Thames Water

Draft Water Resources Management Plan 2019

Technical Appendices

Appendix J: Outage

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Outage

A. Introduction

J.1 This section of our draft Water Resources Management Plan 2019 (draft WRMP19) describes how the temporary loss of resources is allowed for in the supply demand balance. Known as the "outage allowance" or more commonly as "outage", the methodology of how this is calculated is explained and the baseline figure is presented

J.2 Outage allowance is defined and the methodology explained

J.3 This appendix is structured as follows:

- The definition of outage is presented
- The background to the methodology and when to assess outage uncertainty is explained
- The outage allowance methodology is explained together with the principles of the approach
- We describe how we approach outage allowance assessments
- With the aid of examples the potential variance in outages is explained
- The interpretation of risk is discussed
- The base year outage figures are presented

B. Outage definition and methodology

Definition of outage

J.4 Outage is a temporary short-term loss in supply known as Deployable Output (DO); (see Appendix I: Deployable output). For the purposes of producing our draft WRMP19, we've examined the updated guidance, including Section 4.10 of the Final Water Resources Planning Guideline (WRPG)[1] and further Environment Agency WRPG supporting documents on outage from July 2016[2]. We have also used the UKWIR reports Outage Allowances for Water Resources Planning[3] and WRMP 2019 Methods – Risk Based Planning[4].

[1] Environment Agency and Natural Resources Wales and also produced in collaboration with Defra, the Welsh Government, and Ofwat, Final Water Resources Planning Guideline, April 2017
[2] Environment Agency, WRMP19 methods: Outage allowance, July 2016
[3] UKWIR, Outage Allowances for Water Resources Planning, 1995
[4] UKWIR, WRMP 2019 Methods – Risk Based Planning, May 2016

J.5 Note the Environment Agency's 2017 WRPG states that an outage is temporary in the sense that it is retrievable, and therefore DO can be recovered. The period of time for recovery is subject to audit and agreement. If an outage lasts longer than three months, analysis of the cause of the problem would be required in order to satisfy the legitimacy of the outage. The 2017 WRPG indicates that a water company must determine if it will incorporate an "outage allowance" within its WRMP. It also states that the outage allowance that a company can use within its WRMP can be developed by following the principles within the outage allowances for Water Resources Planning Report.

Definition of outage allowance

J.6 We need to provide an outage allowance to cater for the planned and unplanned loss of water resources within its supply demand balance submissions. The allowable outage collectively describes the combined risks of the legitimate unplanned and legitimate planned outages. The outage allowance being the value of allowable outage expressed in mega litres per day (Ml/d).

Background to outage methodology

J.7 Prior to AMP4 we commissioned consultants to assess industry best practice and develop a methodology based upon the UKWIR approach. Their review identified several shortcomings in the earlier methodology and how these could be overcome. The resulting methodology to overcome these shortcomings follows the philosophy behind the UKWIR report referenced by the Environment Agency. It is built around commercially available risk analysis software (@Risk) and it is compatible with the updated methodologies developed by UKWIR for other elements of the supply demand balance. In particular, it is compatible with the headroom methodology outlined in Appendix V: Risk and uncertainty except that it is run on a monthly rather than annual time step.

J.8 The methodology is a pragmatic but conceptually robust method of quantifying the uncertainties in the supply demand balance. The methodology:

- Provides a full analysis of outage uncertainty in the supply demand balance, giving a range of outputs across the planning period with probabilities and confidence limits
- Is sufficiently robust, in conjunction with a wider economic framework, to justify significant investment decisions in new resources or demand management programmes
- Provides a genuine measure of outage uncertainty that is not constrained within particular limits by the methodology itself
- Enables the uncertainty associated with rare but high consequence events to be evaluated, such as the complete loss of a source due to an infrequent flooding incident

J.9 In common with the headroom methodology, it does not provide a fixed outage allowance. Instead, it provides a range of numbers with probabilities and these must be interpreted in conjunction with the other components of the supply demand balance and assessed against a level of risk that is acceptable to the company and its regulators.

When to assess outage uncertainty

J.10 In general the outage uncertainty is not expected to vary over the planning period, unless issues such as maintenance are identified as either starting or being resolved at different stages in the planning period, or if a current outage issue is resolved, such as a pump replacement which enables the full DO of the site to be abstracted.

J.11 If the outage is likely to vary then outage assessment should be carried out for all months during the critical year. Further assessments can be carried out for different years to visualise the impact on outage uncertainty of the removal of an issue.

J.12 In some instances it may not be necessary to carry out a complete and detailed analysis of outage uncertainty. In the situation where DO exceeds demand by at least 25% (the same percentage as in the headroom methodology) then an alternative, simpler methodology can be implemented. An example could be either a blanket estimation (say <5%) across the whole supply area or no allowance as the excess in available resource can deal with any outage requirement.

J.13 In most cases outage uncertainty should be assessed each month during the critical years of the planning period in order to identify the critical month when outage uncertainty is greatest.

Actual outage

J.14 A requirement of the annual regulatory submissions is to report on "actual outage". As there is no formal definition of "actual outage" from regulators or the Water Industry, we have derived a means by which actual outage is measured.

J.15 Actual outage is the temporary loss of DO in the reporting year weighted by the duration of the loss (in days).

Example: a source DO loss of 10 Ml/d lasts 45 days thus

*Weighted outage = 10 * (45 / 365) = 1.23 Ml/d*

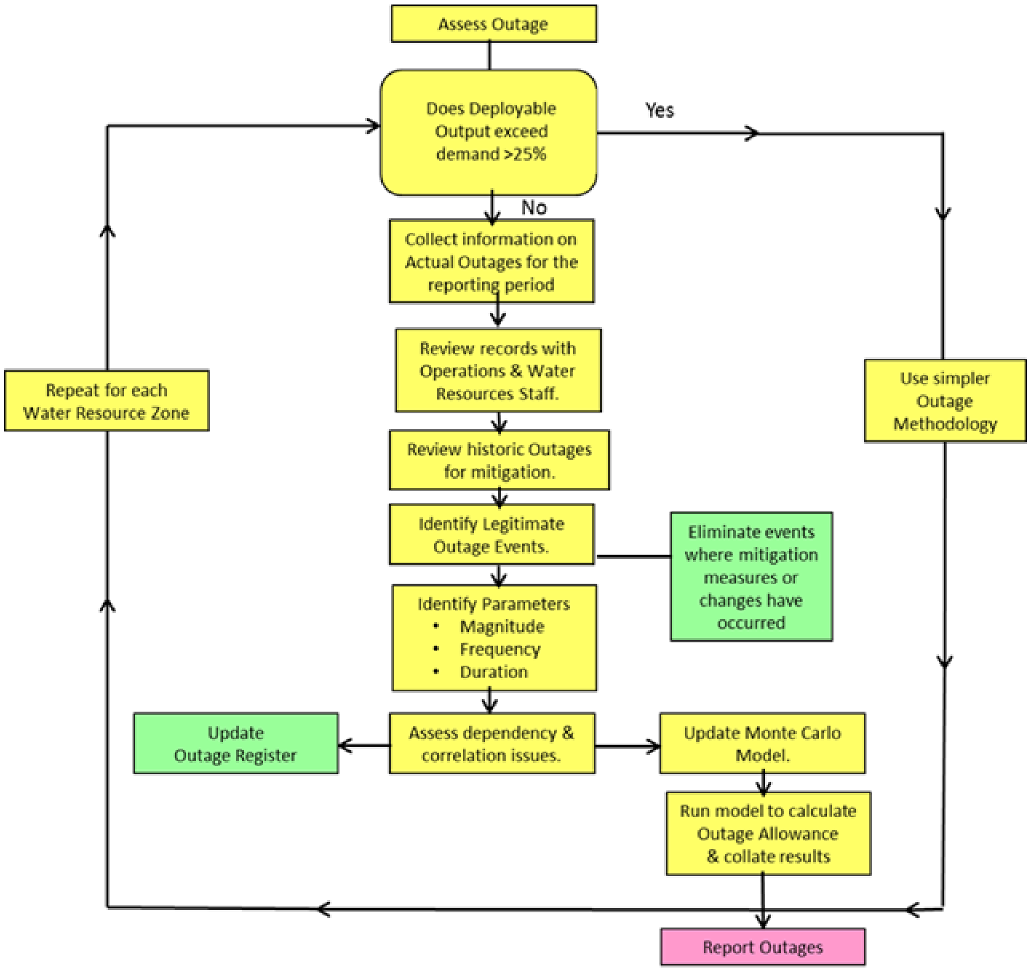
J.16 Each weighted outage is then summed over the reporting year to give a total actual outage for the water resource zone (WRZ). This is fundamentally different to the outage allowance which is based on risk.

C. Outage allowance

Outage allowance methodology

J.17 The methodology starts with an optional screening process to identify whether DO in the resource zone is at least 25% greater than demand. This percentage is the same as that applied to the filter in the headroom methodology. This screening process will determine whether a probabilistic analysis of outage uncertainty is appropriate. A simpler method could be applied if there is evidence that any failures are unlikely to affect supply or the DO. An example of this more simplistic assessment of outage may be a fixed percentage allowance for the resource zone. However, even if there is a significant resource surplus, a full outage assessment may be advisable to provide the level of understanding required within the resource zone.

Figure J-1: Overview of outage methodology



J.18 Having decided to apply the methodology the first stage is to identify, by WRZ, any historic failures of supply. Interviews with relevant staff and interrogation of operational data systems have been used to collect this failure information. Failures generally fall within the following categories:

- power failure (mains or standby)
- algae
- flooding
- turbidity
- pollution of source
- system failure
- raw water transmission
- treatment

- delivery through service reservoirs and treated water pumping
- Supervisory Control and Data Acquisition (SCADA) failures
- statutory Inspections
- engineering upgrades

J.19 A failure to supply, due to incidents of one of the categories above, may not always be classified as a legitimate outage, and further assessment is required to identify which of these failures are legitimate outages.

J.20 In order to assess which of these failures are legitimate outages under the methodology, the mitigation measures that would be employed, should the failure occur, have been reviewed. This provides a means of addressing whether other resources can cover a failure event and whether the resources used can be replaced within a short (seven day) period without impacting on the DO. If this is the case or the failure is for less than 24 hours, then it is not considered as a legitimate outage.

J.21 Once the legitimate outage events have been identified, then the outage issues data can be recorded. The information recorded is associated with the frequency, magnitude and duration of the events. In general, the outage events will be independent, but sometimes one event will be the result of another, therefore they may be correlated, dependent or they may be mutually exclusive (i.e. one or the other will apply at any one time, but not both). Listing this information effectively on the outage issues log defines the problem to be assessed.

J.22 This process is repeated for each of the WRZs within the region.

J.23 A Monte Carlo model has been constructed in @Risk to combine the estimates of frequency, duration and magnitude for each of the events to determine the overall distribution of legitimate outage. The outage model sets out a series of spreadsheets in a way that is auditable and easily combined to calculate this distribution. Each outage component in the model is cross-referenced to the outage issues register so that the origin of the data is clear.

J.24 The Monte Carlo model is run to derive the distribution of legitimate outage and the output is presented in tabular and graphical form. The outage model has established formats for the graphical and tabular output.

J.25 The level of risk for the analysis has been defined as 5% over the relevant planning period, which is the overall planning risk considered to best reflect the level of risk the business should accept. In contrast to headroom, there has been no adjustment to the level of risk with time.

Principles of the approach

J.26 This methodology requires the uncertainty surrounding the frequency, magnitude and duration of each outage issue to be defined as a probability distribution. All the issues are then combined using Monte Carlo simulation to give an overall outage uncertainty.

J.27 First of all, each outage issue is broken down into three probability distributions. This might take the form of a triangular distribution (or a fixed value) for frequency, a triangular or discrete distribution for magnitude, and a triangular distribution for duration that best fits the available data. An example is given in Figure J-2. The basis for defining these probability distributions is described in subsequent sections.

J.28 Outage events are summed for each month to determine the overall outage uncertainty for the WRZ. This is shown in Figure J-3.

J.29 An inherent assumption in this methodology is that the outage issues are independent. Generally this is the case, but some can be inter-related. Two issues may affect the same source but only result in one outage. In this instance it is necessary to modify the Monte Carlo analysis to allow for these inter-relationships.

J.30 Various software packages are available for performing Monte Carlo analysis. This methodology has been developed using @RISK, which operates within a spreadsheet environment. When a Monte Carlo simulation is run, it randomly selects numbers from each probability distribution assigned to each outage component. Each set of random numbers effectively simulates a single 'what-if' scenario for the spreadsheet model. As the simulation runs, the model is recalculated for each scenario and the results are presented as a series of forecast charts for outage uncertainty. The simulation stops according to criteria set by the user, which is normally a number of scenarios or trials. The number of trials must be set to give an acceptable mean standard error for the simulation results, whilst controlling the processing time to workable limits. A typical number of trials might be 1,000 to 5,000. If the mean standard error is too high, then it will be impossible to obtain repeatable results for the same set of data. We use 4,000 iterations determined by sensitivity analysis.

Figure J-2: Example of outage probability distributions

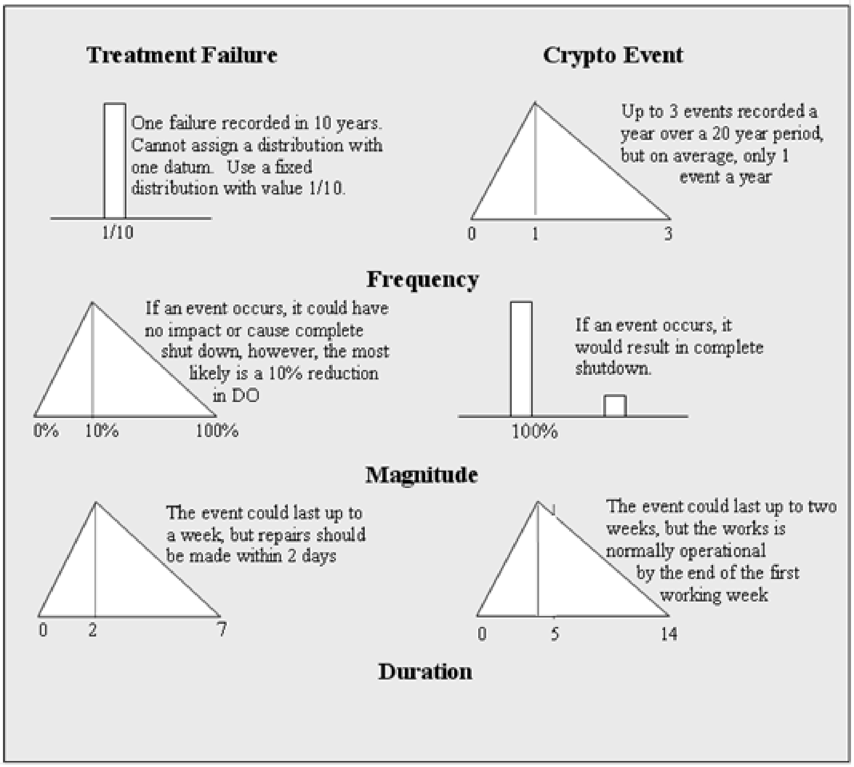
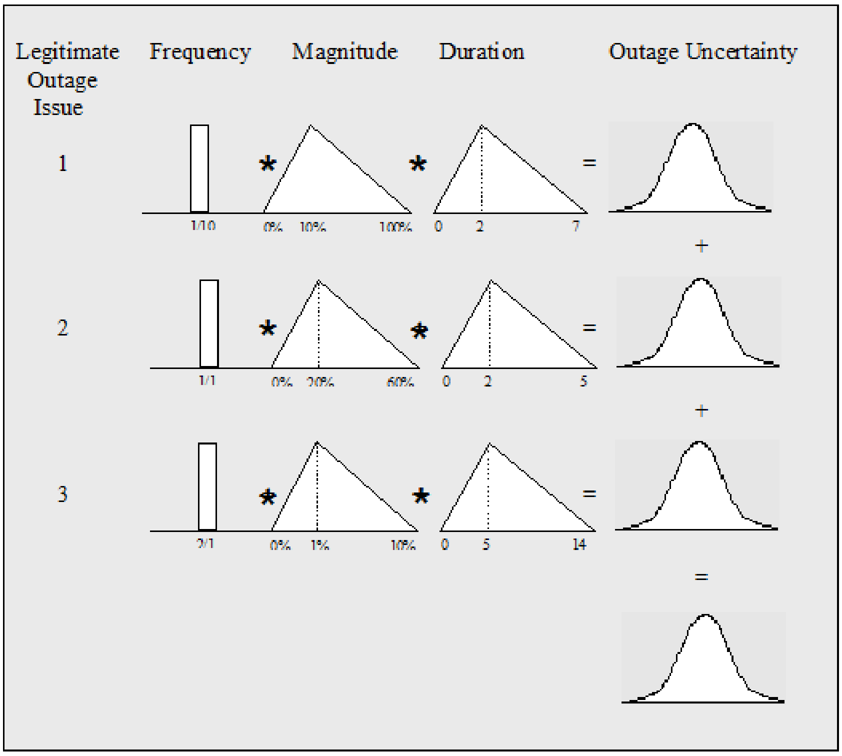


Figure J-3: Summing outage issues



D. Thames Water's approach to outage allowance

Outage records

J.31 A schedule of potential outages is provided by Operations for each WRZ for each fiscal year. The details of each outage event are recorded in terms of the nature of the event, when it occurred, for how long and the impact on DO. Table J-1 is an example of outage records available and includes:

- source name
- outage issue
- source DO and impact on DO
- start and end date of the outage issue

J.32 There may be a total loss or a partial loss of DO depending on the nature of the outage; e.g. the loss of a borehole pump may mean just a partial reduction as water can be put into supply from other boreholes on site. The impact on DO is assessed from the nature of the outage event.

J.33 With regard to potential outages at the London major water treatment works (WTWs) a record is made in just the same way, however, the impact of these WTWs outages on London's DO is assessed by modelling the reduced output capabilities using the Water Resources Management System (WARMS2) and noting the impact (if any) on the DO.

J.34 Each record of potential outages is assessed to see if this is a legitimate outage that can be included in outage allowance. These are assessed to see that they last longer than 24 hours and if during a drought event mitigation measures could be taken to ensure availability of water going into supply. If for example, engineering work is planned to be undertaken, could this be postponed until a more suitable time?

J.35 The actual outage is calculated from the loss in DO weighted by the duration of the outage. For the Broadmead example in Table J-1 this is 6.8 * 92 / 365 = 1.71 Ml/d.

Table J-1: Recording outages for London 2016/2017

Lee Valley WRZ	Reason for outage	Outage start date	Outage end date	Total no. of days outage	Output capacity reduced to Ml/d	Deployable output (Ml/d)	Actual outage (Ml/d)
Barrow Hill	Operational issues	01/04/16	31/03/17	365	0	1.72	1.72
Broadmead	Pump failure	01/06/16	31/08/16	92	0	6.80	1.71
ELReD (East Ham)	Treatment issues	13/05/16	15/05/16	3	0	13.20	0.11
S Box and Old Ford	Damaged raw water transfer main	01/04/16	31/03/17	365	0	11.47	11.47
Turnford	Pump failure	01/04/16	09/02/17	315	0	11.30	9.75
Turnford	Pump failure	10/02/17	31/03/17	50	5.8	11.30	0.75
Waltham Abbey	Low groundwater levels	01/04/16	31/03/17	365	0	6.00	6.00
Wanstead	Pump failure	02/01/17	08/01/17	7	0	5.38	0.10
Wanstead	Treatment issues	21/11/16	30/11/16	10	0	5.38	0.15
						Total	**31.76**

Modelling outage allowance

J.36 Once a probability distribution for each of the risks around magnitude, duration and frequency has been decided, then the outage model requires the probability distribution parameters to be input to the model for each outage issue identified.

J.37 For each outage accepted as legitimate the input to the model includes:

- A unique outage issue reference number
- If event frequency is included in the analysis, the number of events per year and the distribution type
- Minimum, most likely and maximum magnitude of the outage issue, including distribution type

- Minimum, most likely and maximum duration of the outage issue, including distribution type if appropriate
- Any specific comments relating to the outage issue

J.38 The following examples have been compiled to assist the understanding of how an outage allowance is calculated using the outage model. To simplify matters single values have been used for magnitude, frequency and duration although often these would be the parameters of the assigned probability distributions e.g. min, max and most likely of a triangular distribution.

J.39 **Example 1:** Assume that a small source has been out of supply due to a treatment problem and it is the first time this has happened in ten years (NYRS).

- The **magnitude** (m) is the loss of DO which is its total DO of 5 Ml/d and a fixed distribution is used as there has been only one incident by which to define magnitude
- The **duration** (d) of the event is 15 days and impacts on one month of the year, which has to be reflected in the frequency. Only one figure is available from the information sourced for event frequency, so it is not plausible to apply any distributions. Therefore a single value is used in event frequency
- The **frequency** (f) has to reflect how the probabilities are calculated for each month in the model and is not simply the number of events divided by the period of record. This now has to be multiplied by the number of months affected (NM), as determined by the length of the outage event. It is also subjective given the nature of the risks posed and steps taken to mitigate such events. However, for this source the frequency applied is 1 year multiplied by the 1 month divided by the number of years of record:

  *(N*NM) / NYRS = 1*1/10 = 0.1*

J.40 Thus the probability of the event for that month of the year is 0.10

J.41 And hence the outage risk assigned (magnitude*frequency*duration)/no. days affected in the month is (5 * 0.1 * 15) / 31 = 0.24 Ml/d in the month that it occurred and zero for all other months.

J.42 If however, the event were to last for more than one month the calculation is the same but needs to account for those months where the outage has occurred. If say the event lasts all year then;

- The **duration** (d) of the event is 365 days thus impacts on each month of the year, so this also has to be reflected in the frequency. Only one figure is available from the information sourced for event frequency, so it is not plausible to apply any distributions. Therefore a single value is used in event frequency
- The **frequency** (f) has to reflect how the probabilities are calculated for each month in the model and is not simply the number of events divided by the period of record. This now has to be multiplied by the number of month's affected (NM), as determined by the length of the outage event. It is also subjective given the nature of the risks posed and steps taken to mitigate such events. However, for this source the frequency applied is one year multiplied by the 12 months divided by the number of years of record:

  *(N*NM) / NYRS = 1*12/10 = 1.2*

J.43 Thus the probability in any month of the year is 1.2/12 (number of months affected) = 0.10

J.44 Hence the outage risk in each month is (5 * 0.1 * 31) / 31 = 0.5 Ml/d

J.45 The inputs can be far more complicated however, depending on the nature of the events and frequency is particularly open to interpretation.

J.46 The duration and timing of an event within the year is also important as outage allowance is based on outages that occur in the critical month.

J.47 **Example 2:** If there were three sources that experienced outages each of 15 days duration but in different months and had been assigned different frequencies to reflect the ten year record of such events previously then the outage risk would be as in Table J-2. Note if the duration is less than a complete month the m*f*d is divided by the number of days in the month to give a value in Ml/d for the month. The actual outage during the period is shown in, with a total of 1.24 Ml/d.

Table J-2: Outage for the critical month example 2

	Magnitude (Ml/d)	Frequency	Duration days	Outage risk (Ml/d)			Actual outage
				Jan	Feb	Mar	
Outage 1	5	0.3	15	0.73			0.21
Outage 2	10	0.2	15		1.07		0.41
Outage 3	15	0.1	15			0.73	0.62
Total				**0.73**	**1.07**	**0.73**	**1.24**

J.48 Thus February would be the critical month with the largest outage to which a risk of 5% would be applied giving an outage allowance of around 1 Ml/d. The other two outages would therefore not feature as part of the outage allowance thus only 42% of the outage risk occurs in the critical month.

J.49 **Example 3:** If however, Outage 1 actually occurred in February and not January the story would be different as shown in Table J-3.

Table J-3: Outage for the critical month example 3

	Magnitude (Ml/d)	Frequency	Duration days	Outage risk (Ml/d)			Actual outage
				Jan	Feb	Mar	
Outage 1	5	0.3	15		0.80		0.21
Outage 2	10	0.2	15		1.07		0.41
Outage 3	15	0.1	15			0.73	0.62
Total				**0.00**	**1.87**	**0.73**	**1.24**

J.50 Here the outage risk is increased to 1.87 Ml/d from which the outage allowance is determined with a 5% risk and February remains the critical month. The outage in March would not contribute to the outage risk and thus only 72% of the outage risk experienced in that year occurs in the critical month.

J.51 **Example 4:** If however, Outage 1 actually occurred in March the story would be different again as shown in Table J-4.

Table J-4: Outage for the critical month example 4

	Magnitude (Ml/d)	Frequency	Duration days	Outage risk (Ml/d)			Actual outage
				Jan	Feb	Mar	
Outage 1	5	0.3	15			0.73	0.21
Outage 2	10	0.2	15		1.07		0.41
Outage 3	15	0.1	15			0.73	0.62
Total				**0.00**	**1.07**	**1.46**	**1.24**

J.52 Here the outage risk becomes 1.46 Ml/d from which the outage allowance is determined with a 5% risk however, March becomes the critical month. Hence only 58% of the outage risk experienced in that year occurs in the critical month.

J.53 Thus the timing of any outages are critical in determining outage allowance and whilst just three months are shown here the same would apply throughout the year. The examples also show that actual outage can be larger or smaller than outage risk depending on the timing of the outage events in any year.

Interpretation of risk

Impact of record length on outage allowance

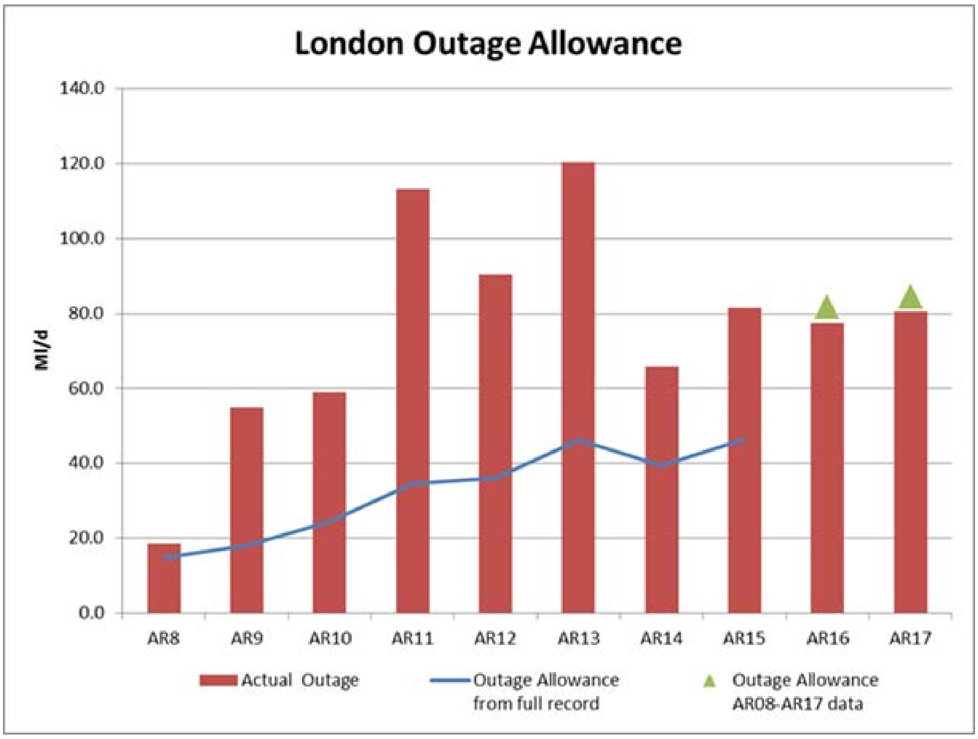
J.54 From an assessment of the historic outage record we noted that the Thames Water outage allowance was biased by the earlier record from which it had been calculated; an important element in the calculation of the frequency of events. On reviewing the results for the reporting period 2015/16 it shows that using the more recent record gives a better reflection of recent events and the level of actual outage. Thus on comparing the London results (seen in Table J-5) the outage allowance is greater using the more recent AR08 to AR16 data compared to that using the AR02 to AR16 data, the full record. It is also noted that the outage allowance is now more in line with the actual outage. Figure J-4 shows for London the difference between actual outage and outage allowance.

J.55 Following detailed discussions with the Environment Agency and after reviewing our approach and datasets against that of other water companies we concluded that our outage allowance would be more representative of the current day if we were to reduce the length of historic data used in the assessment. Therefore, in reporting our outage allowance for the Annual Return, from 2016 we started to use the more recent record of outages in our reporting, the data for which started from the period 2007/08.

Table J-5: Outage allowance using different length of records

Outage allowance – (Ml/d)	n=15 years AR02 to AR16	n=9 years AR08 to AR16
Outage allowance - data and frequency for specified period n (Ml/d)	51.2	81.7

Figure J-4: Annual review 2017 outage allowance and actual outage



J.56 In addition, where measures have been taken to mitigate the risk of an outage being repeated this is also taken into consideration. For example, where a site has been re-commissioned following engineering work, the outages previously experienced that drove the need for the remedial work are likely to be removed. Indeed if the risk is deemed remote then professional judgement may be used to assign frequency.

J.57 Furthermore there are a number of outages that have impacted on reservoir storage in recent years, which if viewed in isolation would be seen as a frequent occurrence. If however, viewed over a longer period, say over 30 years, rather than the ten of the formal record, these events are fairly rare. Thus it was felt appropriate to limit the impact on outage of this type of event. If this decision was reversed and only the ten year record were considered then the outage would increase.

Base year outage allowance

J.58 Each year as part of reporting for the Annual Review we review our outage allowance and examine any changes to the information on which the outage allowance is assessed. The methodology used for evaluating outage is compatible with the latest UKWIR methodology used for assessing headroom uncertainty (see Appendix V: Risk and uncertainty). The method provides an assessment of the uncertainty surrounding outage within the supply demand balance, with a range of probabilities and confidence limits.

J.59 Table J-6 summarises the outage allowances used for strategic planning purposes by WRZ for the years 2015/16 (AR16) and 2016/17 (AR17). The AR17 outage allowance will be used in this plan.

Table J-6: Outage allowance by WRZ

WRZ	Outage (Ml/d)		
	WRMP14	Dry year annual average (DYAA)-AR16	DYAA-AR17
London	46.27	81.72	84.55
Swindon and Oxfordshire (SWOX)	14.88	16.73	17.50
Kennet Valley	1.85	2.80	2.59
Henley	1.05	0.44	0.40
Slough, Wycombe and Aylesbury (SWA)	12.53	10.75	9.99
Guildford	0.81	1.25	1.33
Total*	77.39	113.69	116.36

**The change in methodology since WRMP14 described in Para J.52 and J.53 explains the reason for the step change (increase) in outage allowance for WRMP19.*

J.60 Table J-6 also lists the outage allowance by WRZ as included in the Water Resources Management Plan 2014 (WRMP14) and it can be seen that since our last plan in 2014 the allowances have increased in some WRZs and reduced in others. Given that we are reporting actual outage on an annual basis in the Annual Review it was felt appropriate to simultaneously update the view of the outage allowance in the WRMP, as clearly events in any year influence the risk perceived. For the WRMP we take a snapshot in time as to the outage allowance and assume this applies over the planning period. The outage allowance for draft WRMP19 is as reported at AR17 in Table J-6.

J.61 The outage allowance is different to the actual outage which will occur in any one particular reporting year. There is no standard industry methodology for calculating actual outage and we have derived a means by which it can be measured, as summarised in the equation below.

J.62 Actual outage is the temporary loss of DO in the reporting year weighted by the duration of the loss (in days).

Example: a source DO loss of 10 Ml/d lasts 45 days thus

*Weighted outage = 10 * (45 / 365) = 1.23 Ml/d*

J.63 Each weighted outage is then summed over the reporting year to give a total actual outage for the WRZ, as reported in the Annual Review. This is fundamentally different to the outage allowance in the WRMP, the calculation of which is based on risk and therefore reflects the probability of this event happening again in the future.

J.64 Details of the individual sites which comprise the actual outages are reported in the Annual Review to the Environment Agency together with the outage allowance and are not repeated again here. The information allows actual outage to be compared with the outage allowance, i.e. the figure used for planning purposes in the WRMP. Information has been collated for the period from April 2016 to the end of March 2017 and an assessment of the actual outage for 2016/17 has been made together with an update of the outage allowance. This information has been used to update the baseline outage allowance for each WRZ as reported in Table J-6.

J.65 The level of risk of an outage occurring depends at least in part on the length of record available over which to assess the risk; currently we have ten years of records from 2007/08. This is a relatively short period of record and it is inevitable that not all sources of outages will have been experienced in this period. As our documented experience of different causes of outage increases it follows that our outage allowances can be expected to increase. This is despite the delivery of investment to address outages experienced earlier in the period of record.

J.66 The risk of outage for each month of the year is calculated by sampling the probability density functions (pdfs) of magnitude, frequency of occurrence and duration for each month of the year and multiplying them together. Thus the annual outage allowance is the highest monthly value in the year for the elected risk of 5% as derived from the sample statistics.

J.67 The outage allowance used for planning is now slightly higher than the actual outages which have occurred in the last couple of years. The difference between the outage allowance and the actual outage that has occurred over the period 2007/08 to 2016/17 across all WRZs is shown in Table J-7 and Figure J-4. Whilst there are changes in outages year on year the total actual outage for the Thames Water area as a whole in 2016/17 is 92.2 Ml/d. An update of the outage allowance assessment (at 5%) is also presented, which shows an increase in outage allowance primarily as a result of length of record now being used to calculate outage allowance. The outage allowance in 2016/17 for the Thames Water area is 116.4 Ml/d. A summary of the changes in outage at WRZ as reported in the Annual Review 2017 is given in Table J-7.

Table J-7: Outage assessment annual review June 2017

Outage Assessments forecast for Inclusion in AR16 (Ml/d) -- Outage Allowance @ 5% Risk							
Resource Zone	SWOX	KV	HEN	SWA	GUI	London	Total
Outage Allowance dWRMP08	10.61	1.60	1.07	3.00	0.38	11.53	28.22
Outage Allowance WRMP09/JR08	10.62	1.68	1.05	3.06	0.38	14.76	31.57
Outage Allowance Update 2009	13.33	2.18	1.06	9.53	0.64	17.97	44.70
Outage Allowance JR10	13.14	1.79	1.06	9.71	0.65	24.47	50.82
Outage Allowance JR11	15.28	1.78	1.06	10.84	0.62	34.57	64.15
Outage Allowance AR12	15.04	1.77	1.08	11.97	0.78	36.04	66.67
Outage Allowance AR13 (WRMP14)	14.88	1.85	1.05	12.53	0.81	46.27	77.39
Outage Allowance AR14	15.34	2.14	1.04	12.27	0.77	39.32	70.88
Outage Allowance AR15	16.76	2.01	0.93	13.73	0.85	46.44	80.72
Outage Allowance AR16	16.73	2.80	0.44	10.75	1.25	81.72	113.69
2007-8 Actual Outage	4.27	4.50	0.00	0.00	0.00	18.7	27.4
2008-9 Actual Outage	11.92	4.55	0.61	10.65	1.13	54.8	83.7
2009-10 Actual Outage	4.86	0.02	0.00	5.52	0.00	58.8	69.2
2010-11 Actual Outage	11.59	0.00	0.00	10.97	0.00	113.3	135.9
2011-12 Actual Outage	2.73	0.00	0.01	9.95	1.06	90.4	104.1
2012-13 Actual Outage	3.83	0.02	0.00	18.30	2.08	120.3	144.5
2013-14 Actual Outage	4.18	1.81	0.00	13.84	0.81	65.8	86.4
2014-15 Actual Outage	7.63	1.73	0.00	11.12	2.98	81.5	105.0
2015-16 Actual Outage	3.77	0.00	0.05	1.68	4.14	77.6	87.2
2016-17 Actual Outage	4.72	0.01	0.00	4.84	2.07	80.5	92.2
Outage Allowance AR17	17.50	2.59	0.40	9.99	1.33	84.55	116.4

J.68 As we collect more data on outage events our understanding of the risk improves and simultaneously so does our understanding of the actions that can be taken to reduce the risk. The improved records on outage and the period of time over which these data have been collected means that the total outage allowance in the draft WRMP19 has increased. We anticipate that the outage allowance will level out with time although there will inevitably be some variance as this is the nature with such “unplanned events”. We consider that the current level of outage allowance is reasonable given the complex nature of London’s water resources.

J.69 In addition progress, has been made on restoring many of the London sources of long duration that are driving the outage values for the WRZ. An update on progress is shown in

Table J-8. Some sources are also subject to investigation to establish the cause. Table J-9 gives an update on progress for Thames Valley sources.

J.70 We are however, pro-actively looking to reduce outage events and the length of time sites are out of service. This may eventually lead to a reduction in the number of events being recorded in the database with a knock-on to the reported outage allowance.

Table J-8: London sources with outage of lengthy duration in Annual Return

Source	Reason for outage	Comments
Queen Mary and Mother Reservoirs	Pump outages and restrictions	Pumps repaired.
Staines North Reservoir	Maintenance	Essential work completed on the inlet/outlet tower.
Barrow Hill	Operational issues	New raw water main being installed.
ELRED	Borehole availability and treatment issues	Woodgrange borehole unavailable due to poor water quality therefore DO reduced. Raw water quality and WTW process losses restrict treated water output therefore source deployable output (SDO) reduced.
New River Head	Sand ingress to borehole	Ground condition investigations being planned. SDO reduced to 0 Ml/d for AR17 therefore no longer included as outage.
Brixton	Treatment process issues	WTW in the process of being recommissioned.
Epsom (Railway Borehole)	Turbidity	Railway Borehole available and pumped to WTW for supply SDO reduced to reflect restrictions.
Nonsuch	Turbidity	Electrical supply issues, which have now been resolved, also restricted output for part of AR17 due to turbidity.
Crayford	Contact tank capability	Work completed to restore DO.

Table J-9: Thames Valley sources with outage of lengthy duration in Annual Return

Source	Reason for outage	Comments
Dancers End	Site refurbishment	WTW now being upgraded with new filtration process being installed (June 2017).
Witheridge Hill	Turbidity/operational issues	Return to supply constrained by ability to run to waste for water quality sampling.