Water Supply - Outage Allowance Assessment Report

SES Water's draft Water Resource Management Plan 2019

SES Water

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1. Introduction

1.1 Background

SES Water is required to submit an Outage Allowance (OA) assessment as part of its Water Resources Management Plan (WRMP) submission.

Outage is defined as 'short-term losses of supply and source vulnerability' (Environment Agency, April 2017). The purpose of assessing a water company's outage is to calculate an allowance for inclusion within the supply/ demand balance, to cover the amount of deployable output (DO) that may be unavailable for use at any given time, due to planned or unplanned outage events. Planned events include temporary shutdown of plant for routine maintenance, and unplanned events include less predictable shutdowns due to such factors as turbidity, power or system failure and source pollution.

Based on an analysis of recorded outage events for the period September 1994 - March 2012, SES Water calculated an outage allowance to incorporate within the supply/ demand balance, for their Final WRMP 2014. A summary of the results is given in Table 1-1, and is discussed further in Section 4.3.

Table 1-1: WRMP14 Outage Allowance (at the 95th percentile) for SES Water

Water Resource Zone (WRZ)	Outage Allowance (Ml/d)	
	Dry Year Annual Average	Dry Year Critical Period
Sutton	2.31	1.16
East Surrey	2.76	1.11
Company (Dry Year Annual average)	**5.07**	**2.27**

1.2 Objectives

The aim of the outage assessment is to calculate probability distributions of allowable outage for each outage category, treatment works and planning scenario, and then to combine these into overall probability distributions of company allowable outage for each planning scenario. Outage allowance values can then be determined from the distribution for each period at an appropriate probability or level of risk.

The key objectives of this analysis can be summarised as follows:

- Review SES Water outage data and identify events which may be classified as legitimate outage events;
- Develop suitable probability distributions to represent allowable outage for each treatment works based on event magnitudes, durations and frequencies observed in the data set; and
- Combine the individual probability distributions into single company distribution representing the range of outage allowances at alternative risk levels.

In the current report, Section 2 provides the methodology used to undertake the OA assessment and an analysis of the recorded outage data; Section 3 outlines the analysis of the recorded data; Section 4 outlines the modelling assumptions and summarises the results of the assessment; and Section 5 provides conclusions and recommendations.

2. Outage assessment methodology

The standard method for the calculation of outage allowance, developed by UKWIR in 1995 and recommended by the EA in their WRMP19 methods paper, has been adopted (Environment Agency, July 2016). The full methodology is outlined in 'Outage Allowances for Water Resource Planning: Operating Methodology' (UKWIR, 1995).

In this approach, a probability distribution is assigned to each outage category, based on known data and other relevant information relating to event magnitude (deployable output loss in megalitres/day), event durations (number of days) and event frequencies (average number of occurrences per year). The probability distributions are then combined using the statistical technique of Monte Carlo simulation, which iteratively takes random samples from each distribution and sums them according to specified rules. The summed result of each iteration then forms a point on the curve of the combined distribution; by sampling the distributions over a large number of iterations it is then possible to build up a probability distribution to represent the combined company allowable outage for all treatment works and categories.

The Monte Carlo simulation software @RISK was used for the analysis, which operates in conjunction with the Microsoft Excel spreadsheet package.

Due to the random nature of the Monte Carlo simulation technique, it is not possible to guarantee that identical results will be generated each time the same simulation is run. However, by selecting a suitably large number of iterations for the simulation, to give an acceptable mean standard error for the simulation results, it should be possible to obtain repeatable results to an acceptable level of accuracy. All Monte Carlo simulations undertaken for this outage assessment have been run for 10,000 iterations, which in practice gives fairly consistent results.

For the Final WRMP 2014, SES Water completed a supply/ demand balance analysis for two Water Resource Zones[1] (WRZs), namely Sutton WRZ and East Surrey WRZ. These zones have been combined for the WRMP 2019 submission. This analysis of outage allowance will therefore be carried out for a single company-wide WRZ.

SES Water provided outage data with details on the type of outage (planned/unplanned), reason for outage, duration of the outage and the reduction in output. The outage categories adopted are listed in Table 2-1.

Table 2-1: Outage Categories

Name	Description
Electricity failure	Temporary loss in power resulting in reduced output or complete works shutdown
System failure	Failure in the treatment process resulting in reduced output or complete works shutdown
Turbidity	Source water turbidity resulting in reduced output or complete works shutdown
Other	Outage due any other reason
Maintenance	Planned maintenance of assets resulting in reduced output or complete works shutdown

Two planning scenarios have been considered in this outage assessment, as follows:

- Dry Year Annual Average (DYAA) – based on Dry Year Minimum Resource Level (DYMR) and Minimum Resource Deployable Output (MDO). The assessment of Minimum Deployable Output (MDO) is linked to the critical period (minimum groundwater level and river flow) scenario. Groundwater source 'ADO' assessments (improved methodology) were based on monthly operational data for those months when groundwater levels were at or near their annual minima for the worst drought to have affected the area of the source (UKWIR, 2000). However, the use of data associated with minimum groundwater levels means that the assessments now fall under the category of MDO. MDO is the *"DO for the period in which groundwater levels are at their lowest, usually late autumn"* (UKWIR, 2014);
- Dry Year Critical Period (DYCP) – based on dry year Average Demand in Peak Week (ADPW) and Peak Deployable Output (PDO). Water companies *"may also choose to explain how you will deal with a period of peak strain known as the critical period"* (Environment Agency, April 2017). The assessment of PDO is associated with the 'dry year critical period' (DYCP) planning scenario and also the design drought, where the resource zone supply-demand balance is sensitive to peak demand. PDO is the "*deployable output for the period in which there is highest demand" (UKWIR, 2014)*.

[1] A Water Resource Zone is the largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers experience the same risk of supply failure from a resource shortfall

3. Analysis of Recorded Data

3.1 Deployable output

SES Water's deployable output values, for the Dry Year Minimum Resource and Dry Year Critical Period scenarios, were taken from work undertaken by AECOM in June 2016 towards the WRMP 2019. The deployable output values for the worst drought on historic record were used for both scenarios.

3.2 Outage data

SES Water have kept a record of outages from 1994 till 2017 in a spreadsheet format. Events from 1994 till 2000 were taken from board reports and from October 2000, events were recorded monthly as they occurred. For each outage event the following information is recorded:

- Date of outage event and event duration;
- Affected treatment works;
- Reduction in output as a result of the event;
- Whether the outage event was planned or unplanned;
- The classification of the outage as shown in Table 2-1.

3.3 Determination of Legitimate Outage

A step-by-step audit process was adopted to exclude all events from the assessment which did not meet the EA definition of a legitimate outage event, and amend or re-categorise certain events.

3.3.1 Zero DO loss

There were several events where although an outage was logged, there was no loss of output. The majority of these were due to an electrical failure when output may have been maintained by a generator on site, or the duration of the failure was not sufficient to result in a loss of output. These events do not represent an unavoidable loss of deployable output (are not legitimate outage events) and therefore have not been included in the analysis.

3.3.2 Zero DO impact

Several sites have buffer storage tanks which can maintain supplies during an outage event. Details of this storage capacity are shown in Table 3-1. Outage events where the buffer tanks can maintain supplies (i.e. duration of the outage is less than the time the buffer storage tank can maintain supplies) are not included in the analysis. This is because a drop in output at these times is not considered to be a genuine outage as supply is maintained.

Table 3-1: Buffer storage available at SES treatment works

Treatment works	Treatment works capacity (Ml/d)	Buffer tank capacity (Ml)	Buffer time (days)
Cheam	90	0.81	0.01
Woodmansterne	45	0.48	0.01
Kenley	45	12.8	0.28
Elmer	84	18.2	0.30
Clifton's Lane	4.8	0	0.00
Godstone	16	0.91	0.05
Westwood	8	0.9	0.11
Bough Beech	55	9.1	0.17

3.3.3 Re-categorisation

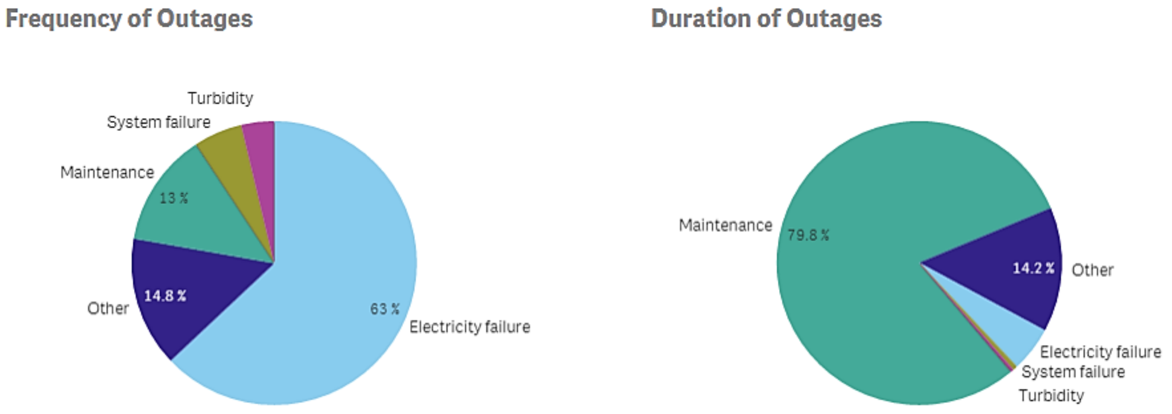
There were some events where the type of outage or the reason for the outage could not be determined. Where there was an uncertainty as to whether the outage event was planned or unplanned, an unplanned outage was assumed in order to provide a conservative outage allowance. Where the reason for the outage could not be determined, the event was categorised as “Other”. Where there was uncertainty about the duration of the outage, a duration of one day was assigned in order to provide a conservative estimate.

With respect to event magnitudes, all events have been assumed to have an outage magnitude of 100% of the DO. This is likely to be conservative, since several events resulted in only a reduction in output rather than a complete loss of output. Where no outage events were identified at a source works in the 2012-2016 data, a minimum of 1 event lasting 1 day has been applied over a four year time period, to provide a conservative estimate.

3.4 Summary of legitimate outage events

Following the above process, a total of 54 legitimate outage events were identified, which lasted a total of 584.6 days from the period January 2012 till the end of December 2016. Of these 54 legitimate outage events, 9 events (lasting 467.35 days) were planned maintenance events while 45 events lasting a total of 117.2 days were unplanned. Figure 3-1 shows the distribution of various causes of outage in terms of their frequency and duration.

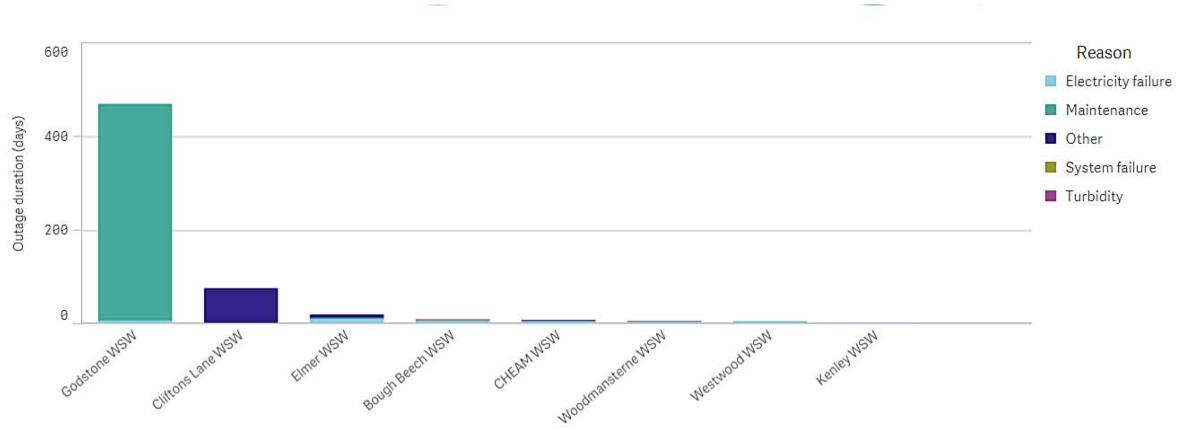
Figure 3-1: Overall frequency and duration of outages for the period 2012-2016



The majority of outages were a result of electricity failure; however they did not constitute the events with the longest durations. This means that although electricity failure caused a majority of the outages, the failure did not last very long therefore the loss in DO was likely to be minimal. Outages that lasted the longest were during planned maintenance and as these events are relatively frequent, they are likely to have a larger impact on the DO.

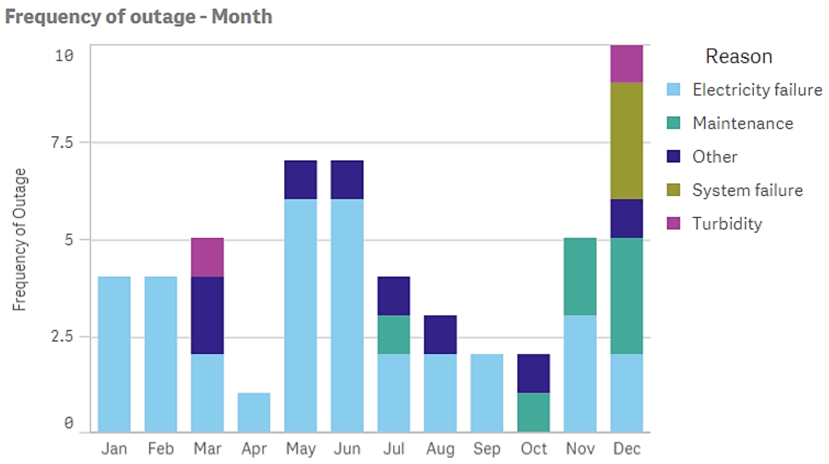
The analysis was further broken down to determine which site experienced the most outages and the most common reason for the outage as shown in Figure 3-2. Godstone experienced the most outage events, the reason for which was planned maintenance which lasted between 73 and 151 days. This was followed by Clifton’s Lane , where it is suspected that the site was being run to waste prior to being brought online, however as this could not be confirmed, the reason for outages was assigned as “Other”. Three events contributed to 69 days of outage; however it is important to note that this site is only used as a drought option and is operated as a “back-up” treatment works.

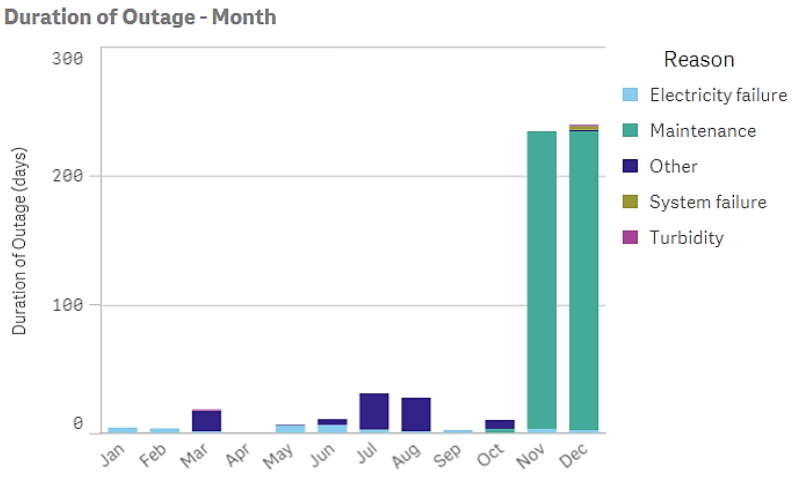
Figure 3-2: Summary of outages at the different sites for the period 2012-2016



The seasonal distribution of outages is illustrated in Figure 3-3 below, which indicates that the majority of outages occur during December. It is also evident that electricity failure is experienced throughout the year (except for October) and is often the only reason for outages. In December however, there are several contributors to outage such as maintenance, system failure, turbidity and “other” which result in a high frequency of outage. Due to the length of time required to carry out planned maintenance, the longest duration of outages are also experienced in November and December. This is because demand for water is lower in the winter while supplies are replenished therefore maintenance is planned during this period.

Figure 3-3: Seasonal distribution of all legitimate outage for the period 2012-2016, in terms of frequency and duration





4. Probabilistic modelling assumptions and results

This section outlines the assumptions adopted in determining the sites DO, and outage event durations and frequencies used to specify the probability distributions for each treatment works. It also outlines the approach undertaken to complete the probabilistic modelling and provides the final outage results.

4.1 Modelling assumptions

The following assumptions were made in order to complete the analysis:

- Outage results in a 100% loss in DO i.e. all event magnitudes are assumed to be equal to the full DO value of the relevant treatment works (this is likely to be conservative);
- Where no outage events have been identified at a source works in the 2012-2016 data, a minimum of 1 event lasting 1 day has been applied over a four year time period (this is conservative);
- The average duration of an event is identified as the most likely to occur duration (50th percentile);
- The DO for the treatment works has been calculated as the sum of the individual DO's of source works feeding the water treatment works during the worst drought on historic record (as determined by the AECOM DO assessments (AECOM, 2017)). Peak DO's are used in the DYCP analysis and Minimum Resource DO's are used in the DYAA analysis (See Appendix A).

4.2 Assessment of results

The results of the probabilistic assessment are shown in Table 4-1 and Table 4-2 below. The outage values to be taken forward into SES Waters' supply/ demand balance analysis for WRMP 2019 are based on the 95th percentile, i.e. the values with a 5% risk of exceedance. The outage allowance values adopted are therefore 8.10 Ml/d for the DYAA and 3.61 Ml/d for the DYCP scenarios.

It should be noted that the outage allowance values by treatment works in Table 4-1 and Table 4-2 below do not sum to the company total outage allowance values. This is due to the probabilistic nature of the Monte Carlo simulation in which outage events in all treatment works do not occur simultaneously in each step of the iteration. However the results by individual treatment works provide an indication of their relative contributions to the combined company total values.

Table 4-1: SES Outage Allowance (DYAA)

Treatment works	Probability 50%	55%	60%	65%	70%	75%	80%	85%	90%	95%*
Cheam	0.18	0.19	0.19	0.20	0.21	0.21	0.22	0.22	0.23	**0.24**
Woodmansterne	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	**0.12**
Kenley	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	**0.02**
Elmer	1.20	1.29	1.38	1.48	1.58	1.69	1.81	1.95	2.12	**2.34**
Clifton's Lane	0.11	0.12	0.13	0.13	0.14	0.14	0.15	0.16	0.17	**0.19**
Godstone	4.51	4.62	4.73	4.85	4.97	5.11	5.26	5.44	5.64	**5.91**
Westwood	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	**0.02**
Bough Beech	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	**0.15**
Total company outage allowance Ml/d	6.43	6.56	6.69	6.83	6.96	7.11	7.29	7.48	7.73	**8.10**
Total company outage allowance as % of DO	2.98%	3.04%	3.10%	3.17%	3.23%	3.30%	3.38%	3.47%	3.59%	**3.75%**

**Outage values to be used in the dWRMP 2019*

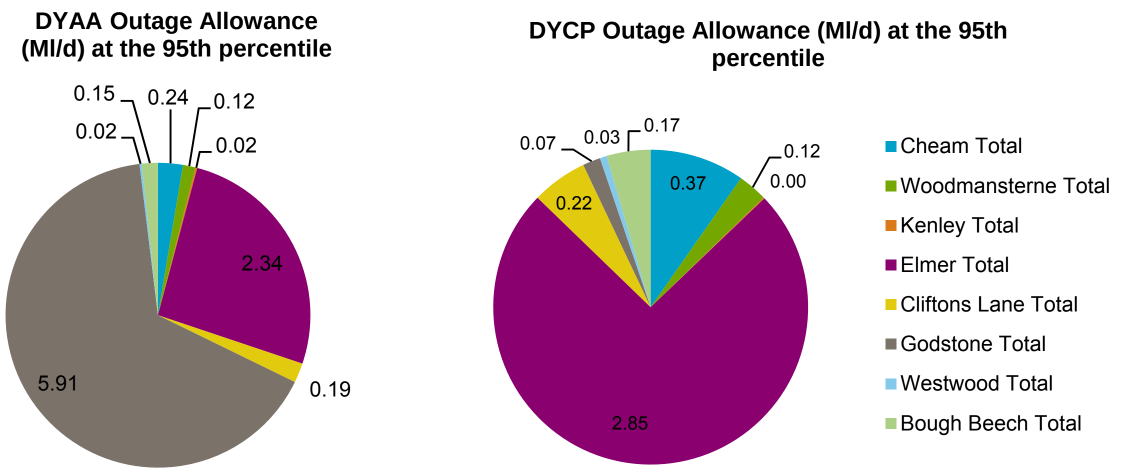
Table 4-2: SES Outage Allowance (DYCP)

Treatment works	Probability 50%	55%	60%	65%	70%	75%	80%	85%	90%	95%*
Cheam	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35	0.36	**0.37**
Woodmansterne	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	**0.12**
Kenley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Elmer	1.39	1.50	1.61	1.74	1.87	2.01	2.17	2.36	2.57	**2.85**
Clifton's Lane	0.14	0.14	0.15	0.16	0.16	0.17	0.18	0.19	0.20	**0.22**
Godstone	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	**0.07**
Westwood	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	**0.03**
Bough Beech	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	**0.17**
Total company outage allowance Ml/d	2.18	2.29	2.41	2.53	2.66	2.81	2.97	3.15	3.37	**3.65**
Total company outage allowance as % of DO	0.73%	0.76%	0.80%	0.84%	0.89%	0.93%	0.99%	1.05%	1.12%	**1.21%**

Outage values to be used in the dWRMP 2019

Figure 4-1 below shows how each treatment works contributes to the company's outage allowance. As can be seen, Godstone contributes the most to the DYAA. This is because of the annual maintenance carried out at Godstone in the winter, which contributes significantly to the DYAA allowance. The DYCP allowance only considers unplanned outages and in this case Elmer has the highest contribution to the allowance. It should be noted that Elmer still contributes significantly to the DYAA outage allowance and this is because the DO (See Appendix A) for Elmer is approximately four times higher than that of Godstone. This means even shorter outages at Elmer result in a higher loss of DO than longer outages at Godstone. A further breakdown of the contribution of the treatment works to the outage allowance can be found in Appendix B.

Figure 4-1: Relative contributions of treatment works outage to the total outage allowance (DYAA and DYCP)



It should be noted that the relative contributions of each treatment works to the overall outage values reflect the occurrences at these treatment works within the recorded outage data for 2012-2016. The apportionment of the outage allowance between these treatment works will not necessarily represent the apportionment of actual recorded outage events in future; however the recent recorded data has been used to produce a representative value for the total company outage that may be expected in future.

4.3 Comparison with previous assessment

For their WRMP14 submission, SES Water undertook an outage assessment for two WRZ's. These have since been combined; therefore this WRMP19 assesses outage in a single company-wide WRZ. This is not thought to have had any impact on the company's total outage allowance.

The current assessment has produced a higher outage allowance of 8.10 Ml/d and 3.65 Ml/d for DYAA and DYCP scenarios respectively, compared to 5.07 Ml/d and 2.27 Ml/d (DYAA and DYCP respectively) in the previous assessment (see Table 4-3 below). However, when considering the outage allowance as a percentage of DO, the WRMP19 allowance is lower than in WRMP14. This is as a result of an increase in the DO values following reassessment (AECOM, 2017). It should be noted that the DO values have been defined using the worst drought on historic record scenario.

Table 4-3: SES Water outage allowance at the 95th percentile - comparison with previous results

Submission	DYAA (Ml/d)	DYCP (Ml/d)	DYAA (% DO)	DYCP (%DO)
WRMP14	5.07	2.27	5.2	1.7
dWRMP19	8.10	3.65	3.75	1.21

5. Conclusions and recommendations

Table 5-1 below shows a summary of the results of this outage allowance assessment. The deployable output values for the worst drought on historic record were used for both scenarios. These figures are incorporated within SES Water's supply/ demand balance analysis and dWRMP2019 report due for submission in December 2017.

The selected outage values are for a probability of 95%, or exceedance probability of 5%. The outage allowance is based on five categories namely electricity failure, system failure, turbidity, other and maintenance.

Table 5-1: SES Water outage allowance at the 95th percentile

Submission	DYAA (Ml/d)	DYCP (Ml/d)	DYAA (% DO)	DYCP (%DO)
dWRMP19	8.10	3.65	3.75	1.21

5.1 Recommendations

Stakeholder comments that arise from the dWRMP19 report should be taken on board for the final WRMP19.

6. References

AECOM 2017. Water Supply – Deployable Output Assessment Report.

Environment Agency and Natural Resources Wales, 2017. Interim Water Resources Planning Guidelines (WRPG) update FINAL April 2017.

Environment Agency, July 2016. WRMP19 methods: Outage allowance.

SES Water, 2014. Final Water Resource Management Plan.

UKWIR, 2014. Handbook of source yield methodologies.

UKWIR, 2000. A Unified Methodology for the Determination of Deployable Output.

UKWIR, 1995, Outage Allowances for Water Resource Planning: Operating Methodology.

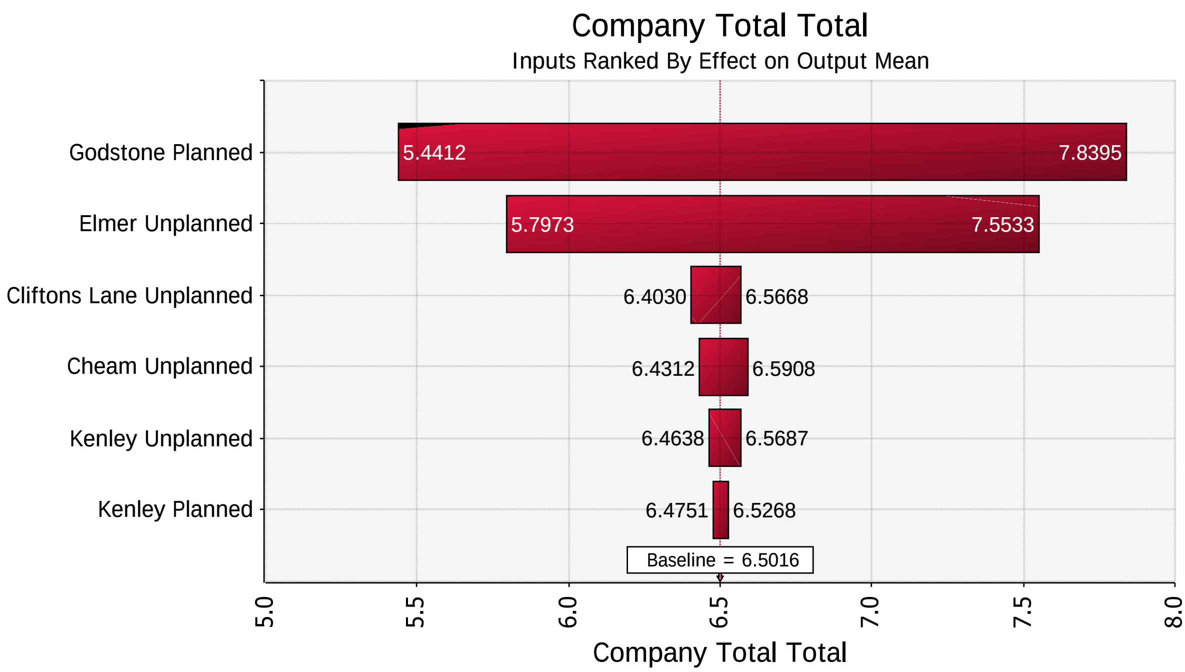
Appendix A - DO of water treatment works

The table below summarises the calculated DO’s for the water treatment works, which are based on the worst drought on historic record. The DO for the treatment works has been calculated as the sum of the individual DO’s of source works feeding the water treatment works during the worst drought on historic record (as determined by the AECOM DO assessments (AECOM, 2017)).

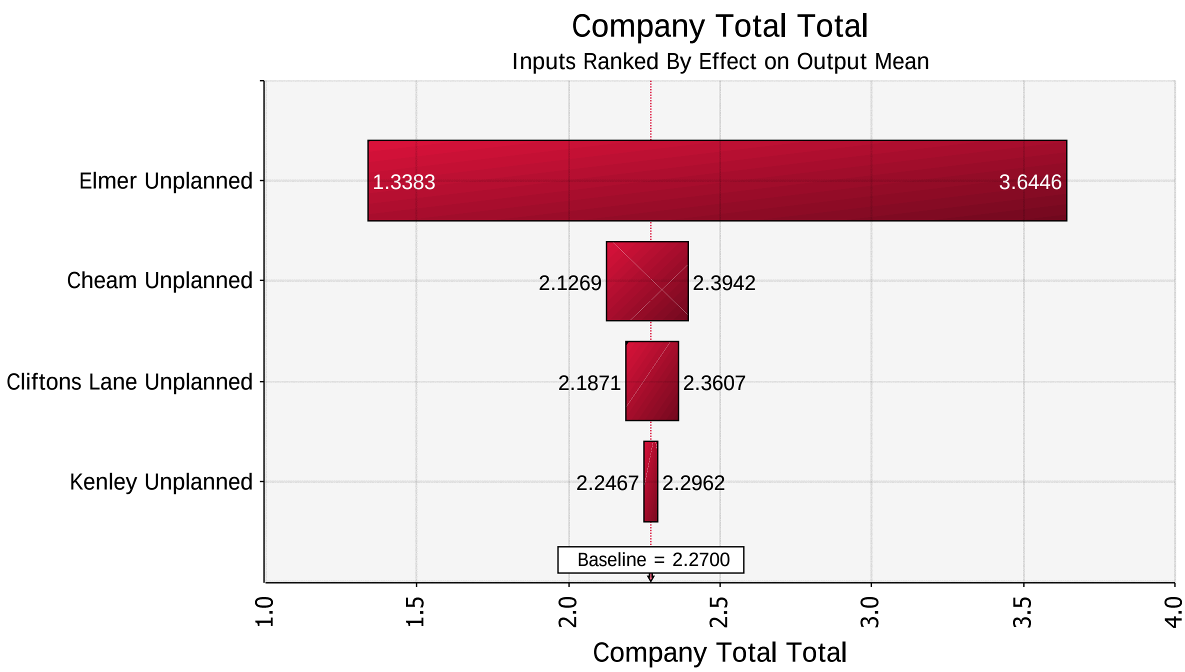
Treatment works	**Treatment works capacity** (Ml/d)	**Sum of PDOs** (Ml/d)	**Sum of MDO's** (Ml/d)
Cheam	90	79.57	46.86
Woodmansterne	45	33.68	31.81
Kenley	45	41.28	22.79
Elmer	84	81.72	63.25
Clifton’s Lane	4.8	2.70	2.27
Godstone	16	20.38	15.73
Westwood	8	9.79	6.88
Bough Beech	55	31.6	26.1

Appendix B – Contribution of planned/unplanned outages at various treatment works to the total outage allowance

B.1 DYAA



B.2 DYCP



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