Final Water Resources Management Plan 2024

Appendix 5Ab – Outage

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Portsmouth Water WRMP24
Outage Allowance Summary

Project:	Portsmouth Water WRMP24 Outage for WRSE		
Our reference:	100100812	**Your reference:**	239523
Prepared by:	RM	**Date:**	30th May 2023
Approved by:	SB	**Checked by:**	CP
Subject:	Summary approach, assumptions and results		

1 Scope of Work

The key tasks were specified as follows:

- Populate a WRSE outage modelling tool (OMT) template (as delivered for the WRSE outage methodology in September 2020) with outage event data and deployable output data to be provided by you.
- Run the model to determine an initial outage allowance.
- Screen and process your outage events data in the OMT in line with the WRSE outage methodology published September 2020.
- Make an appropriate outage allowance for the new Havant Thicket reservoir, liaising with members of the detailed design team as required.
- Identify options to reduce outage which provide a quantifiable WAFU benefit, to be added to the unconstrained list of supply options for WRSE/WRMP24 appraisal.

2 Approach

Outage event data was obtained from two files:

- Outage_Assessment_PW_01122016 (data up to 2016)
- PRT Outage Register post March 2016_For MM (data post 2016)

This raw data was processed as follows:

1. Compile all data into a single table (post 2016 events)
2. Remove duplicated events
3. Determine event start date and time from date & time restored minus event duration
4. Determine outage event magnitude as “Corrected Deployable Loss” / “Corrected (duration)”
5. Add “planned” as an outage classification, based on the planned/unplanned column

The processed event start/end dates, corrected durations, event magnitudes and event classifications were then copied and pasted into a WRSE outage model template (version 5.3).

2.1 Deployable Output

Deployable output data was added to the WRSE model from the Sourceworks DO_WRMP19 provided by email from Portsmouth Water on 2nd October 2020, and updated with values provided by email from Atkins on 8th March 2023, based on updated modelling between draft and revised WRMP24. We assume that the deployable loss values apply to peak daily deployable output (PDO). Where average annual DO (ADO) or minimum DO (MDO) is less than PDO, we adjust the event magnitudes for DYAA and DYMDO conditions, to reflect the difference.

Where WRMP19 preferred options are specified for delivery before 2030, the benefits of these options have been included in the DO assessment and therefore the outage assessment. The [Source S] drought permit option has a DO benefit of 3.4 Ml/d, compared to the baseline DO of 1.9 Ml/d. Historical outage events have magnitudes no higher than 2.5 Ml/d, so if we increased model DO by 3.4 Ml/d, the distribution magnitude would only increase slightly and remain no higher than 2.5 Ml/d. Instead, we therefore test increasing the (triangular) magnitude distribution parameters in proportion to the increase in DO. This increases outage slightly but by no more than 0.1 Ml/d, so is not material to the results. The final model includes this distribution adjustment for [Source S].

Separate models were created for DYAA, DYCP and DYMDO conditions. DYAA included all events. DYCP excluded planned events, and DYMDO was tested with and without planned events.

2.2 Event Screening for Legitimacy

Event impacts were determined as the product of magnitude and duration, and the highest impact events identified for discussion with Portsmouth Water: all events with an overall impact on supply greater than 100 Ml, roughly equivalent to the top 50% of events by overall Ml impact, were discussed in detail. A conversation with Luke Sibley identified the following:

- [Source B] feed the same water treatment works ([Works A]). Legitimate outage is recorded effectively at [Works A] itself, where events impact DO. Therefore, there is no loss of DO associated with [Source B] events.
    - All events at these works were therefore excluded.

- [Source H] 274 day “other” event was for crypto detection. The source was out of supply, but has now been restored. The failure related to an oil spill originally, source turned off as precaution and then crypto incident.
  - The event remains included in the outage allowance (capped at 90 days – see below)
- [Source K] nitrate: Luke is unsure whether this outage would overlap with headroom.
  - Further discussion with Liz Coulson indicated that nitrate events at [Source K] will be mitigated by a network improvement scheme (see below). [Source L] nitrate excluded.
- [Source Q] 138-day other event for “damage to old well by contractors” - could have been returned more quickly.
  - Event included in ADO and MDO, capped to 90 days. Event excluded from PDO scenario as considered very unlikely to impact supplies under these conditions.
- River Itchen outage is low confidence.
  - See further discussion below: low magnitude, long duration events excluded.
- [Source F] Unit No.1 fault: the works includes 3 filtration units, so losing this one would result in no loss of DO.
  - These events excluded.

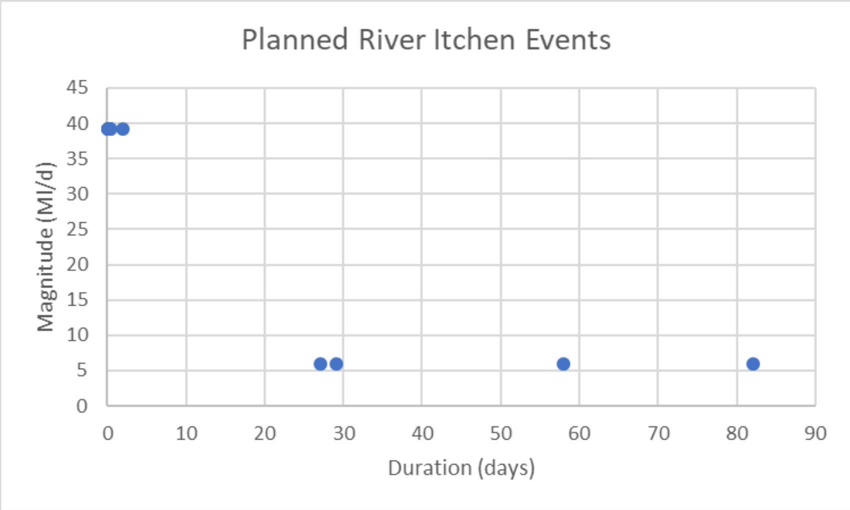
Further discussion with Liz Coulson identified that nitrate outage at [Source K] will be mitigated by the end of AMP7 as a result of a scheme to supply [Source K] demand centres from [Reservoir A], which is supplied by [Source A], [Source C], [Source F] and [Source H]. Reviewing outage at these sources, there is significant difference between total PDO and total ADO (28 Ml/d), so assuming the AMP7 scheme connects up these sources fully, for a nitrate event at [Source K] to impact group ADO, [Source A] would need to fail simultaneously, as well as one of the other three sources. This has never happened historically, so we assume that the work at [Reservoir A] will remove the nitrate risk at [Source K], without increasing any risk elsewhere.

We were also provided with an AECOM technical note on outage assessment dated 17th May 2019. This specified the removal of all events including faulty hatch alarms and cryptosporidium events at [Source Q] and [Source R], which are no longer a risk after UV treatment has been installed. Outage events were excluded from our analysis accordingly. [Source U] had DO written down to zero at WRMP19, so all historical events recorded at the source are also excluded from the analysis.

The outage model was run for each planning scenario to identify baseline outage. As initial inputs, frequency was fixed, duration specified as lognormal distributions, and magnitude as triangular distributions.

Given the uncertainty associated with some long-duration events, we also tested a scenario where all events were capped at 90 days. Capping at 90 days reduced DYAA outage by 2 Ml/d, and was considered the most appropriate assumption for dry year conditions, and to align with the WRMP guidelines, which state that failures longer than 90 days should result in source DO being written down.

We then reviewed the results broken down by source and event category. This indicated considerable impact of planned outage at River Itchen, whose actual impacts on DO are known with low confidence. Further review of planned River Itchen events showed a significant correlation between magnitude and duration. High magnitude events (39 Ml/d) occurred with only very short duration (< 2 days), whilst longer duration events were of uniform magnitude (5.9 Ml/d).



These longer events were all associated with replacement or regeneration of the rapid gravity filters. We assume the loss of output for these events is relative to the PDO of 38.7 Ml/d, compared to the ADO of 20.1 Ml/d. Therefore, these longer events would not impact DYAA or DYMDO scenario DO, and we exclude them from outage allowance for these scenarios. Having identified this issue at the River Itchen, we went on to set the DYAA duration = 0 days for all events with no loss of output under DYAA conditions for all sources, to avoid skewing duration distributions in the same way as for River Itchen planned outage. This reduces DYAA outage by 2.5 Ml/d.

For DYCP conditions, the issue of negative correlation between magnitude and duration is only material for System failure events at [Works A] and River Itchen. To avoid artificially increasing the outage allowance for these events, we separate events into long and short duration, and specify probability distributions for both separately.

We reviewed the choice of distribution for all site/hazard combinations with a contribution to outage >0.2 Ml/d. The original choices were appropriate in most cases, but triangular duration distributions better fitted the observed data for planned outage at [Works A], [Source P], [Source H] and [Source R], as well as for pollution at River Itchen, and Other events at [Source H]. These distributions were updated and the model re-run accordingly. The choice of distributions is important, as shown below:

DYAA	**MC P70 Ml/d**	**MC P80 Ml/d**	**MC P90 Ml/d**	**MC P95 Ml/d**
Impact of varying duration distribution types between triangular and lognormal	1.9	3.7	4.1	3.6

For the DYCP scenario, we identified that a single 21-day chlorine failure event at [Source P] was a significant outlier and adjusted this down to 7 days. We also found a significant Telemetry failure event at [Source N], which is considered very unlikely to impact PDO under DYCP conditions, and as such, this event is screened out from the allowance.

DYCP Scenario	**P70 Ml/d**	**P80 Ml/d**	**P90 Ml/d**	**P95 Ml/d**
Single set of System distributions at all sites	3.5	4.1	5.1	6.3
System events at [Works A] and Itchen separated into long/short duration.	3.6	4.0	4.7	5.3

Lastly, we tested the number of Monte Carlo iterations required to avoid significant changes between model runs, and found a value of 5,000 iterations to be acceptably high for DYAA conditions, with 2,000 acceptable for the DYCP scenario.

2.3 Havant Thicket

A new raw water storage reservoir is under construction at Havant Thicket, due to supply [Works A] WTW from 2029-30. This will increase deployable output by the values shown in Table 2.1 below.

Table 2.1: Havant Thicket Reservoir modelled deployable output

Scenario	Deployable Output (Ml/d)
1 in 100 average	12.3
1 in 100 peak	9.4
1 in 200 average	17.8
1 in 200 peak	14.6
1 in 500 average	20
1 in 500 minimum	20
1 in 500 peak	18.1

The introduction of a large new raw water reservoir to Portsmouth Water's supply system has the potential to change the duration, magnitude or likelihood of outage events of every category at [Works A] WTW. To evaluate these potential changes, we contacted the Principal Engineer responsible for reservoir design, Jim Leat. His response is as follows:

> *In terms of outage allowances all new works are standard water infrastructure assets and all planned maintenance can be programmed when the reservoir and DAF plant are not in operation.*
>
> *There will be periods each year when the reservoir is being neither filled nor used, and hence maintenance of the new pumps at [Source B2] (reservoir fill pumps and [Works A] booster transfer pumps) could be undertaken during these offline periods. Similarly, maintenance of the DAF plant should be achievable when reservoir water is not in use. Adding GAC into [Works A] will mean periodic removal for regeneration but this would be done on a cell by cell basis during periods of normal demand and the design would allow for up to 2 cells to be out of service (one for regeneration and one for backwashing) at a time, to avoid any site outage.*
>
> *Hence although the Havant Thicket reservoir is adding new infrastructure, there should not be a need to increase the planned or unplanned outage allowances already included within Portsmouth Water's WRMP, as a percentage of water into supply, on the basis that the assets can be maintained during periods when the reservoir is not in operation. This assumes however that the existing outage allowances for [Source B2] and [Works A] WTW are adequate, which we have not seen.*
>
> *The DAF plant at [Works A] has been specifically designed to mitigate the risk of algal bloom from blocking the rapid gravity filters. Hence any residual outage risk at [Works A] due to algae within the Havant Thicket reservoir is considered to be very low.*

On this basis, we have assumed Havant Thicket will not materially change the duration or likelihood of outage at [Works A] and have simply upscaled the magnitude of distributions for all outage types in proportion to the increase in ADO and PDO for the relevant scenario. The reservoir is due to come online in

2029 and therefore we run outage scenarios with and without Havant Thicket included, which can be used to specify outage before and after 2029.

2.4 MDO outage

Dry year minimum deployable output (MDO) outage is calculated in the same way as for DYCP, but with a 30-day period specified, which somewhat alters the likelihood of events occurring during that period. A decision to be made for the DYMDO scenario is whether or not planned events should be included. Whilst most companies avoid carrying out planned maintenance during periods of peak summer demand, avoiding MDO periods is less straightforward and it is not clear whether this would be a valid assumption for Portsmouth Water. We therefore tested scenarios for DYMDO including/excluding planned outage. The results are tabulated below, which show that whether or not planned outage is included impacts the allowance by c.1 Ml/d.

		MDO			
Scenario	**Havant Thicket included?**	**MC P70 Ml/d**	**MC P80 Ml/d**	**MC P90 Ml/d**	**MC P95 Ml/d**
Baseline MDO excluding planned outage	No	3.1	3.9	5.0	6.0
Baseline MDO including planned outage	No	3.8	4.5	5.6	6.5

2.5 Length of Data Record

At the internal outage audit carried out on 4th January 2021, a query was raised over the significant change in the number of events recorded annually in the historical record.

Year	Number of Events
2007	**10**
2008	**13**
2009	**48**
2010	**40**
2011	**116**
2012	**90**
2013	**637**
2014	**789**
2015	**734**
2016	**1052**
2017	**1097**
2018	**1104**
2019	**1206**
2020	**1072**

There is a risk that by using data across the full available dataset, we could artificially decrease the frequency of events of certain types at certain sites. We therefore test three datasets for comparison: 2007 to

2020; 2013 to 2020; and 2016 to 2020. The results are tabulated below, showing some impact on outage allowance under all percentiles.

Dataset		2007 to 2020 (full dataset)	April 2013 to Oct 2020	Jan 2016 to Oct 2020
	MC P70 Ml/d	4.4	4.7	5
	MC P80 Ml/d	5.2	5.4	6.2
	MC P90 Ml/d	7.2	6.7	8.9
ADO	MC P95 Ml/d	10.1	8.7	11.8
	MC P70 Ml/d	3.6	5	6.4
	MC P80 Ml/d	4	5.5	7.1
	MC P90 Ml/d	4.7	6.4	8.3
PDO	MC P95 Ml/d	5.3	7.3	9.5
	MC P70 Ml/d	2.9	3.5	4.3
	MC P80 Ml/d	3.2	4	4.9
	MC P90 Ml/d	3.8	4.6	5.7
MDO	MC P95 Ml/d	4.3	5.2	6.4

The general trend of increasing outage as the record length is reduced to more recent years is mainly a result of changes in the frequency distribution: if the full record is used, some event site/hazard combinations have many events recorded recently, but only one or two earlier in the record. Therefore, specifying the full record has the effect of decreasing apparent frequency of event occurrence. We consider the more recent data to be more representative of true frequency: Portsmouth Water recognise that outage event recording has improved over time.

Balancing data quality with capturing a sufficient period of data, we recommend using the results based on the outage data record from 2013 to 2020.

3 Scenario Testing

Having established baseline values for outage under all three planning scenarios, we then considered uncertainties and the potential for supply-side WRMP options to reduce outage and therefore benefit the supply demand balance. Further to the data processing described in Section 2, the most significant contributors to the baseline outage allowance are as follows:

- Planned outage at [Source P]
- Planned outage at [Source R]

We tested the individual contributions of planned outage at these two sites by excluding planned events at each site in turn, re-running the model and comparing the outage results to baseline. The results are tabulated below.

	ADO benefits v baseline			
Scenario	MC P70 Ml/d	MC P80 Ml/d	MC P90 Ml/d	MC P95 Ml/d
Excluding planned outage at [Source P]	0.57	0.64	0.65	0.45

	ADO benefits v baseline			
Excluding planned outage at [Source R]	0.43	0.42	0.53	0.19

The planned outage at [Source R] is driven mainly by installation and clearance pumping of a new borehole between 2007 and 2013. Portsmouth Water confirm that new borehole drilling/clearance pumping might result in loss of source output in a dry year, at [Source R] or any other source. There would be insufficient lead-in time to low groundwater levels to avoid this type of event in a dry year. Therefore, we continue to include these events in the DYAA scenario.

Planned outage at [Source P] is driven by several different events, including upgrades to station controls and well pumps, chlorination upgrade, membrane plant commissioning, and repairs to surge vessel. Portsmouth Water believe that the majority of these could not easily be avoided in a dry year. Therefore, we continue to include these in the DYAA scenario outage.

4 Choice of Outage Percentile

4.1 WRMP19 Outage

The WRMP19 results for outage were as follows for DYAA:

Company Outage Allowance by Probability	Chlorine	Cryptosporidium	Pollution	Power	System	Turbidity	Total	% of DO
50%	2.45	0.05	0.95	0.26	5.77	0.90	10.58	3.96%
55%	2.58	0.05	0.98	0.26	6.06	0.95	10.86	4.07%
60%	2.71	0.06	1.02	0.27	6.38	0.99	11.18	4.19%
65%	2.85	0.06	1.05	0.28	6.70	1.03	11.49	4.31%
70%	3.01	0.06	1.09	0.28	7.03	1.09	11.85	4.44%
75%	3.18	0.06	1.13	0.29	7.37	1.15	12.24	4.58%
80%	3.36	0.06	1.18	0.30	7.75	1.21	12.64	4.73%
85%	3.59	0.07	1.23	0.31	8.24	1.28	13.11	4.91%
90%	3.85	0.07	1.29	0.32	8.85	1.36	13.72	5.14%
95%	4.26	0.07	1.38	0.34	9.69	1.48	14.64	5.49%

And for DYCP:

Company Outage Allowance by Probability	Chlorine	Cryptosporidium	Pollution	Power	System	Turbidity	Total	% of DO
50%	1.96	0.06	0.23	0.30	7.17	0.62	10.47	3.04%
55%	2.06	0.07	0.23	0.31	7.50	0.65	10.83	3.14%
60%	2.18	0.07	0.24	0.32	7.89	0.69	11.23	3.26%
65%	2.30	0.07	0.25	0.32	8.26	0.72	11.60	3.37%

Company Outage Allowance by Probability	Chlorine	Cryptosporidium	Pollution	Power	System	Turbidity	Total	% of DO
70%	2.41	0.07	0.25	0.33	8.65	0.76	12.04	3.49%
75%	2.54	0.07	0.26	0.34	9.06	0.80	12.45	3.61%
80%	2.69	0.08	0.27	0.35	9.59	0.84	12.94	3.75%
85%	2.86	0.08	0.27	0.36	10.19	0.89	13.51	3.92%
90%	3.06	0.08	0.29	0.38	10.89	0.95	14.24	4.13%
95%	3.35	0.09	0.30	0.40	11.97	1.03	15.37	4.46%

The significantly higher outage results at WRMP19 appear to be due to:

a) Higher deployable output values specified for DYCP, particularly at [Works A] (108 Ml/d at WRMP19 v 39 Ml/d at WRMP24). This value includes a benefit from Havant Thicket, and also appears to be based on a more normal rainfall year.
b) In all models, magnitudes for most event types/sites are fixed at complete loss of DO, rather than using triangular distributions based on the partial outage losses recorded in the historical record (WRMP24). Some magnitudes are adjusted downwards to reflect a lower average partial outage magnitude for certain event types/sites.
c) In all models, duration distributions are based on triangular magnitudes, rather than log-normal.
d) Exclusion of fewer events on grounds of dry year legitimacy at WRMP19.
e) A different data record (2007 to 2016 only, compared to 2013 to 2020 for the updated values determined here).

These differences are a result mainly of applying the WRSE consistent outage methodology for WRMP24.

At WRMP19 an increasing outage profile was specified as follows:

Planning Scenario	2020-21	2022-23	2028-29 onwards
SEAA Outage Ml/d	13.05	13.50	14.64
SEAA Outage %ile	85th	90th	95th
SECP Outage Ml/d	12.50	12.63	15.37
SECP Outage %ile	75th	77th	95th

The justification for the profile is unclear, but may have been to make an allowance for Havant Thicket coming online. For WRMP24, the range in outage between P70 and P95 is somewhat higher than at WRMP19. This is likely a result of specifying lognormal duration distributions rather than triangular, which provide a better fit to the observed outage data.

The decision over outage percentile will depend upon a variety of factors, such as the degree of connectivity within the water resource zone, the ability to respond to simultaneous outage events and appetite for risk.

5 Results

5.1 Assumptions

Outage allowance distributions have been calculated assuming the following:

- The most appropriate data record for determining the outage allowance is from April 2013 to October 2020
- Ml/d loss of output recorded in the outage record is relative to DYCP DO
- Events at [Source B] do not directly impact DO, only those specified at [Works A]
- [Source K] nitrate events will be fully mitigated by the AMP7 scheme to supply [Source K] demand centres from [Reservoir A]
- Cryptosporidium events at [Source Q] and [Source R] are fully mitigated by the new UV plant on those sites
- “Hatch alarm” events are not legitimate outage
- Chlorine failure at [Source P] could be limited to 7 days under DYCP conditions
- Telemetry failure at [Source N] would not impact supplies under DYCP conditions

5.2 Outage Allowance Results

We determine outage allowance distributions for DYAA, DYCP and DYMDO scenarios as follows.

Scenario	Drought conditions	Havant Thicket Included	MC P70 Ml/d	MC P80 Ml/d	MC P90 Ml/d	MC P95 Ml/d
DYAA	1 in 200	Excluded	4.5	5.2	6.6	8.4
	1 in 200	Included	4.8	5.5	6.8	8.7
	1 in 500	Excluded	4.4	5.0	6.3	7.8
	1 in 500	Included	4.8	5.5	6.6	8.0
DYCP	1 in 200	Excluded	5.3	5.7	6.6	7.5
	1 in 200	Included	5.4	6.0	6.9	7.7
	1 in 500	Excluded	5.1	5.7	6.5	7.4
	1 in 500	Included	5.3	5.9	6.8	7.8
DYMDO	1 in 200*	Both	3.5	4	4.6	5.2

*1 in 200 year drought is representative of 1 in 500 year drought for minimum DO conditions.

The P90 DYAA outage values are c.3.5% DYAA DO and P90 DYCP outage values are c.3% of DYCP DO.

Potential options to reduce outage were identified at [Source R] and [Source P], and the potential DO benefits quantified. However, discussion with Portsmouth Water indicated that none of these options could be delivered with sufficient certainty to enable a WRMP24 supply option to be specified.

5.3 Recommendations

In order to improve the outage results for subsequent analysis, we recommend the following:

- Improved recording of outage magnitude and the actual impact on DO. Record either:
  - The volume that could have been put into supply (excluding any reductions due to a lack of demand or non-outage operational decision); or
  - The loss of output AND the benchmark value that loss of output is measured against (both in Ml/d).

- Recording time/date when source could have been returned to supply, which may be notably earlier than when it actually went back into supply.
- Routine checking of data log and compilation spreadsheet against the source data, with records of these checks. Clearly set out the QA process which should be followed, and the evidence to show it has been followed.
- More automation of data logging to minimise the risk of human error. But with careful design of any automation to ensure the data captured is appropriate and sufficient to determine outage against both the Ofwat unplanned PC and for WRMP allowance. And to maintain the inclusion of notes describing the outage which can be very useful for determining legitimacy.

Liaison with other water companies (in WRSE and/or elsewhere) would be recommended to learn from their experiences with automation/data capture and ensure application of best practice.

Portsmouth Water has considered these recommendations and responded to them, as presented in Annex A overleaf.

A. Portsmouth Water Response to Recommendations

Motts Recommendation	Portsmouth Water Reply
Improved recording of outage magnitude and the actual impact on DO. Record either: • The volume that could have been put into supply (excluding any reductions due to a lack of demand or non-outage operational decision); or • The loss of output AND the benchmark value that loss of output is measured against (both in Ml/d).	We do not propose to record capacity lost against the Deployable Output (DO) as that number can change over time which makes managing a consistent data set difficult. At present we record outages against the Peak Week Production Capacity (PWPC) which can be a different value to the DO of a source. Therefore, we propose to record Capacity Lost and Capacity Remaining against the PWPC. These numbers would then allow for offline adjustments to calculate DO outage losses for water resources planning as and when needed. The logging of outages will also account for the volume of water which could be put into supply, not what actually did go into supply (i.e. there may have been a lack of demand or a non-outage operational decision).
Recording time/date when source could have been returned to supply, which may be notably earlier than when it actually went back into supply.	We will consider the practicalities of implementing this recommendation further. Any implementation of this recommendation would need to ensure we are able to provide robust audit trails to justify and evidence the date the site could have been returned to supply.
Routine checking of data log and compilation spreadsheet against the source data, with records of these checks. Clearly set out the QA process which should be followed, and the evidence to show it has been followed.	Since PR19 our current outage records have been recorded against the Unplanned Outage metric method (which is a current performance commitment), which provides detailed guidance and data standards. The data is subject to internal review and external assurance for year end annual reporting. These current data records would be used for future Water Resource Management Plan (WRMP) outage allowances. Whilst we need to continue to report outage to PR19 methodology to assess against of PR19 Performance Commitments, we can confirm that our processes are also aligned to the updated PR24 Unplanned Outage metric, ensuring we can report against both PR19 and PR24 methods ahead of 2025/26
More automation of data logging to minimise the risk of human error. But with careful design of any automation to ensure the data captured is appropriate and sufficient to determine outage against both the Ofwat unplanned PC and for WRMP allowance. And to maintain the inclusion of notes describing the outage which can be very useful for determining legitimacy.	The logging of outages requires a detailed review process to ensure the outage is correctly recorded against the correct outage classification type (i.e. there may be multiple alarms on site during an outage and analysis is needed to determine the root cause of the outage) and to ensure the correct capacity lost volume is recorded. Therefore at present, we plan to maintain outage logging as a manual process.