Microbiological Programme Technical Review

Anglian Water Services

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Quality information

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No	Yes	Marina Pombo, Cost Intelligence Manager, Anglian Water Services

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Table of Contents

Figures

No table of figures entries found.

Tables

Introduction

AECOM has been engaged by Anglian Water to undertake a desktop technical review of 12 Microbiological Treatment schemes, at Anglian Water Wastewater Recycling Centres, proposed for upgrade during AMP8. The scope of this study includes the following:

- Review input data such as incoming and receiving water quality parameters and any site constraints.
- Independently calculate the requirements of the Microbiological treatment, based on the input data provided and the standards required to be met.
- Produce 'AECOM version' of scope of works based on process calculations and site requirements, referencing any Anglian Water Design Standards where appropriate.
- Undertake a comparison between the 'AECOM version' scope of works and the scope list provided by Anglian Water. Highlight any deviation between the scopes and comment on the reasoning for this and how material the difference is in the context of the overall design/engineering judgement.

Scope of Review

AECOM have been provided with the following documents for review:

1) Four no. ppt. presentations from Stantec.
2) Intertek document: *Intertek Preliminary Dilution Factor Assessment.*
3) Trojan design summary.xls (specification for various UV irradiation options at the sites).
4) EA Document: *Guidance for the design permitting and operation of UV irradiation systems for wastewater, 2022_03 DRAFT v0.2*.
5) 2X-WWG-PSG-DSG MAS Process Selection Matrix (Anglian Water document).
6) Microbiological Cost Breakdown.xls (Cost curve allocations for each site, Anglian Water document).
7) 12 no. TOTEX Information Reports (TIR) spreadsheets detailing the options considered and quantification of costs and benefits (one report per site, Anglian Water document)
8) Microbiological Schemes Summary_.xls (Summary table of the 12 schemes with allocation of costs between CAPEX and OPEX and between different drivers, Anglian Water document)

This is a desktop-based review using existing information, provided above, and there was no requirement for any site visits or surveys. Please note that we also examined the cost curves and benchmarks for each site but were not tasked with reviewing the specific quantum of costs allocated for each process unit, just the scope incorporating the recommended design elements for the site and whether they were included in the cost curves appropriate to the site upgrade, with respect to the AMP8 microbiological discharge limits.

Review Comments

Subject to the scope and time constraints of the review, we note the following comments:

- UV irradiation is the last step in the Water Recycling Centre (WRC) treatment process, which provides the final log reduction (typically 2 – 3 log_{10}) to achieve the desired microbiological standard at the end of pipe discharge (excluding the dilution factor). The upstream assets are all valid (and site specific) as they provide additional log reductions through the process stream, depending on the assets, these will contribute an additional log reduction value (LRV) to the crude effluent, prior to the UV irradiation step.
- In order for the UV irradiation to be effective, and to provide the necessary LRV, it needs to be afforded the optimum operating conditions. This generally means effluent total suspended solids (TSS) concentrations to be below 20mg/L, which is achieved either through provision of Tertiary Solids Removal (TSR) after the secondary treatment process, or a long sludge age ASP with effective final settlement via final settlement tanks (FST's), to consistently achieve < 20mg/L TSS.
- The effectiveness of UV irradiation is achieved by the analysis of dose response curves, which is the observed increase in log reduction in Faecal Indicator Organisms (FIO) by the increase in UV dose (mJ/cm^2). However, this is highly influenced by solids shielding effects because of increased suspended solids concentrations in the effluent. Research by Cranfield University has also revealed the presence of very fine solids or pin floc can result in high solids shielding potential with a resultant reduced UV dose response.
- The type of secondary treatment is highly significant in relation to downstream UV irradiation efficacy. For example, seasonal sloughing of Trickling Filters (TF) can produce periods of poor effluent quality (low UV / high suspended solids) that can compromise UV irradiation efficacy because of solids shielding effects. UV dose response is typically poorer for effluent from trickling filter plants due to the characteristics of the humus solids compared to typical floc from Activated Sludge Plants (ASP).
- As a consequence of the above, many of the sites have recommended new secondary treatment streams for AMP8, e.g., new long sludge age ASP and FST's, TSR, or in some cases a membrane bioreactor process (MBR), which are valid conclusions based on the existing site configurations and other information / data, and the requirement for UV irradiation to provide the final LRV step prior to discharge. See **Table 1** below for a summary of the AMP8 site recommendations (new assets) and the subsequent interpretation and translation to the Anglian Water costing templates (detailed in *Microbiological Cost Breakdown.xls*).
- Stantec have provided some typical UV dose response curves as examples in their presentation documents.
- The Stantec methodology is valid in that it starts with the end point standard for microbiological discharge, either a designated licence Shellfish Water standard at the Shellfish Water boundary, or the Bathing Water standard at the Bathing Water boundary, and then applies a dilution factor (DF) to calculate what the FIO, in this case E. coli or virus, is at the end of pipe discharge from the WRC. The required LRV required from the UV irradiation system is then calculated, based on the current upstream process treatment.
- Stantec in their initial presentations assumed a range of dilution factors for the various site discharge locations; this was further refined by the work completed by Intertek in their presentation of the dilution factors applicable to each discharge point, i.e., the *Preliminary Dilution Factor Assessment* report.
- Our work is focussed on the more specific dilution factor assessments arising from the Intertek report, which were examined and presented via a software screening model (QUICK-PLUME®).
- The Stantec assumption of a crude E. coli concentration of 2 x 10^7 cfu/100mL is in line with industry standards; their assumption of a log reduction of 1.5 log (log_{10}) for a TF secondary

process, and 2 log reduction for an ASP secondary process is also in line with typical industry standards. In the case of Southwold, where specific information was available, they used a lower LRV than this across the secondary treatment (TF), to account for unique site operational conditions.

- In the case of the Shellfish Water sites (Kings Lynn STC, Boston WRC, Maldon WRC, Tollesbury WRC) additional commentary and key issues were stated for each site, based on existing operational information and data, and influent E. coli data was also presented in certain cases, e.g., Kings Lynn and Boston.
- We identified through our review that there were some discrepancies between the process recommendations made by Stantec, and what had been included in scope of the preferred option that had been costed by Anglian Water. We raised queries on these with Anglian Water and were provided the following reasoning for the differences in scope:
  - King Lynn WRC – We identified that a sludge liquor treatment plant had not been included in the costs, only a centrate dosing unit. Anglian Water explained that they did not have a suitable cost model for a sludge liquor treatment plant and therefore used the dosing unit combined with tertiary solids removal treatment as an alternative. We considered this to be a reasonable surrogate.
  - Tollesbury WRC – We identified that Stantec's recommendation would have been for an MBR plant due to the very low dilution at this location, Anglian Water had priced for an ASP alternative. Anglian Water explained that they had taken this approach as the MBR plant had a significantly higher Whole Life Cost (WLC) and there was low confidence in the cost model and performance reliability of this treatment option. We recognise that the industry's experience in using MBR for wastewater treatment is limited and that in the small number of cases where this is in operation there has been higher than expected operational costs associated with maintaining and replacing the membranes to achieve required solids removal prior to UV treatment. Therefore, we consider this approach is reasonable, although we would highlight that Anglian Water may be underestimating the costs to achieve the benefit for this site due to the very low dilution factor or that the ASP solution may not achieve the required turbidity for effective UV disinfection.
  - Multiple WRC's – For multiple sites (see Table 1 for identification of sites) we found that additional or replacement FST capacity had not been included in the costed solution to complement new or upsized ASP treatment. Anglian Water explained that they had reviewed existing FST capacity on these sites and taken a risk-based approach by assuming that existing capacity could be repurposed to meet the need. We have not reviewed the calculations for existing FST capacity but would flag that, in general, new or upsized ASP's and long sludge age ASP's are likely to require additional FST's to achieve the solids separation required for tertiary treatment processes and UV disinfection. Therefore, Anglian Water may be underestimating costs on some of these sites if additional FST capacity turns out to be required.
- Our technical approach review has focused on the selected options and Stantec process recommendations. In addition to this Anglian Water have shared with us their TOTEX Information Report's (TIRs) for each site that details the multiple options considered and the whole life costs, benefits and risks of these options. It was not within our scope to review each of these options in detail but the overall approach to comparing options to identify the best value (cost, risk, performance balance) appears reasonable.
- We identified that Cost Breakdown's for some of the sites included assets specific to drivers other than WINEP UV Disinfection. Some sites have Storm Overflow drivers to address (IMP4 and IMP5) with changes to inlet works configuration and storm storage capacity. Southwold WRC has maintenance works included. Anglian Water provided a summary spreadsheet which shows the allocation of costs between different drivers. We have not reviewed the methodology for this proportional allocation in detail as this was beyond our scope, however, the scale of costs assigned to each driver appeared reasonable based on the primary asset allocations. Only Southwold WRC included a split of costs to Capital Maintenance. Anglian Water confirmed to us that the other 11

microbiological treatment schemes do not contain any maintenance investment and that, where maintenance was identified, this would be funded separately through their Maintenance Portfolio.

Conclusions and recommendations

- The assumptions used by Stantec in their methodology for process design is within the bounds of industry standards, and the conclusions are structured and logical. Our review has concluded that there is no deviation between the scope proposed by Stantec and the scope we would have proposed, given the input information available.
- We did identify that there were some differences between the process recommendations made by Stantec and the options costed by Anglian Water. Following discussion and receipt of further information we understand the reasoning for these differences and the assumptions made by Anglian Water in their approach to costing solutions. We conclude that these omissions from the scope are reasonable and align with a risk-based approach to costing solutions. We would highlight that there remains a risk that some, or all, of this scope may turn out to be required which would increase the cost for delivery of this programme.
- Anglian Water has demonstrated their approach to option assessment (inc. cost benefit analysis) and to the proportional allocation of costs to different drivers (storm overflow and capital maintenance). This has not been reviewed in detail (due to the constraints of our scope) but appears reasonable from the information we have been sent. We note that all solutions have been sized and costed based on current consented DWF and FFT. Some sites may have future new development which would trigger a review of DWF and FFT, this should be considered as part of the design process with a proportional allocation of any additional cost to the ‘Growth’ driver.

Table 1. Summary table showing Stantec recommendations and items included in development of AW project cost

	Sites	Discharge Area	Dilution Factor as per Intertek (FFT to DWF) [log_{10}]	Stantec Recommended	Stantec UV Target Dose [mJ/cm2]	Translation to AW Costing Spreadsheet	Comments (included in AW costing) Differences to recommendation in red
SF	Kings Lynn WRC	The Wash [South East Wash SFW]	1.6 - 2.1	Extend existing ASP to increase sludge age/ possible trade pretreatment/ sludge liquor treatment/ TSR + UV	40	UV Disinfection, 6 x Aeration Tank, with FBDA, 4 x FST, 2 x Storm Tanks, 3 no. Continuous sand filters	ASP (incl. FST) + UV Included TSR Included No cost curve for sludge liquor plant. TSR and dosing used as equivalent.
	Boston WRC	The Wash [West Wash SFW]	2.0 - 2.5	Replace secondary treatment with ASP + TSR plus UV Existing Trickling Filters + TSR + UV	40	UV Disinfection, 6 x Storm tanks, 4 no. Continuous sand filters, TSR PS	UV included TSR Included ASP or FST Excluded
	Maldon WRC	Blackwater Estuary [Blackwater SFW]	2.9 - 3.4	(1) ASP + UV AMP8 ONLY (2) MBR + UV AMP8 / AMP9	40 [ASP+UV] 20 [MBR+UV]	UV Disinfection 2 x Aeration Tank, with FBDA 2 x FST, 6 x storm tanks	ASP (incl. FST) + UV Included Also, option for TSR + UV, due to DF >2 log_{10} and existing ASP
	Tollesbury WRC	Blackwater Estuary [Tollesbury Ch. SFW]	0	Replace treatment with MBR + UV Upgrade treatment with ASP + TSR + UV	20	UV Disinfection, 1 x Aeration Tank, with FBDA, 1 x Storm Tank, 1 no. continuous sand filter	ASP (excl. FST) + UV Included, TSR Included MBR option not included (change to Stantec recommendation based on low dilution) due to low confidence in cost and practicality of this option.
BW	Southwold WRC	Southwold The Denes BW	2.8 - 3.3	Replace treatment with (1) ASP + UV, (2) MBR + UV, (3)	20	UV Disinfection, 1x Aeration tank with FBDA, 3 x Storm	ASP (excl. FST) + UV Included

	[Coast]		Relocate effluent of transfer flows to another works		Tanks, 1 PST, 1 no. Humus Tank	Challenges: there is insufficient secondary treatment/ settlement biological capacity to treat FFT. A totally new works required as per site Ops (change the site to ASP), challenges for demolition / rebuilding new equipment, limited land space to build, SSSI on surrounding land. Allocation of costs to Capital Maintenance included.
Woodbridge WRC	River Deben Estuary [Waldringfield BW]	2.5 - 3.1	Replace treatment with (1) Existing secondary treatment + TSR + UV, (2) Replace with ASP or Nereda + UV	20	UV Disinfection, 1 x Aeration tank with FBDA, 3 x Storm Tanks	ASP (excl. FST) + UV Included Excluding TSR
Melton WRC	River Deben Estuary [Waldringfield BW]	3.2 - 3.7	Replace treatment with (1) Existing treatment (assuming no operational / performance issues) + UV	20	UV Disinfection, 1 x Storm Tank	UV included only
Easton WRC	River Deben Estuary [Waldringfield BW]	4.9 - 5.5	Replace treatment with (1) ASP + UV, (2) MBR + UV, (3) Relocate effluent to another works, 200 PE	20	1 x Storm Tank	ASP + UV Excluded Propose pump away option, site is very small and pump away represents best WLC
Manningtree WRC	Stour Estuary [Manningtree Beach]	2.1 - 2.6	Replace treatment with (1) Existing treatment + TSR + UV (for 1.5 log virus). AW Site summary comments: upgrade with long sludge age ASP + UV	40 or 30	UV Disinfection 1 x Aeration Tank, with FBDA 1 x Storm Tank	ASP (excl FST) + UV Included Excluding TSR

Haslingfield WRC	River Cam [Sheep's Green BW]	1.3 - 1.5	Replace treatment with (1) ASP/ oxidation ditch + UV, (2) MBR + UV	40 or 30	UV Disinfection, 1 x Aeration Tank, with FBDA, 1 x Storm Tank	ASP (excl FST) + UV Included Excluding TSR
Sudbury WRC	River Stour [Friars Meadow BW]	0.8	(1) Long sludge age ASP + UV, (2) Nereda + TSR + UV, (3) MBR + UV, (4) Transfer effluent downstream of BW	40	UV Disinfection 1 x Aeration Tank, with FBDA 1 x Storm Tank	ASP (incl. FST) + UV Included Excluded TSR Potentially more than 1 FST required
Oakham WRC	Rutland Water [Sykes Lane BW Whitwell Creek BW]	3.5 - 4.0	Replace treatment with (1) Existing treatment (assuming no operational / performance issues) + UV	20	UV Disinfection 1 x Storm Tank	UV Included

Source: Stantec ppt presentations, Intertek documentation and AW Microbiological Cost Breakdown.xls