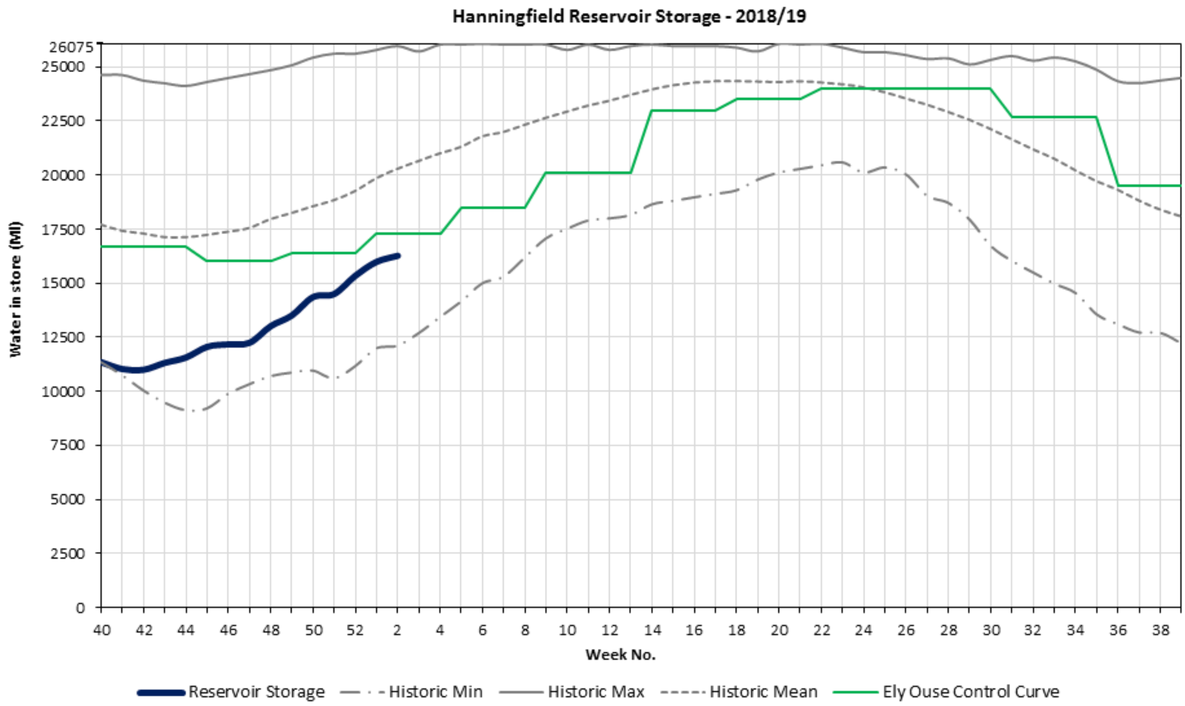


Fig. 9



Consequences of these Events on our Estimation of Current Resilience

Having developed the raised Abberton reservoir, and building a significant surplus of raw water compared to forecast demands, we had assumed that the Essex WRZ was now in a resilient position. The 2016 and 2018/19 events detailed above have now forced us to reconsider the resilience of this WRZ due to combinations of un-forecastable outage events. Whilst neither event led to any effect on our customers, it is now conceivable that a different combination of these issues coming together or existing for a longer duration, could seriously threaten our ability to provide water to our stated Level of Service, or worse. This shift in the resilience of the Essex WRZ is due to changes to water quality because of the reservoir raising and the effects of climate change.

The knowledge gained from these events has raised our estimate of risk of supply failure from **low likelihood, high consequence** to **medium likelihood, high consequence.**

The consequence of Hanningfield reservoir being too low to provide water to Hanningfield WTW would be grave and not something we could ever contemplate for our customers or something they would accept. The only way to overcome this situation would be severe restrictions on use and the disruption of laying overland pipes from Abberton to the Hanningfield reservoir's river water pumping station at Langford.

Options for avoiding the increased risk

Only two options exist to remove the increased risk presented by these events:

1) Increase the reliable maximum output from Layer WTW
2) Transfer raw water from Abberton reservoir in to the Hanningfield system.

<u>Option 1</u>

Layer WTW is currently designed to treat a seven day peak output of 145Ml/d and an average annual output of 120-130Ml/d. Changes to reservoir water quality as a result of the raising has increased outage significantly, due to algal blooms, meaning both of these figures are not being met. A resilience scheme, installation of a Dissolved Air Floatation (DAF) front end, to overcome these changes has been put in to our PR19 Business Plan.

The enlarged Abberton reservoir, and the associated infrastructure and licenses, can support a deployable output of 210Ml/d. Feasibility and Conceptual Designs for eventually increasing Layer's output were produced at the time of the Abberton Scheme planning by the engineering consultancy MWH. (07/4/2006 – MWH-ESW Layer 145-Feasibility and Conceptual Design Report V3). This report defined the work needed to increase the Layer treated water output to first 165Ml/d and the further work to reach the maximum output of 210Ml/d. Each stage of increase timed for when growing demand would require higher outputs.

The treatment increase to 165Ml/d and 210Ml/d is scheduled to follow the increase in peak demands due to growth. The treatment solution is also different to the current Slow Sand Filter (SSF) treatment, although the existing WTW will remain to produce the 145Ml/d. The new WTW will be physico/chemical and will be a side stream to the existing WTW. Land for its construction was acquired as part of Abberton Scheme. The first additional 20Ml/d WTW (Layer 165) has a 2006 capital cost of £32m for the WTW and an additional £10.8m for sludge handling.

In addition to building a further 20Ml/d WTW it will also be necessary to further triplicate the strategic mains that take the flows from Layer and Langham in the North of Essex to its demand sites in the South. The current strategic mains are limited to a total capacity of 180Ml/d, meaning if Layer is on full flow of 145Ml/d then the maximum Langham WTW can produce is 35Ml/d compared to its DO of 55Ml/d. Increasing Layer to 165Ml/d requires triplication of the mains as follows:-

Layer Marney to Tiptree	6km
Tiptree to Oxley Green	1km
Woodham Walter PS to Butts Green	7.1km
Total	14.1km
Approximate cost	£14m-£16m

If Layer was eventually upgraded to 210Ml/d, it will be by increasing the capacity of the new side stream WTW. The 2006 estimated cost was £13m.
Further triplication of the strategic mains will also be necessary and involves a further 13.2km of triplicated mains at an estimated cost of £13m -£14m.

<u>Option 2</u>

The resilience proposal is to “link” the two Essex reservoirs, Abberton and Hanningfield, and rather than treat additional water at Layer WTW, pipe up to 50Ml/d from Abberton for treatment at Hanningfield. To understand why this is the favoured option to build resilience into the Essex WRZ by overcoming future multiple outage events, it is necessary to understand the Langford/Hanningfield system.

The rivers Chelmer and Blackwater come together at Langford. Langford has a standalone WTW with a DO of 56Ml/d and is a physico/chemical works very able to treat water of poorer quality, including algal blooms. The main outages associated with this WTW are nitrate and pesticide levels in the river water, especially in the autumn/early winter flows. Water is abstracted from the rivers to firstly satisfy the needs of Langford WTW and excess flows pumped 14km to Hanningfield reservoir. When flows allow, up to 240Ml/d can be pumped to Hanningfield reservoir.

The concept of the Abberton reservoir to Hanningfield reservoir link is not that water from Abberton is piped directly to Hanningfield reservoir but goes by substitution. Abberton reservoir water will be piped directly onto Langford WTW, via its bank-side storage reservoir. This removes all concerns, and required additional treatment, associated with Invasive Non Native Species that would arise if Abberton water was piped in to the river Blackwater to be abstracted at Langford and pumped onto Hanningfield reservoir.

By feeding between 30Ml/d - 50Ml/d of Abberton water on to Langford WTW, the equivalent volume is then left available in the 2 rivers for pumping onwards to Hanningfield reservoir. This then allows Hanningfield WTW to increase its average output by the equivalent 30 – 50Ml/d without increasing its normal drawdown.

A further benefit of water going directly on to Langford WTW from Abberton reservoir is the improvement to quality in the autumn/winter of Abberton reservoir water compared to that in the river Chelmer and Blackwater. Both reservoirs are predominantly filled in the autumn/winter where, following dry summers, rainfall washes out nitrates from agricultural land in to the rivers. These nitrates reduce significantly in the reservoirs during summer leaving low nitrate water. By using Abberton water at Langford WTW, all of the outage due to nitrate and most pesticide outages are removed.

Advantages of Option 2

- This builds in resilience over the outage events and dry autumn faced in 2016 and 2018/19 as Hanningfield can meet the flows required when other works have extended outages but the reservoir is not drawn down to unacceptable levels;
- If we increase the treatment and potable water transfer capacity at Layer to balance equal % drawdown of the reservoirs we effectively mothball a significant percentage of Hanningfield WTW's existing treatment capacity. This removes that happening and allows Hanningfield's full water treatment capacity to be employed.
- The cost of the link pipeline is £20.2m in 2017/18 cost. The cost of taking Layer WTW to 165Ml/d and triplicating the next stage of the strategic mains is £57m (£43m at 2006 prices);
- Further resilience and efficiency is derived from the option to transfer the water from Abberton to Hanningfield, or not depending on the circumstances of each year.
- Having the ability to treat Abberton reservoir water at Langford WTW removes a large volume of outage from Langford caused by river nitrates and pesticides.
- Building the link defers upgrade to Layer WTW outside of the 25 year demand forecasts currently calculated.

Conclusion

The experiences since 2016 within the Essex WRZ has clearly demonstrated that this WRZ is not as resilient to extreme events as previously assumed due to unpredictable outage events. Weather conditions of recent years, especially 2018 where Beast from the East and the hot, dry summer were both 1 in 100 year events yet both occurring in one year, strongly suggests extreme events will become more regular. The autumns of 2016-18 have all been unusually dry leading to Hanningfield reservoir being pulled down to, and even below, long term minimum levels.

Whilst the proposed pipeline taking raw water from Abberton reservoir effectively in to Hanningfield reservoir does not alter our supply demand balance, the flexibility it brings to moving raw water around Essex and reducing outages makes the WRZ much more resilient.

Depending on the weather and water quality position of each year, the water can be left at Abberton and treated at Layer WTW or moved for treatment to the more advanced Hanningfield WTW. This is also a more economically sensible option for our customers. Rather than spend over £60m at Layer WTW to ensure the reservoir draw-downs are balanced, and effectively “mothball” a proportion of Hanningfield WTW’s treatment capacity, transferring the water is a much lesser cost at £20.2m.

Whereas the risk of severe restrictions, and the associated civil and economic consequences thereof, were previously thought to have a low likelihood but with high consequences, currently we now estimate the likelihood as medium, with the consequences high. Building the reservoir link main returns the likelihood to low.

LAYER WATER TREATMENT WORKS UPGRADE

Background

The Essex WRZ has five Water Treatment Works (WTW) producing over 98% of the potable supplies. Two small groundwater sources make up the remainder. The WTWs have two distinct methods of treating water, using either traditional slow sand filtration or chemical treatment and rapid gravity filtration. Layer WTWs, which supplies over 300,000 properties, is a Slow Sand Filter (SSF) works where water is primarily filtered and then slowly passes through large beds of fine grade sand where bacteriological processes established on the sand bed aid purification of the water.

The enlargement of Abberton reservoir has increased the Essex WRZ deployable output and has provided a supply surplus up to at least 2065. However, it has also increased turbidity and algae within the reservoir, making it more difficult to treat using the existing Layer WTW. This has increased unplanned outage due to water quality. Increased turbidity could be a consequence of enlarging the reservoir, removing the concrete skirting that had circled the original reservoir and of flooding the new reservoir footprint. Increased algal blooms have accounted for most of the WTWs outage. This is likely to be due to:

i. the leaching of nutrients from newly flooded soils which has fed the algae; and / or
ii. the new surface area and depth of the reservoir.

We have therefore included in our PR19 Business Plan a new treatment process to address the impact of raw water deterioration at Abberton reservoir on the treatability of water at Layer WTW.

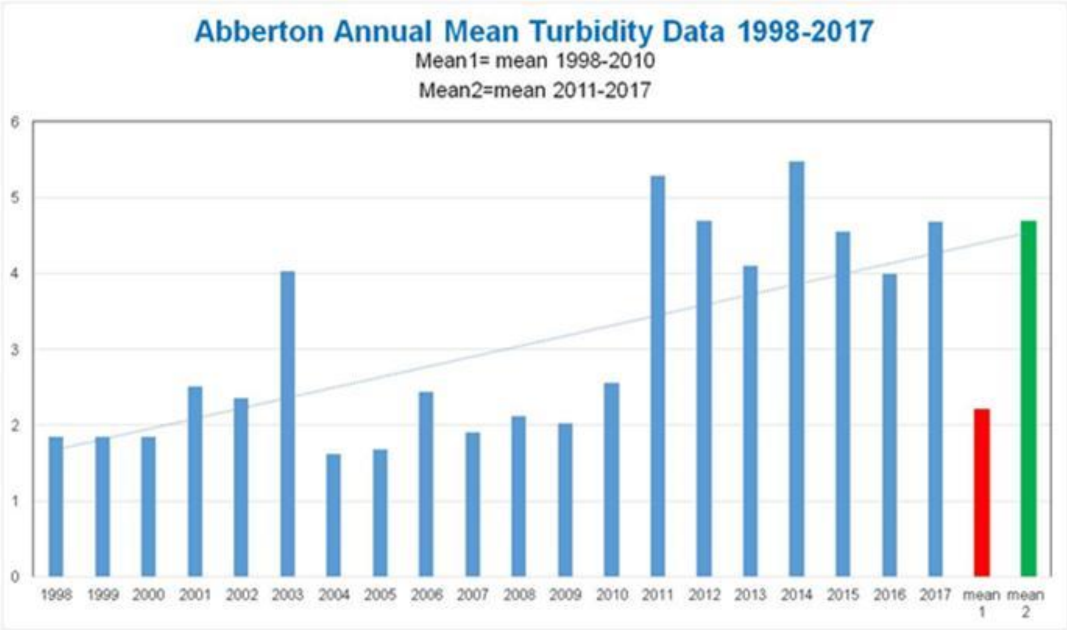
It is important to note that this scheme does not provide additional deployable output and so is not a supply demand balance driven scheme. It is a resilience driven scheme as it will ensure unplanned outage remains in line with our PR19 outage allowance. Without it, and should Abberton reservoir water quality deteriorate further, there is a risk that restrictions more frequent than our planned levels of service would be required. However, when combined with improvements to the resilience of our raw water transfer capability provided by the new Abberton to Langford Pipeline, the new treatment process will ensure we are able to provide resilient supplies in line with our Levels of Service.

Changes in water quality in catchments and Abberton Reservoir since 2010

Enlargement of Abberton reservoir took place between 2010 and 2014. Clear evidence has emerged that changes in catchments and climate have led to unpredictable changes in the raw water quality of Abberton reservoir. Since enlargement of the reservoir in 2010 this deterioration appears to be accelerating. An internal review of water quality data shows that since the start of the enlargement of Abberton in 2010, there has been a significant deterioration in reservoir turbidity.

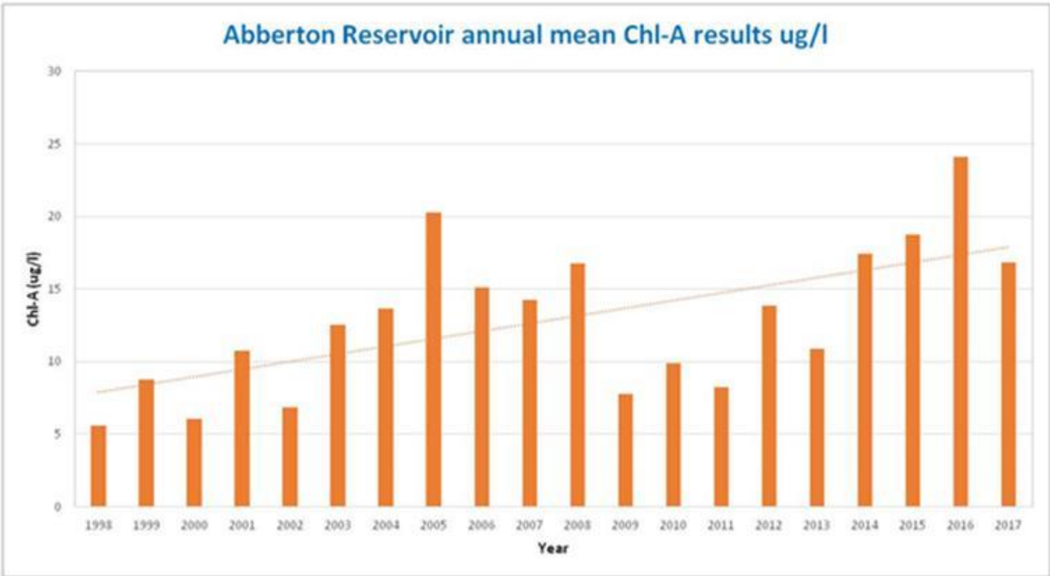
The figure below illustrates annual average turbidity (blue bar) for each of the years between 1998 and 2017 and an increasing trend line. The 1998 to 2010 mean turbidity (red bar) was 2.22 NTU but increases to 4.68 NTU post 2010 (green bar).

Abberton Annual Mean turbidity 1998 to 2017.



The figure below illustrates annual average Chlorophyll A concentrations for Abberton and can be used as an indicator of how much algae was present in the water column.

Abberton Annual Mean Chl-A 1998 to 2017



This shows that a peak concentration of just under 25 µg/l was observed in 2016, the highest value since before 1998. It also shows that the previous four years had concentrations that were on the whole higher than the previous 12 years with the exception of 2005 and 2008.

Scheme Justification of Need

As summarized above, the water quality deterioration experienced at Abberton is impacting upon the effectiveness of our treatment works at Layer WTW and at times leads to a reduction in works output (i.e. unplanned outage). This has been most noticeable in the dry periods since 2016 (including the long hot summer of 2018) and elevates the risk of restrictions on water use in the Essex Water Resource Zone.

The highest outages in the Essex supply area are experienced at Layer WTW, driven by algal blooms and turbidity changes. This is evidenced by the table below which compares outage figures for four of the Essex WTWs.

Summary of Essex Outage data 2018

Water Resource Zone		Raw Water Source	Planned	Unplanned - Algae	Unplanned - Nitrates	Unplanned - Pollution of Source	Unplanned - Power Failure	Unplanned - System Failure	Unplanned - Turbidity	Grand Total
Total Ml										
	Chigwell	Reservoir	552	4,775				1,516		6,843
	Langford	River	3,862	1,232	1,215	1,357	57	330	1,912	9,965
Essex	Langham	River	5,145	4,303	92	1,855		2,030	502	13,927
	Layer	Reservoir	3,996	17,351				219	13,442	35,007
	Total		**13,555**	**27,661**	**1,308**	**3,212**	**57**	**4,096**	**15,856**	**65,743**
Total Days										
	Chigwell	Reservoir	14	229				64		307
	Langford	River	112	68	95	167	2	35	71	550
Essex	Langham	River	282	219	12	115		109	36	773
	Layer	Reservoir	104	456				9	240	809
	Total		**512**	**972**	**107**	**282**	**2**	**217**	**347**	**2,439**
(Average Ml/d)										
	Chigwell	Reservoir	0.30	2.62	-	-	-	0.83	-	3.75
	Langford	River	2.12	0.68	0.67	0.74	0.03	0.18	1.05	5.46
Essex	Langham	River	2.82	2.36	0.05	1.02	-	1.11	0.28	7.63
	Layer	Reservoir	2.19	9.51	-	-	-	0.12	7.37	19.18
	Total		**7**	**15**	**1**	**2**	**0**	**2**	**9**	**36**
(Average Days / Year)										
	Chigwell	Reservoir	2.80	45.80	-	-	-	12.80	-	61.40
	Langford	River	22.40	13.60	19.00	33.40	0.40	7.00	14.20	110.00
Essex	Langham	River	56.40	43.80	2.40	23.00	-	21.80	7.20	154.60
	Layer	Reservoir	20.80	91.20	-	-	-	1.80	48.00	161.80
	Total		**102**	**194**	**21**	**56**	**0**	**43**	**69**	**488**

Optioneering and Scheme Development

We have considered a number of options. The Do nothing option was discounted as we believe there is sufficient evidence to demonstrate that Abberton reservoir water quality has not stabilised and that we could in fact encounter higher than historical outage.

We have also considered five treatment options. All of the options included variants around using a new Dissolved Air Floatation (DAF) process in order to address increasing algal concentrations and sedimentation issues. The options considered are summarised as follows:

Option	Option Description	Viable
1	Modify existing treatment plant and then build parallel treatment streams of the required capacity, comprising of dissolved air flotation (DAF), followed by rapid gravity filtration (RGF), and followed by granular activated carbon (GAC) contactors. As the study proceeded it became clear that the design of this option would mean that at times Layer would be unable to achieve output in excess of 110 Ml/d, so this option was quickly discounted.	Discounted
2	This option proposed that in order to reach flows of 145Ml/d the existing works would be abandoned, and a whole new treatment train would be constructed comprising DAF, RGFs and GAC contactors. This option was discounted on the basis of increased costs from having to construct an entirely new treatment works.	Discounted
3	This option was also designed to hit the required 145Ml/d WTW outputs, and with a DAF plant proposed upstream (and thereby more efficient) of the existing treatment processes.	Recommended
4	This option was identical to Option 3 but would potentially look to treat higher quantities of up to 165 Ml/d, potentially requiring interstage pumping and further treatment downstream. This option was later discounted as this level of output is not currently required, so the increased costs to do this cannot be justified.	Discounted
5	This option also included an upstream DAF process stream but only on one rather than both of the current process streams. This option was later discounted due to concerns over whether this option would meet the required treatment works output.	Discounted

Preferred Option

Following appraisal of the options, the proposed scheme is to install a new front end DAF (dissolved air floatation) treatment process stream at Layer WTW to address the changes to catchment water quality at Abberton (principally turbidity and algae). This will ensure that the works can maintain its full deployable output (i.e. unplanned outage remains within our allowance should water quality continue to deteriorate) and will ensure the risk of supply restrictions to over 300,000 properties does not increase above our planned levels of service.

2.2 Point 2: 3 (d) the emissions of greenhouse gases which are likely to arise as a result of each measure which it has identified in accordance with section 37A(3)(b), unless that information has been reported and published elsewhere and the water resources management plan states where that information is available

Defra commented as follows:

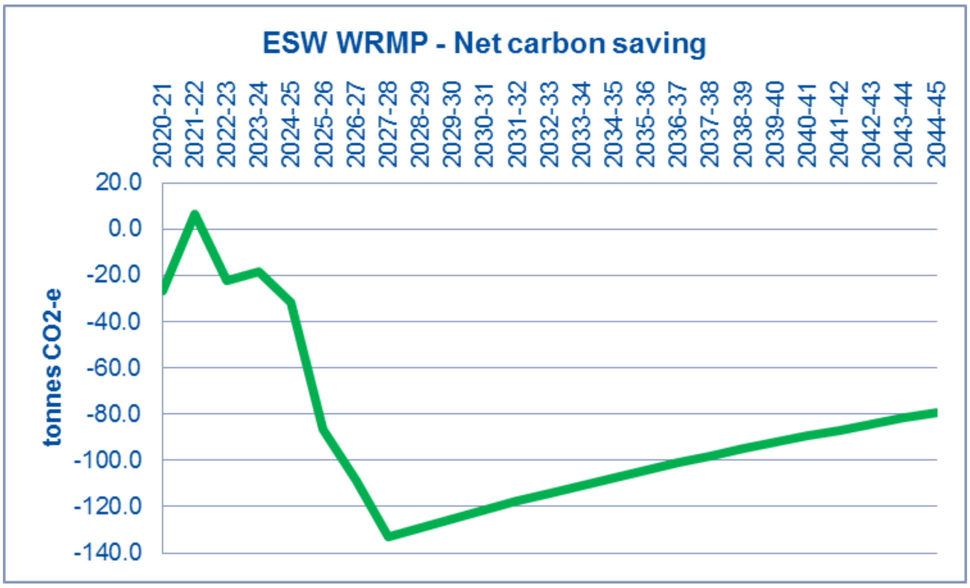
The company has provided further information detailing how operational greenhouse gas emissions are forecast to fall, however it has not described the emissions from its current or future operations. The company must state its estimate of greenhouse gas emissions associated with its current baseline operations and each preferred (final plan) demand option individually to meet Direction 3(d).

We have updated Section 6.11 of our revised draft Water Resources Management Plan to include the following information.

The Impact of Our Planned Actions on Carbon Emissions

We have provided elsewhere in this plan a descriptive account of the environmental impacts of our planned actions, including those relating to carbon emissions. Here we set out the impact in quantitative terms.

Overall we expect to see our emissions increase over the period of the plan as a result of the actions we propose. How the emissions relating to plan will change over the period through to 2045 is shown in the chart below. Savings are viewed as positive; the negative figure indicates an increase in emissions. This will peak in 2027-28, then fall thereafter.



The overall increase is small, peaking at a little more than 130 tonnes CO2-e annually. To understand the small scale of this increase, our emissions for the water service for ESW were around 45,000 tonnes in 2017-18. The impact of the plan proposals adds less than 0.3% on the same basis.

However, any increase in emissions might seem surprising given that the proposals will reduce demand and with it the volume of water we need to supply. As such the projected increase requires explanation.

The main reason for the rise is that from 2018-19 there will no longer be any emissions linked to our use of electricity. This follows a switch in our energy supplier to Orsted who provide all their power from renewable sources.

Our emissions have fallen considerably since we first started routinely calculating these in 2008. Whilst some of this fall is due to actions we have taken to be more efficient in our use of energy, or through the development of low carbon renewable energy, much of this reduction has come from lower emissions linked to our use of grid electricity.

Grid electricity use has to date been by far the biggest single component of our greenhouse gas emissions. In recent years the emissions value linked to each unit of electricity has been falling, as coal fired power stations have been replaced with cleaner gas and renewable power generation. This is set to continue and by the middle of this century the emissions linked to electricity use will be a small fraction of what they are today.

Some electricity suppliers are leading this switch to low emissions energy, which is a growing market in the electricity supply industry. In 2015, in order to encourage this growing provision, international and national reporting protocols were changed to allow purchasers of cleaner energy to reflect the lower emissions attached to it in their reporting, as long as the emissions were backed with certification of origin. We are in a position to adopt this approach going forward.

Our 2017-18 baseline emissions linked to the supply of drinking water within the ESW region we estimate to be 43,973 tonnes CO2-e. This equates to 267 kgs CO2-e for every Ml put into supply.

Most of these emissions are associated with the use of grid electricity. These are mainly Scope 2 emissions directly linked to the use of power in support of our operations, but include some Scope 3 emissions reflecting losses in the transmission and distribution of electricity to our sites.
In April 2018 we switched electricity supplier and are now supplied by Orsted, one of the companies leading the transition to a decarbonised energy sector. As a result our baseline emissions going forward reduce significantly.

We expect the emissions linked to the provision in water in ESW to be in the order of just 4,500 tonnes CO2-e this reporting year (2018-19), then continue to fall through to 2027-28 when we expect to become net carbon zero. This is the point at which our operational activities no longer add to the problem of global warming. 4,500 tonnes will mean around 27 kgs CO2-e for every Ml of water into supply.

This change has a major impact on our estimate of the emissions impact of our water resources plan. Although we have no supply side proposals in our plan, we will undertake a range of activities that will help to manage demand, under the three headings of leakage management, water efficiency and metering. For each of these areas we have assessed the impact of our proposed actions on the greenhouse emissions for which we are responsible.

Each of our proposed actions will deliver a saving in the volume of water we need to supply, and with that there will be a fall in emissions in the early years until we become carbon neutral. After that point any saving in water will not produce a reduction in emissions. Even in the early years of the plan the fall in emissions we will see will be a much smaller effect than had we continued to use the UK national grid emissions factor, because of the switch in our reporting approach.

Alongside this effect, with some of the actions there will be an increase in operational activity that might increase emissions. An example would be the employment of more technicians to find and fix leaks. Such staff will increase our emissions through their use of vehicles and vehicle fuel in carrying out their duties.

In each case the emissions linked to the action is changing over time. In the case of leakage technicians the development of cleaner vehicle technologies will mean that the emissions for a given level of activity will fall over time. We have made an assumption about the pace of this fall.

It is the effect in emissions terms of these two counter-acting factors that determines the projected emissions impact going forward, and results in the rise we expect to see. Had we continued to use the national grid factor our programme of work would have produced, in any year of the plan, a saving in grid related emissions of around twenty times the increase resulting from the work involved.

Emissions impact of each proposed measure

Within this overall context of the impact of our proposals on greenhouse gas emissions we can also quantify this for each specific measure proposed in our plan. There are no supply side proposals needed within the timeline of the plan. We do though have demand side proposals in the three areas of demand management, leakage management and metering. The way that these contribute to the overall carbon impacts previously set out is shown in the chart and table below.

The chart shows how each the proposed actions contributes to the change in overall emissions year by year. The table summarises this information for each future five year AMP period through to 2045.

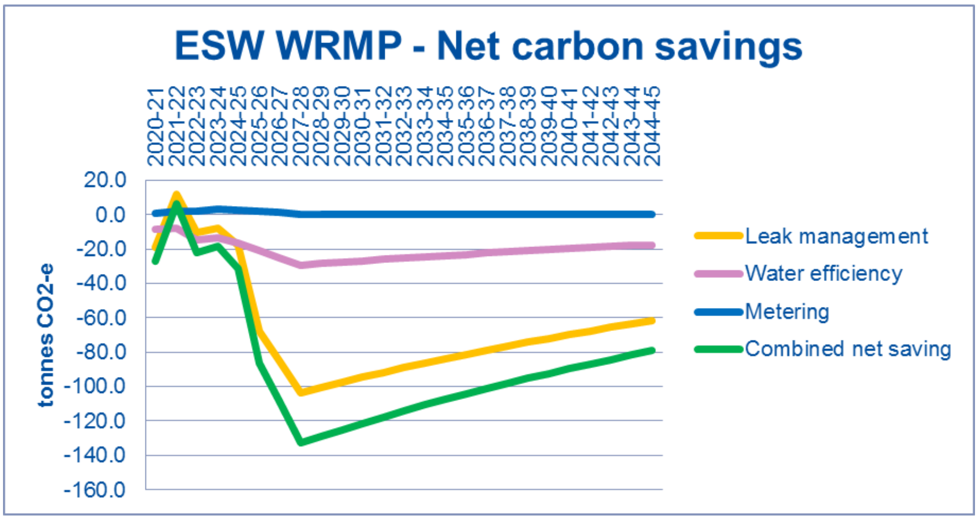


Table showing impact on GHG emissions of each demand side proposal

	AMP7 2020-2025	AMP8 2025-2030	AMP9 2030-2035	AMP10 2035-2040	AMP11 2040-2045
Leak management	-43.6	-454.6	-445.1	-382.2	-328.2
Water efficiency	-60.3	-131.1	-126.1	-108.3	-93.0
Metering	11.5	3.6	0.0	0.0	0.0
Combined net saving	-92.5	-582.1	-571.2	-490.5	-421.2

Valuing these carbon impacts

Alongside quantification of the impact in emissions terms we have also examined the economic impact of what we propose. Applying the latest projected carbon values published by UK government in line with the Treasury Green book there is a progressive rise in the carbon cost of the proposed programme of work. That said, by 2045 the carbon cost of the programme remains small, not even reaching £15,000 a year by the year 2045. Unsurprisingly, the value of carbon has no impact on decisions relating to the WRMP. This is true both in overall terms and for each of the proposed measures.

2.3 Point 2: 3 (e) the assumptions it has made as part of the supply and demand forecasts contained in the water resources management plan in respect of— (i) the implications of climate change, including in relation to the impact on supply and demand of each measure which it has identified in accordance with section 37A(3)(b)

Defra commented as follows:

The company has not assessed and described the impact of climate change on each of the options in its final planning scenario. The company must clearly state the impact of climate change on each preferred (final plan) demand option individually, including the assumptions made in the assessment, to meet Direction 3(e).

We have added Section 6.12 to our revised draft Water Resources Management Plan to include the following information.

The impact of climate change on the proposed measures

As well as examining how our proposals will impact on the greenhouse emissions that drive climate change, we have also considered what the implications for climate change might be on our proposed actions. We have looked at the potential impact on each of the demand side measures we propose on demand management, leakage management and metering.

Both for demand management and for metering we identify that any changes in climate will have no impact at all on our proposals. The actions we are taking are independent of any climatic effects.

Climate change may have an impact on future leakage, but no allowance has been made for this in this plan. The reasoning behind this assumption is set out below.

The predicted future climate is one of hotter drier summers and warmer wetter winters. More frequent and severe droughts are also expected. This has the potential to lead to changes in ground movement in clay based soils, which in turn can have an impact on burst frequency and leakage. In summer this movement is likely to increase burst frequency and leakage. Warmer winters will mean that freeze-thaw events causing ground movement will be less frequent. This means that burst frequency and leakage in winter is likely to fall.

This understanding is based on work undertaken in 2009 (Making the Earth Move: Modelling the impact of climate change on water pipeline serviceability by Goodchild, Rowson and Engelhardt). This established a relationship between burst frequency and actual evaporation, daily rainfall, minimum grass temperature, and soil moisture deficit. A change in burst frequency implies similar changes in leakage.

However, this relationship only holds for asbestos cement and cast iron pipes in clay and loam soils. This pipe/soil combination is seen only across a small proportion of our network, a figure that is falling as these older pipes are replaced. With other combinations of pipe and soil there is no established effect.

The quantification of these impacts that act in opposite directions across the seasons is not straightforward. In the short run the changes in temperature and their impact on soils will be too small to have a significant impact. It is only towards the end of the plan period that the potential effect will be greater, though even here this impact will be mitigated as the proportion of polyethylene pipe in the network grows as cast iron and asbestos cement pipe is replaced.

The analysis undertaken suggests that in the Essex and Suffolk region there would be a net increase in bursts. The projected decrease in winter bursts is more than balanced by an increase in summer.

In this plan we have not included for this impact. Instead we have assumed that leakage will not be affected by this climate driven effect. There are two reasons for this.

Firstly, as yet we are also unable to quantify the impacts of two other proposed actions to lessen leakage. These are the development of innovative techniques and customer-focused activities, which are neither defined at this stage, or their impacts quantified. We have allowed for no impact of either of these planned actions in reducing leakage, and have made the assumption that they will not be affected by the changing climate.

This assumption feeds into the second reason in that the Ofwat target for leakage is no longer based on an assessment of what is an economic level of leakage where the marginal cost of additional management actions equates to the value of water saved. Instead a fixed target is set. We intend to meet this target by a range of actions. With two of these – the deployment of new pressure management schemes and the installation of new semi-permanent correlating noise loggers – we are able to estimate the impact. However, this is not the case with either innovative techniques or customer-focused activities.

Any further leakage reduction to achieve the Ofwat target that exists after taking these actions will be met by a change in the rate of mains replacement. This is scheduled to take place from AMP 8. The impact of changes in the climate will be one underlying driver that affects the scale of replacement work needed. The success of the innovative techniques and customer-focused actions is another.

However, the leakage levels seen will not change. Instead we will vary the amount of mains replacement needed, to the extent required to hit the leakage target. As a result we are able to assume that the level of leakage will not be impacted by climate change, although our responses in terms of mains replacement may be. This also means that there is no wider impact on supply and demand.

2.4 Point 3: 3 (f) its intended programme for the implementation of domestic metering and its estimate of the cost of that programme, including the costs of installation and operation of meters

Defra Commented as follows:

The company has set out the programme costs of its preferred metering strategy for the first five years of its plan, however it has not set out these costs for the whole planning period. The company must set out the installation and operational costs associated with its metering programme over the whole planning period to meet Direction 3(f).

The company has not met the requirements of the Northumbrian Water (Essex and Suffolk) Water Resources Management Plan Direction 2014 which requires an assessment of likely impact of compulsory metering on customers' water bills and proposals for a strategy to manage those impacts. The company must provide a numerical assessment of the impact on bills.

The company has discussed the perceptions of its customers about the benefits of being metered in its statement of response, and states that not all customers would see a fall in bills. However, there is no evidence that the company has undertaken a quantified assessment of the impacts compulsory metering would have on its customers' bills. The company has also not set out sufficient information to describe how it might manage the impact of compulsory metering on its customers' bills. The company must present a quantified, numerical assessment of the impacts compulsory metering would have on its customers' bills and proposals to manage these impacts to comply with Direction 3 – 2(d).

We have updated Section 5.2 of our revised draft Water Resources Management Plan to include the following information.

Metering Programme Strategy Costs

The costs of our metering programme for Essex and Suffolk through the full planning period are summarised below in 2017/18 prices. The capex costs are for meter installations only and do not include the cost of meter replacement. The opex costs are cumulative and reflect the escalating opex costs associated with all the meter installations made from 2020 onwards.

Table 1: Essex meter installations costs to 2045

	AMP7	AMP8	AMP9	AMP10	AMP11
Installation numbers	67,500	36,500	10,000	7500	7500
Capex £'m	£10.066	£10.877	£3.014	£2.423	£2.423
Opex £'m (cumulative)	£0.297	£0.603	£0.860	£0.969	£1.064
TOTEX £'m	£10.364	£11.480	£3.875	£3.392	£3.487

Table 2: Suffolk meter installation costs to 2045

	AMP7	AMP8	AMP9	AMP10	AMP11
Installation numbers	2975	1450	250	250	250
Capex £'m	£1.344	£0.428	£0.074	£0.075	£0.075
Opex £'m (cumulative)	£0.035	£0.051	£0.060	£0.064	£0.069
TOTEX £'m	£1.379	£0.479	£0.135	£0.140	£0.144

Note: Our capex costs in Essex increase from AMP7 to AMP8 despite the fact that the number of installations we make will significantly reduce. The reason for this is that we are taking the opportunity to boost our meter penetration in AMP7 by filling empty boundary boxes in whole areas at very low cost. The knock on effect will be that the number of drop in installations we make for optants in subsequent years will be significantly reduced, increasing our costs overall.

Assessment of compulsory metering & impact on customers

In order to numerically assess the impact of compulsory metering on customers' bills we looked at the impact that switching to a meter has had on bills historically. We have looked at this in two ways by using historical billing data and evidence from customer research.

Billing data

It would not be appropriate to look at the impact switching to a meter has had on optants' bills because customers who voluntarily switch to a meter will usually see a financial benefit. Those who would be metered under compulsory metering would include a much larger proportion of customers who would not benefit financially. The change of occupier metering programme in Essex gives the best available indication of the impact compulsory metering would have on individual household bills. The most reliable 'before and after' billing data we have for a full year's change of occupier installations is for 2015/16. Data from the following years has been affected by the introduction of our new billing system in 2017/18 and also our decision to stop the change of occupier metering programme at the end of the same year.

We installed 4772 meters under the change of occupier programme in Essex in 2015/16. For the purpose of analysis we have taken the average rateable value and removed results outside of one standard deviation to reduce the sample size to just under 3000 properties. After taking account of leak allowances, our findings are that:

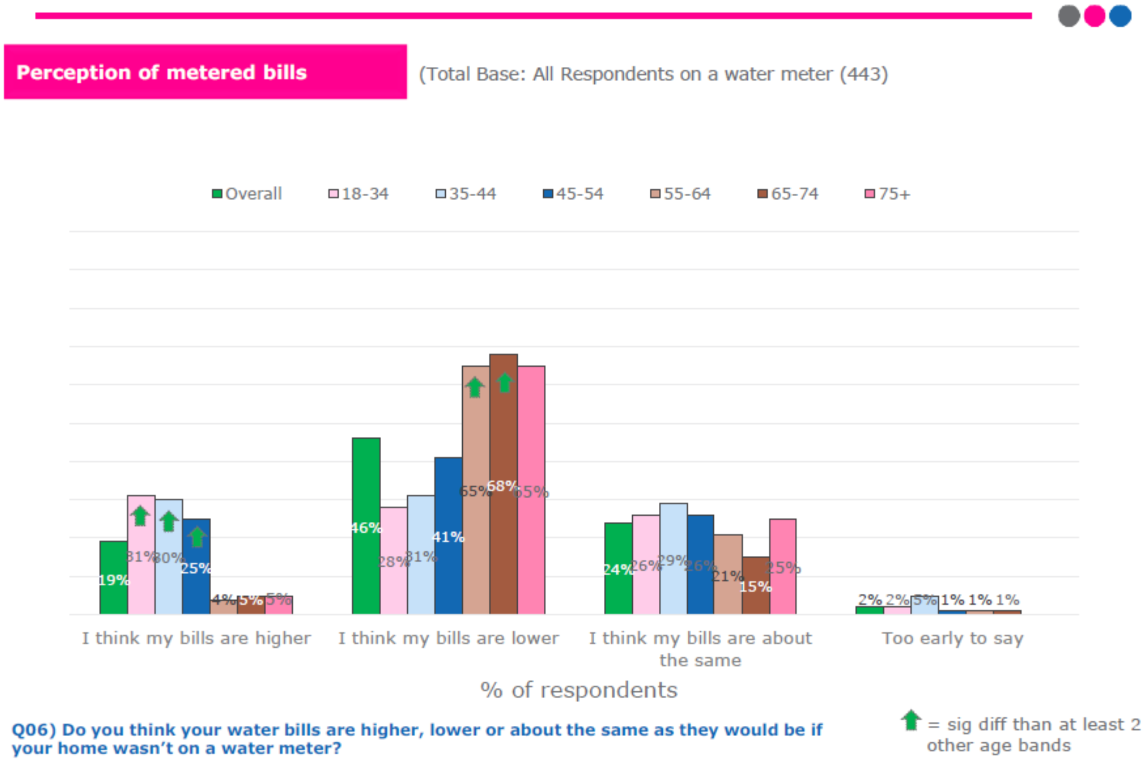
- 20.4% of households (605 properties) saw their bills increase.
    - 72 households' bills more than doubled – which is about 2.5% of the sample.
- 12.7% of households (377 properties) did not see a significant change (i.e. their measured bill was 91% to 109% of their unmeasured bill).
- 66.7% of households (1970 properties) saw their bills decrease.
    - Some of these households will have gained financially from being on a meter simply because the property was not occupied throughout the full year. There are some clear examples where households paid almost nothing above the fixed rate and so although classed as 'occupied' the homes were in fact largely vacant. It is difficult to establish what proportion of properties this applies to but based on the amount households were billed in terms of the volumetric charge for actual usage over a year this could be true of 15-20% of these properties.

Overall, this evidence suggests that at best two thirds of customers may benefit financially from switching to a meter. However, we have to account for the significant proportion of households which used very little water throughout the first year of being on a meter. It is likely that this is related to rental properties being frequent candidates for the change of occupier metering programme. It would not be uncommon for rental properties to have a period of vacancy between occupants which would of course reduce the annual bill. If we exclude 12.6% properties with very low consumption from the group of those who gained from switching to a meter this reduces the proportion of customers who benefitted to 54.1%.

Evidence from customer research

Our customer research from our *Metering & WRMP research* in 2017 supports and sheds further light on these numbers. We carried out a survey as part of this research which included 443 ESW customers who are on a meter. A minority (40%) of the metered participants had switched to a meter by their choice; the remainder inherited a meter or had one installed when they moved in to their home. We asked these customers whether they though their bill had increased, decreased or stayed about the same since changing to a measured bill. The results are consistent with our historic billing analysis for change of occupier meters in that 19% of customers felt their bill had increased. However, only 46% of customers thought their bill had reduced. 24% though their bill was about the same and the remaining 11% were unsure.

We note from our research that there is a clear divide in the way customers from different age groups are affected by switching to a meter. Older customers are much more likely to save financially by switching to a meter than younger people – who are actually slightly more likely to see an increase to their bill than a decrease. This reflects the tendency for customers with families to be adversely impacted by switching to a meter. It could also be a reflection on generational differences in behaviour around water usage. If this is the case, the number of customers benefitting from switching to a meter could reduce in future.



Likely impact of compulsory metering on bills

We conclude from these two sources of evidence that it is likely that around half of customers would benefit financially from switching to measured charges under a compulsory metering programme. For up to half of customers, compulsory metering would not benefit them financially and for about 20% there would actually be a noticeable increase to their bill.

How we would manage the impact of compulsory metering on bills

If we were to be required to universally meter our customers on a compulsory basis we would build on the experiences of other water companies who have delivered such programmes and work with CCWater to ensure the experience for our customers was as positive as possible.

This would include giving customers a transition period of two years following meter installation before moving the household on to a measured bill. Where customers' measured bills worked out lower or about the same we would automatically switch customers to measured charges. We would also make the customer aware that they still had the option to remain on unmeasured charges for two years if they chose to take advantage of the transition period for reasons we might not have foreseen. Where we identified that customers would see an increase to their bill we would encourage and support them to use their two year transition period to reduce their consumption and ensure their bill is affordable for them.

Our particular concern would be for those customers who are already struggling with financial hardship or whose circumstances make them vulnerable. We would aim to use the programme to help towards identifying customers who need additional support and could benefit from the services we can offer. For example, we may identify customers who would qualify for the WaterSure tariff or be able to recommend another of our new tariffs designed to help people out of water poverty.