Thames Water

Water Resources Management Plan 2024

Technical Appendix K –

Treatment Capability & Process Losses

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Background and Introduction

In this section of the Water Resources Management Plan 2024 (WRMP24) we describe the methods we use to define Water Treatment Works (WTW) capability and process losses for use in modelling our water supply capability.

Our approach includes use of WTW mass balance and resilience models that we have developed and use for water asset management planning purposes.

The method of including WTW capabilities and process losses in our modelling of deployable output (DO) is explained.

The implications of raw water quality challenges and the impact of climate change is presented.

K.1 Having sufficient and appropriate water treatment in place is fundamental in providing a water supply to our customers that is wholesome, with its quality needing to meet the regulatory standards for drinking water. It follows, therefore, that it is necessary to assess and monitor the water quality hazards and contaminants in the water that passes through our WTWs. This includes hazards associated with the raw groundwater and river water resources from which we abstract, as well as hazards that can arise within our storage reservoirs.

K.2 In addition to ensuring we have treatment in place that is appropriate to remove contaminants to concentrations or values required by drinking water regulations and our own internal risk assessment processes, we need to account for the capability of the WTW. Specifically, we need to quantify how much water our WTWs can treat under different raw water quality challenges and account for this capability in calculating the Deployable Output (DO) of our individual water sources and our WRZs.

K.3 If the WTW capability is sufficient to treat the raw water available, while experiencing the identified water quality hazards, then it will not necessarily be a constraint on DO. This is, however, more complex where and when water treatment produces waste streams.

K.4 At any WTW, even very simple plants, for every litre of water that is abstracted from the environment and treated before passing into the distribution network, a small fraction of the water will be unsuitable for supply. This fraction of water is known as the waste stream. The water that comprises the waste stream contains any separated raw water contaminants that can arise from plant cleaning and maintenance and also for health and safety reasons, such as eye baths or showers required in the event of chemical spillages.

K.5 The sum of all the waste streams is generally referred to as the process loss for a WTW. Generally, the more complex a WTW, which can have multiple treatment processes, the greater the proportion of process losses. Although WTWs are designed to limit the amount of process losses, such losses do occur. Some of the waste streams are treated and recycled indirectly back into the WTW, while some waste streams are treated then "run to waste". In practice these components of the process water waste stream may be discharged to rivers directly, while others may be discharged to a sewer and returned to the environment via a wastewater treatment plant.

K.6 As a result of the variable complexity of water treatment process, it is important to understand and quantify WTW capability and process losses, especially as the latter can result in loss of water as a resource. In addition, it is important to understand where process losses are returned to the environment and, as a result, can contribute again as a valuable raw water resource for abstraction or environmental benefit.

K.7 This appendix describes the modelling approaches that we take to quantify the capability of our WTWs and the process losses that can occur, including the raw water quality scenarios that are appropriate for use in water resource management planning. It also sets out the water resource system approach we take in accounting for significant WTW process loss returns to the environment and, therefore, account for where these returns provide water resource benefits.

Water treatment mass balance models

K.8 To enable us to have an appropriate level of understanding and quantification of WTW capability and process losses, we have developed and maintain a series of Mass Balance models, with a model being available for each of our operational WTWs. These models implement a steady state mass balance calculation in which water flow and contaminant loadings on the treatment processes are established, providing a means of simulating the capability of a WTW for a given raw water condition. The models are run to produce deterministic outputs that are reflective of the inputs defined in the scenarios considered.

K.9 By including design limits and water quality standards, e.g. disinfection policy, potable water requirements, on each treatment process stage and that the output of each process is controlled within these limits, the quality of the treated water is always preserved. This reflects the practice of needing to operate our WTWs to ensure they do not fail and that they provide wholesome water to our customers.

K.10 The models also account for factors such as asset capability, e.g. pump and filtration capability, as well as process operation. The representation in the models of processes such as Rapid Gravity Filtration (RGF) and Slow Sand Filtration (SSF), for example, include filter run times, cleaning triggers and durations as well as process water use.

K.11 More complex WTWs with multiple treatment processes, and often greater proportional losses, are designed to include processes that recover, treat, and recycle as much of their waste streams as economically possible to reduce net process losses. Treatment process losses are taken into account conceptually and quantified within the WTW Mass Balance models as are processes that recover, treat and recycle waste streams.

K.12 The Mass Balance models are modular such that the treatment train in each of our WTWs can be represented by selecting the necessary processes to include in each model. The range of processes required to model each stage of the processes in our WTWs include those summarised in Table K-1 with others being included as necessary.

Process Stage	Balance Model
Abstraction	Abstraction & Pre-Treatment
Screening	Abstraction & Pre-Treatment
Raw water pumping & storage	Abstraction & Pre-Treatment
Aeration	Treatment
Ozonation	Treatment
Chemical dosing & flocculation	Treatment
GAC adsorption	Treatment
Rapid & Slow Sand filtration	Treatment
Membrane filtration	Treatment
Reverse osmosis	Treatment
Ortho-phosphoric dosing	Treatment
Disinfection	Treatment
Service water take-off	Process Water
Wash water settlement	Process Water
Wastewater treatment	Process Water
Sludge treatment	Process Water

Table K-1: Process stages included in WTW Mass Balance models

K.13 Through the use of our WTW Mass Balance models, we can quantify WTW capability and process losses. As a result, the models provide key inputs to the assessment of DO, identification of potential constraints on DO, as well as enabling an assessment of raw water quality hazards to treatment capability and ultimately DO.

K.14 The WTW Mass Balance models are reviewed and updated to reflect changes in treatment works assets, water quality standards and operating practices, being carried out as part of our business-as-usual process. Through this his review and update process, identified changes in WTW capabilities and process loss can be taken into account.

K.15 In our WRMP19 methodology, source deployable outputs (SDOs) were reported net of process losses but for WRMP24 process losses are required to be identified more explicitly. As a result, process losses associated with each WTW are identified and are subtracted from the supply capability when calculating Water Available for Use (WAFU) as described in Appendix I: Deployable Output.

Treatment of groundwater and run-of-river sources

K.16 The methodology[1] that we use for the determination of groundwater SDOs identifies treatment capability and process water losses as key constraints to the amount of water that can be made available for water supply. This method of calculation is applied to those groundwater sources where abstracted water is pumped into their own WTW without blending with other river and/or reservoir water sources. Examples include the Harpsden WTW in the Henley WRZ, which is fed groundwater from the Chalk aquifer, and the Gatehampton groundwater source in the SWOX WRZ, which also provides groundwater from the Chalk aquifer into Cleeve WTW.

K.17 This same approach of identifying constraints such as treatment capability and process water losses on DO is also applied to run-of-river abstraction sources that are treated locally, and not transferred via aqueducts and raw water reservoirs to treatment works. There are two sources of this type, Fobney WTW in the Kennet Valley WRZ, which is fed by water abstracted from the River Kennet, and Shalford WTW in the Guildford WRZ, which is fed by water abstracted from the River Wey and the River Tillingbourne.

K.18 In calculating WTW capability and process losses for groundwater and run-of-river SDOs, a representative raw water quality scenario is considered and analysed using the WTW Mass Balance models. A range of challenging water quality scenarios could be modelled but the representative scenario accounts for the current operating philosophy of each WTW with an average raw water quality excluding more extreme raw water quality.

K.19 Examples of the peak capability and process losses at WTW fed by groundwater and run of river abstractions are summarised in Table K–2. For these WTW, the process losses are expressed in Ml/d as well as a proportion of the raw water inflow into the WTW.

WTW (source)	Capability (Ml/d)	Process Loss (Ml/d & as %)
Harpsden (groundwater)	6.50	0.00 (0.00%)
Gatehampton (groundwater)	101.4	0.08 (0.08%)
Fobney (river)	63.7	8.26 (10.3%)
Shalford (river)	27.8	1.72 (5.83%)

Table K–2: Examples of capability and process losses for groundwater & run-of-river WTW

[1] Procedure for the Assessment of Groundwater Source Deployable Outputs 2017, Groundwater Resources, Water Strategy, Planning and Assurance

Treatment of raw water reservoir source waters

K.20 In SWOX and London, between 45% and 70% of the water supply during drought is fed from our raw water storage reservoirs, which are filled predominantly with river water supplemented by groundwater. Although the storage of raw river water in these reservoirs provides the first stage of the water treatment process, the quality of the water stored is influenced by the variability of river water quality, the weather as well as retention time in the reservoirs, all of which influences the quality of water inputs into the WTWs.

K.21 The most significant parameters that influence the reservoir stored water and its treatability are turbidity and, most importantly, algae. As the growth of algae of different species within the reservoirs is influenced by factors such as temperature, sunlight hours, wind and nutrient concentrations, there can be significant variability in the scale of seasonal blooms as well as natural variability from year to year. This raw water variability, especially algal bloom challenges, affects the severity of the water quality challenge faced by the WTWs and, as a result can affect the volume of the process water losses and consequentially the output of the WTWs.

K.22 The water stored in our Farmoor reservoir (SWOX WRZ) and in our West London and Lee Valley reservoirs (London WRZ) is treated by a series of Large Process Plants (LPPs), each comprising of a treatment train of multiple processes, with most including RGF and SSF treatment stages. It is evident that, in any given year, the LPPs can experience the result of algal blooms of different severity and that there will be a change in process losses during such a period, particularly affecting the RGF and SSF treatment stages. Historically in the River Thames catchment we have algal bloom challenges during spring and autumn, each bloom lasting four to six weeks, although there is evidence that this is changing. These raw water quality challenges and their variability can differ depending on the source water, the reservoir storage characteristics as well as the WTWs treatment processes.

K.23 Our WTW Mass Balance models for the LPPs enable their capability and process losses to be calculated under a range of raw water quality challenges, including the algal bloom challenges. An example of the Mass Balance model outputs is included in Table K-3, showing the capability and process losses for Coppermills WTW in the Lee Valley area of the London WRZ. Both the capability and process losses are presented as Dry Year Annual Average (DYAA) values, which are inputs into our models used for calculating DO. For the LPPs drawing on reservoir storage, the process losses are expressed in Ml/d as well as a proportion of the treated water output from the WTW.

Coppermills	Base Case	1 in 1-year algae	1 in 5-year algae
Process Loss (Ml/d & as %)	19.6 (3.24%)	36.9 (6.32%)	61.6 (16.9%)
DYAA Process Loss (Ml/d & as %)	35.9 (6.67%)		
Capability (Ml/d)	604.2	583.8	364.5
DYAA Capability (Ml/d)	537.5		

Table K-3: Modelled capability & process losses for Coppermills WTW

K.24 The Base Case scenario represents the current asset condition and operation including any agreed deviations from asset standards[2], with average raw water quality excluding more extreme raw water quality. The 1 in 1-year algae scenario reflects the Base Case, that is an expectation that this concentration can be anticipated to be normal, but with deteriorating water quality algae concentrations of 10 µg/l and turbidity of 5 NTU[3] occurring on a sporadic basis. Similarly, the 1 in 5-year algae scenario also reflects the Base Case but with more challenging raw water quality having algae concentrations of 25 µg/l and turbidity of 10 NTU.

K.25 To reflect the varying magnitude and duration of algal blooms that create challenges for the LPP, a weighted average process loss and capability are calculated to give DYAA values. For Coppermills WTW, the DYAA values reflect an annual average comprising of five months of Base Case raw water quality, four months of 1 in 1-year algal conditions and three months of 1 in 5-year algal bloom conditions. These durations of blooms of different algal concentrations reflect the best available view of the raw water quality challenges that could be faced by the Coppermills WTW.

K.26 The magnitudes and durations of algal challenges reflect historical raw water conditions in the Lee Valley reservoirs. This is supported by analysis carried out for us by the UK Centre of Ecology and Hydrology (UKCEH), using their Protech modelling software. This analysis has explored how algal blooms in reservoirs could have occurred during historical droughts, in particular their timing, magnitude and duration. This analysis has accounted for the historical weather influences on algal growth, likely reservoir nutrient loads as well as the drawdown of reservoir storage that would have occurred during drought.

K.27 Process losses at Coppermills pass as a wastewater flow through a treatment process that enables recovery of up to 35 Ml/d of water that is pumped back into the Lee Valley reservoirs, i.e. a maximum recovery scenario. During more severe algal blooms however, there is likely to be a need for increased RGF and SSF backwashing and recovery time, generating increased process water flows. As a result, the wastewater treatment process is likely to be operating at a reduced efficiency with flows greater than the recycling capacity being produced. This increase in process losses can be seen from the difference in Table K-3 between the 1 in 1-year and 1 in 5-year algal bloom scenarios.

K.28 The WTW capabilities and process losses presented here are those used in the Annual Reporting process covering AR22.

[2] These include risk-based exemptions from internal standards that are approved and documented in the Site Operating Manuals (SOM) for each WTW.
[3] NTU = Nephelometric Turbidity Unit. This is a measure of how opaque water is due to the presence of suspended solids.

Water treatment capability and process loss figures

K.29 The most significant WTW in terms of the magnitude of their capability are the LPPs in the London and SWOX WRZs. It follows that these LPPs also have the most significant process losses that need to be taken into account in the modelling of our water supply capability. In Table to Table below, the capability and process losses for each of the LPPs is presented based on output from each of the WTW Mass balance models. The average capability and process losses reflect raw water quality inputs and wastewater recycling that varies between the LPPs, reflecting differences in the quality of the source waters and the treatment process.

K.30 For Hampton WTW (Table K - 4), the DYAA values reflect an annual average of 10 months of Base Case raw water quality and 2 months of 1 in 1-year algal bloom conditions. Algal concentrations of 1 in 5-year severity are not included in the calculation of annual average capability and process losses.

K.31 The treatment processes, including the RGF and SSF at Hampton WTW produce wastewater and there is a system to collect and clarify the filter backwash water. After clarification of this process water, it is discharged to the River Thames under an Environmental Permit.

Hampton	Base Case	1 in 1-year algae	1 in 5-year algae
Process Loss (Ml/d & as %)	12.8(1.70%)	40.3 (5.54%)	79.1 (13.95%)
DYAA Process Loss (Ml/d & as %)	17.4 (2.32%)		-
Capability (Ml/d)	753.2	728.0	567.2
DYAA Capability (Ml/d)	749.0		-

Table K-4: Modelled capability & process losses for Hampton WTW

K.32 For Kempton Park WTW (Table K-5), the DYAA values reflect an annual average of 10 months of Base Case raw water quality and two months of 1 in 1-year algal bloom conditions. With 1 in 5-year algal concentrations the modelling of the Kempton Park treatment process suggests a 0 Ml/d output, however this scenario is not included in the calculation of annual average capability and process losses.

K.33 Dirty washwater from the Kempton Park treatment processes is collected and treated before the wastewater that is produced is discharged back into the River Thames via a tributary, the Portlane Brook that joins the River Thames upstream of Hampton WTW. This is covered by an Environmental Permit. The sludge produced in the wastewater recycling process is disposed of directly to the foul sewer network, which results in the sludge then being processed at a sewage treatment works before being discharged back into the water environment.

Kempton Park	Base Case	1 in 1-year algae	1 in 5-year algae
Process Loss (Ml/d & as %)	1.55 (0.92%)	3.57 (2.2%)	-
DYAA Process Loss (Ml/d & as %)	1.89 (1.13%)		-
Capability (Ml/d)	168.5	162.5	0
DYAA Capability (Ml/d)	167.5		-

Table K-5: Modelled capability & process losses for Kempton Park WTW

K.34 For Ashford Common WTW (Table K-6), the DYAA values reflect an annual average of 10 months of Base Case raw water quality and two months of 1 in 1-year algal bloom conditions. Algal concentrations of 1 in 5-year severity are not included in the calculation of annual average capability and process losses.

K.35 The treatment processes, including the RGF and SSF at Ashford Common WTW produce wastewater that is collected and clarified. After clarification the wastewater that is produced is discharged under an Environmental Permit to the River Ash, a tributary that joins the River Thames upstream of Walton WTW.

Ashford Common	Base Case	1 in 1-year algae	1 in 5-year algae
Process Loss (Ml/d & as %)	9.88 (1.42%)	30.9 (4.59%)	35.9 (6.74%)
DYAA Process Loss (Ml/d & as %)	13.38 (1.94%)		-
Capability (Ml/d)	693.5	672.2	573.7
DYAA Capability (Ml/d)	689.9		-

Table K-6: Modelled capability & process losses for Ashford Common WTW

K.36 For Walton WTW (Table K-7), the DYAA values of capability and process losses reflect an annual average of 10 months of Base Case raw water quality and two months of 1 in 1-year algal bloom conditions. Algal concentrations of 1 in 5-year severity are not included in the calculation of annual average capability and process losses. This reflects the greater resilience of Walton WTW to raw water quality as it is a chemical coagulation/flocculation treatment works and also because the raw water can be sourced and blended from multiple raw water reservoirs.

Walton	Base Case	1 in 1-year algae	1 in 5-year algae
Process Loss (Ml/d & as %)	6.17 (4.63%)	11.9 (9.48%)	14.8 (12.0%)
DYAA Process Loss (Ml/d & as %)	7.12 (5.4%)		-
Capability (Ml/d)	133.2	125.6	123.0
DYAA Capability (Ml/d)	132.0		-

Table K-7: Modelled capability & process losses for Walton WTW

K.37 Dirty washwater at Walton WTW is collected, chemically treated, clarified and filtered before the wastewater that is produced is discharged back into the River Thames under consent and Environmental Permit issued by the Environment Agency. The sludge is collected and thickened before being disposed of to a sewer. This is a very small percentage of the washwater flow. The receiving sewage treatment works (STW) discharges its final effluent into the River Thames upstream of Teddington weir.

K.38 Hornsey WTW is fed by raw water from the New River aqueduct, which is sourced from water abstracted from the River Lee and groundwater abstracted from the Northern New River Wells south of Hertford as well as the North London Artificial Recharge Scheme (NLARS) when it has been triggered for dry weather and drought use.

K.39 As a result, Hornsey WTW is not fed by stored water from the Lee Valley reservoirs. The DYAA capability and process loss values reflect an annual average of 10 months of Base Case raw water quality and two months of 1 in 1-year raw water quality.

K.40 The process washwater at Hornsey WTW is treated through a clarification process. This produces a high-quality clarified wastewater stream that can be recovered to the head of the WTW, minimising the process losses. This is recovered about 80% of the time when the WTW is in operation as operationally we will not recover the water if there is a water quality risk, i.e. 20% of the time. When the process water is not being recovered, it is discharged into the New River Aqueduct under an Environmental Permit.

K.41 Table K-8 shows the components used in calculating the average capability and process losses.

Hornsey	Base Case	1 in 1-year water quality
Process Loss with Recovery (Ml/d & as %)	0.12 (0.29%)	0.29 (0.74%)
Process Loss Non-recovery (Ml/d & as %)	1.59 (4.14%)	1.46 (3.79%)
DYAA Process Loss (Ml/d & as %)	0.43 (1.09%)	
Capability with Recovery (Ml/d)	39.9	39.7
Capability Non-recovery (Ml/d)	38.4	38.5
DYAA Capability (Ml/d)	39.6	

Table K-8: Modelled capability & process losses for Hornsey WTW

K.42 Chingford WTW is fed by stored water from the Lee Valley reservoirs but as it has a chemical-based treatment process it is more resilient to deterioration in raw water quality from, for example, algal blooms.

K.43 The process washwater at Chingford WTW is treated through a clarification process. This produces a high-quality clarified wastewater stream which can be recovered to the head of the WTW, minimising the process losses. This is recovered about 80% of the time when the WTW is in operation as operationally we will not recover the water if there is a water quality risk, i.e. 20% of the time. As a result, the DYAA capability and process losses for Chingford WTW reflect an annual average of wastewater processing with and without recovery (Table K-9).

K.44 When the process water is not being recovered from Chingford WTW, it is discharged into the Willing Girling reservoir intake under an Environmental Permit.

Chingford	Base Case
Process Loss with Recovery (Ml/d & as %)	0.08 (0.19%)
Process Loss Non-recovery (Ml/d & as %)	1.29 (3.33%)
DYAA Process Loss (Ml/d & as %)	0.32 (0.82%)
Capability with Recovery (Ml/d)	38.7
Capability Non-recovery (Ml/d)	38.7
DYAA Capability (Ml/d)	38.7

Table K-9: Modelled capability & process losses for Chingford WTW

K.45 For Farmoor WTW (Table K-10), the DYAA values of capability and process losses reflect an annual average of four months of Base Case raw water quality, four months of 1 in 1-year algal conditions and four months of 1 in 5-year algal bloom conditions.

K.46 The process washwater at Farmoor is treated to a sufficiently high quality so that much of the resultant wastewater stream can be recovered to the head of the WTW. The remainder of the treated wastewater stream is discharged under Environmental Permit back to the River Thames downstream of the Farmoor abstraction point but upstream of the Swinford and Kings Weir intakes.

Farmoor	Base Case	1 in 1-year algae	1 in 5-year algae
Process Loss (Ml/d & as %)	1.76 (1.65%)	2.57 (2.57%)	3.05 (3.62%)
DYAA Process Loss (Ml/d & as %)	2.46 (2.54%)		
Capability (Ml/d)	106.8	99.6	84.2
DYAA Capability (Ml/d)	96.9		

Table K-10: Modelled capability & process losses for Farmoor WTW

K.47 For Swinford WTW (Table K-11), the DYAA values of capability and process losses reflect an annual average of four months of Base Case raw water quality, four months of 1 in 1-year algal conditions and four months of 1 in 5-year algal bloom conditions.

Swinford	Base Case	1 in 1-year algae	1 in 5-year algae
Process Loss (Ml/d & as %)	1.50 (1.73%)	1.50 (1.97%)	1.50 (2.02%)
DYAA Process Loss (Ml/d & as %)	1.5 (1.95%)		
Capability (Ml/d)	80.9	76.1	74.2
DYAA Capability (Ml/d)	77.1		

Table K-11: Modelled capability & process losses for Swinford WTW

K.48 The process washwater at Swinford WTW is treated to a sufficiently high quality so that much of the resultant wastewater stream can be recovered to the head of the WTW.

Accounting for water treatment in system modelling

K.49 As set out in Appendix I: Deployable Output, we use water resource system models to calculate our water supply capability. In WRMP19 we used the WARMS2 model while for WRMP24 we are using a series of Pwyr models. When combined, the Pywr models represent the Thames Water supply area as well as the water resource, water supply and wastewater interactions with neighbouring water companies.

K.50 The Pywr models contain nodes that represent demand centres for treated water, as well as nodes and links which represent rivers, reservoirs, and other water supply infrastructure. All of the WTWs that treat river and reservoir raw water are represented explicitly as individual WTWs. This means that the Hampton, Ashford, Kempton, Walton, Coppermills, Hornsey and Chingford WTW are represented explicitly in the London Pywr model, as are the process losses from each of the WTW. This is also the case for Farmoor and Swinford WTW in the SWOX Pywr model (although Farmoor and Swinford are aggregated in a single model node) Fobney WTW in the Kennet Pywr model and Shalford in the Guildford Pywr model. The capabilities and process losses for our other WTWs are accounted for in the inputs to the Pywr models. Where there are process losses at these other WTWs they are not identified explicitly but are accounted for by reducing abstraction of raw water by an equivalent amount. This enables returns of process water to the environment to be simulated in the Pywr models.

K.51 While individual WTW process losses might seem significant, their discharge may be supporting downstream abstraction as well as having environmental benefit through increased river flows. It is necessary however, to operate wastewater treatment processes to ensure that their discharges protect the quality of any receiving watercourse and so meet Environment Agency requirements.

K.52 All of the process losses from those LPPs in West London are discharged back into the River Thames and, as a result, can generally be re-abstracted at intakes further downstream. From Coppermills WTW process water that is not recycled back into the Lee Valley reservoirs goes into River Lee below any abstraction intakes. For the Chingford and Hornsey WTWs, the process losses are very small and their potential return as inflows to Chingford WTW and Coppermills WTW not accounted for explicitly in the Pywr system model.

K.53 Conceptually therefore, the significant WTW process losses are represented in the Pywr model to be consistent with their permitted discharges back into the water environment and are aligned with their representation in the WARMS2 model.

K.54 Treatment capability and process loss figures for our LPPs are used in system modelling as a percentage of the raw water that is abstracted, or a percentage of the water that is put into supply. This means that the magnitude of process losses varies with the quantity of water that these treatment works need to produce to meet customer demand for water. As set out in paragraph K.23 and Table K-3 for the Coppermills WTW, capability and process loss are characterised as single values, with the latter being expressed as a percentage, but it is important to understand that process losses will change as a function of the quality of the raw water. As raw water quality deteriorates, so the volume of the waste stream needed to remove contaminants also increases resulting in higher process losses.

K.55 The single representative capability and process loss values are required for each of the LPPs for use in system modelling using Pywr. In some cases, modelling simplifications are made within Pywr, which results in the case of Farmoor WTW and Swinford WTW in the amalgamation of treatment works into a single model node. The representative values for each WTW are the most reasonable approximation as they are considered to account for varying raw water quality conditions that might have been expected to occur during varying historical weather and hydrological conditions. The capability and process loss for key WTWs are collated in Table K-12; for those WTWs whose raw water is sourced from reservoir storage the process losses are expressed as a proportion of outputs.

Water Treatment Works	Area	Capability (Ml/d)	Process Losses (Ml/d & as %)
Ashford Common	West London	690.0	13.4 (1.94%)
Hampton	West London	749.0	17.4 (2.32%)
Kempton Park	West London	167.5	1.89 (1.13%)
Walton	West London	132.0	7.12 (5.44%)
Chingford	Lee Valley (NE London)	38.7	0.32 (0.82%)
Coppermills	Lee Valley (NE London)	537.5	35.9 (6.67%)
Hornsey	Lee Valley (NE London)	39.6	0.43 (1.09%)
Farmoor	SWOX WRZ	96.9	2.46 (2.54%)
Swinford	SWOX WRZ	77.1	1.50 (1.95%)
Fobney	Kennet Valley WRZ	63.7	8.26 (11.47%)
Shalford	Guildford WRZ	27.8	2.20 (7.91%)

Table K-12: Key WTW capabilities & process losses included in water supply system modelling

Implications of raw water quality challenges and climate change

K.56 It should be noted that process losses, e.g. returns to river, included in WRMP Annual Reviews are a reflection of raw water quality and weather from the reporting year as well as customer demand and water production operating strategies. For example, it can be the case during wet winter and spring weather that raw river water quality deteriorates such that reduced volumes of process water are recycled, this is to mitigate potential quality risks to WTW inputs and their treated water outputs. As a result, reporting year processes losses should not necessarily be expected to align with those figures used for planning purposes; this includes the DYAA figures presented here for the LPPs.

K.57 In the event that the water quality challenge experienced at a WTW in a given year is greater than that assumed in the calculated representative values, the actual process losses may be higher than the values in Table K-12 that are used in system modelling. This potential challenge from raw water quality results in a risk that WTW process losses could increase and, as a result, capabilities decrease; this is particularly the case for the LPPs fed from raw water reservoirs.

K.58 In particular, during times of algal blooms in reservoirs that are more severe than those accounted for in calculated representative capabilities and process losses, the recycling of process water is likely to be reduced. This would mean that less of the process losses would be treated to water quality standards acceptable for discharge back into the reservoirs and, consequently, more would be discharged back into the environment and not recycled. Overall therefore, algae can affect the treatability of reservoir water and increase the cost of treatment and production of drinking water.

K.59 In principle, increasing the recovery of process water waste streams would require larger, potentially more complex treatment plants. This would incur increased and potentially disproportionate costs for water supply in treating wastewater that already supports downstream abstraction and the environment. In this context, it is also of note that the return period for a significant algal bloom event does not necessarily correlate with the dry year annual average planning scenario used in WRMP.

K.60 To capture the risk of poorer raw water quality in reservoirs, we have included new components in our Target Headroom modelling for WRMP24 (Section 6). These components are operational factors that pose a risk to DO. They include the risk that river water quality during the winter and spring may be sufficiently poor that abstraction into reservoir storage may need to stop. As a result, this could delay and put at risk the recovery of reservoir storage following summer and autumn drawdown.

K.61 Of more direct relevance to treatability and WTW process losses, we have also included a component of uncertainty related to early implementation of emergency drought restrictions in extreme drought scenarios. Emergency drought restrictions may be imposed earlier than stated in our WRMP if it is found that exceptionally poor water quality exists at the bottom of reservoirs such that we could not make use of all the stored water.

K.62 It is evident that our WTW outputs and water supply, particularly the LPPs dependent on reservoir storage, can be vulnerable to seasonal raw water quality, especially algal blooms. A UKWIR study on climate change implications for water treatment identified algae could become more problematic for water supply as process losses are likely to increase further and WTW capability reduce.

K.63 Previous work with Imperial College London investigated the frequency and severity of algal events in raw water reservoirs. Using 30 years of data from the early 1980s, through the 1990s to the 2000s, patterns of algal behaviour linked to climate were assessed. This suggested that the timing and duration of the algal bloom challenge was changing, with the duration of the bloom period extended (see Figure K-1). Evidence suggests that the percentage of the year subject to an algal challenge of greater than 10 µg/l has increased from 42% to 63%; this elevated level of challenge is likely to be "the new normal" under future climate conditions[4].

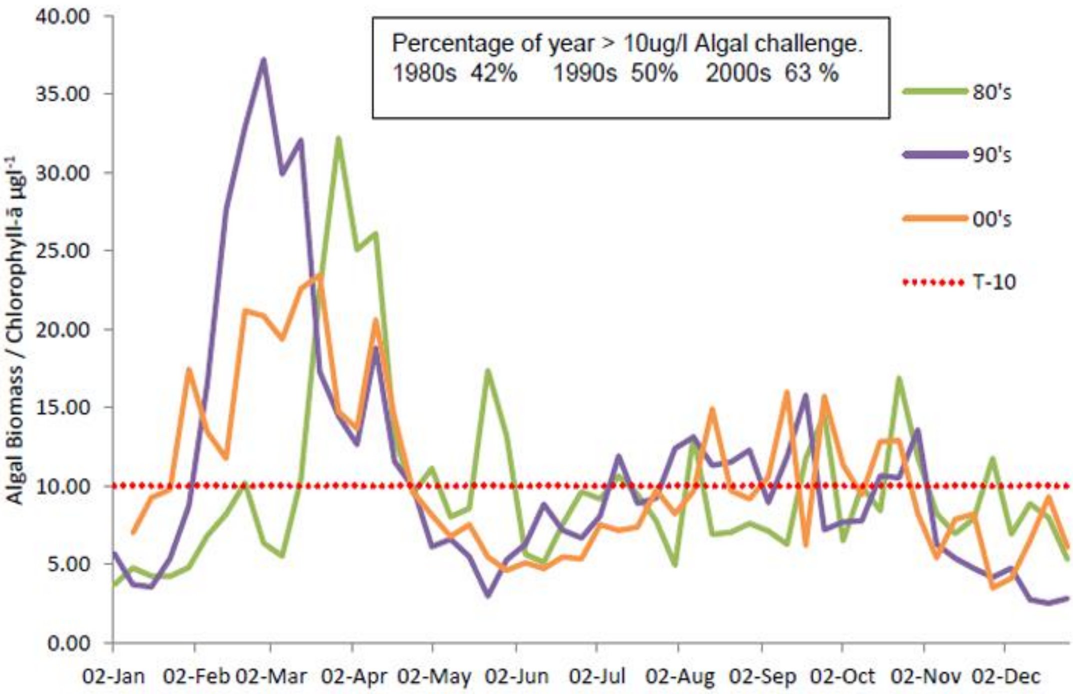

Figure K-1: Average decadal pattern of changing algal blooms[5]

K.64 By looking at the resilience of our raw water storage and supply network we have found that the change in algal bloom severity and duration is dependent on individual reservoir characteristics, including their physical structure and management. For example, deeper reservoirs have better control measures to manage the raw water quality and therefore are more resilient to the impacts of climate change.

K.65 Nevertheless, as well as future raw water resource availability (see Appendix U: Climate Change), the water quality challenge and how this may change in future climates is an important factor to account for in planning. Evidence indicates that the impact of climate change is increasing the range of species of algae that can cause a bloom event in our reservoirs and also increasing the duration for which our reservoirs are at risk of algal bloom. We have an ongoing programme working with subject matter experts to develop

[4] UKWIR, 11/CL/08/02: Climate Change Implications for Water Treatment, 2011
[5] Imperial College, Merle Anderson, MSc Storage Reservoirs, Algal Blooms and Climate change, June 2013

decision support tools to assess potential raw water quality behaviours, with algal impacts on LPP performance being a focus.

K.66 We have engaged the UK Centre of Ecology and Hydrology (UKCEH) to undertake Protech modelling to develop a quantitative assessment of our raw water storage reservoirs in the London WRZ. This will help determine the volumes of reservoir raw water that may be available for treatment at our LPPs under drought scenarios as well as the consequences for the representative LPP capabilities and process losses. We have modelled the drought impact on raw water quality in four of our reservoirs that are representative of West London and the Lee Valley in the London WRZ and, via the National Environment Research Council (NERC) project, MaRIUS[6], have modelled impacts in our Farmoor reservoir in the SWOX WRZ. These reservoirs have been the focus as the London and SWOX WRZs are potentially vulnerable due to their reliance on storage reservoirs.

K.67 Our aim continues to be to better inform our evaluation of system resilience and to be able to base judgements on sound quantitative modelling. Following assessment of these results and establishing their significance in terms of risk to our existing supply demand balance, we will continue our programme of investigation to establish the magnitude of impact to assist in making more informed decisions and to target investment to improve system resilience. With our developing view of raw water quality impact from algae and potential consequences for treatability and process losses, we have included a component within our Target Headroom that allows us to recognise the associated risk and uncertainty.

[6] Managing the Risks, Impacts and Uncertainties of drought and water Scarcity

Summary

K.68 Through the development and use of WTW mass balance and resilience models, we have undertaken a review of treatment capabilities and process losses using updated information and modelling. This has enabled updating and improvement of data used in the calculation of source and WRZ DO, the latter through use of our Pywr systems models, which contributes to improved understanding and the production of a reliable assessment of DO.

Annex – Changes Between Plan Iterations

Changes between dWRMP24 and rdWRMP24:

- In order to ensure that our supply forecast is as up to date as possible, we have updated process loss and WTW capability figures in line with modelling done to support our Annual Review 2022.

Changes between rdWRMP24 and final WRMP24:

- No changes

Thames Water