Draft Water Resources Management Plan 2024

Appendix 5a – 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:**	8 January 2021
Approved by:		**Checked by:**	MC
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 2 October 2020. 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 outage allowance. This is specified by adjusting the DO values specified for Source O, Source C, Source H and Source J. At all these sources historical event magnitudes are close to the DO after allowing for preferred options, so we assume the historical magnitudes are correct, and so the update to DO simply avoids capping magnitude at a lower value.

One other WRMP19 preferred option is specified for delivery before 2030 at Source S: a drought permit option with DO benefit of 8.5 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 8.5 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 Person ‘LS’ 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 is out of supply now, but the aim is to get it back in asap, therefore DO should not be written down. 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: Person ‘LS’ is unsure whether this outage would overlap with headroom.
  - Further discussion with person ‘LC’ indicated that nitrate events at Source K will be mitigated by a network improvement scheme (see below). Source K 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 three filtration units, so losing this one would result in no loss of DO.
- These events excluded.

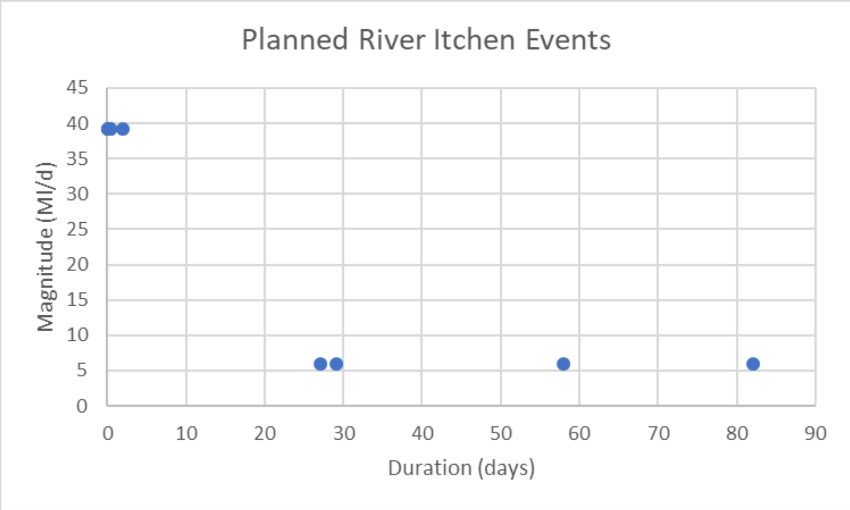
Further discussion with Person ‘LC’ identified that nitrate outage at Source K will be mitigated by the end of AMP7 as a result of a scheme to supply Source K demand centres from the Nelson service reservoir, which is supplied by Source A, Source C, Source F and Source H. Reviewing outage at these sources, 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 Nelson 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 17 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 source 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 (Source A), 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 39.4 Ml/d, compared to the ADO of 20 Ml/d and MDO of 32.4 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 ADO at Works A by 21 Ml/d from 42.9 Ml/d at present, and PDO by 25 Ml/d from 39 Ml/d at present.

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, Person 'JL'. 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 two 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.

The model was re-run including Havant Thicket and the results show an increase of no more than 0.4 Ml/d.

	DYAA				DYCP			
	MC P70 M l/d	MC P80 M l/d	MC P90 M l/d	MC P95 M l/d	MC P70 M l/d	MC P80 M l/d	MC P90 M l/d	MC P95 M l/d
Impact of Including Havant Thicket	0.2	0.2	0.3	0.1	0.2	0.3	0.3	0.4

The impacts of outage events at Havant Thicket on outage allowance is within the uncertainty range for outage, and it may be acceptable not to vary outage in response to including DO from Havant Thicket as a preferred option.

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 1-in-500 year DO outage

The WRSE simulator and investment model will determine an optimised portfolio of options for a 1-in-500 year drought scenario. Portsmouth Water provided DO values for such as event in the Sourceworks DO file. A scenario was run using these values of DO for DYAA planning conditions. No DYCP or DYMDO scenarios were run because 1-in-500 year drought DO appears to be not materially different to 1-in-200 year conditions for these planning scenarios.

Because Portsmouth Water records partial outage, reductions in DO associated with 1-in-500 year drought only affect outage where 1-in-500 year DO is less than the specified loss of output recorded historically. We do not have values for Havant Thicket 1-in-500 year DO, so assume there is no reduction in Works A DO.

The reduction in outage associated with 1-in-500 year DO is as follows:

	ADO			
Percentile	**MC P70 Ml/d**	**MC P80 Ml/d**	**MC P90 Ml/d**	**MC P95 Ml/d**
Reduction in outage under 1 in 500 year DO	0.9	1.1	1.2	0.8

2.6 Length of Data Record

At the internal outage audit carried out on 4 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**

Year	Number of Events
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
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%
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:

1. Higher deployable output values specified for DYCP, particularly at Works A (108 Ml/d at WRMP19 versus 3 Ml/d at WRMP24). This value includes a benefit from Havant Thicket, and also appears to be based on a more normal rainfall year.
2. 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.
3. In all models, duration distributions are based on triangular magnitudes, rather than log-normal.
4. Exclusion of fewer events on grounds of dry year legitimacy at WRMP19.
5. 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. 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 Summary

5.1 Assumptions and Results

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 Nelson service reservoir
- 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
- Havant Thicket reservoir has been excluded from the baseline outage allowance, as it is being specified as a supply option for WRSE, but in any case, its commissioning into supply would increase outage allowance by no more than 0.3 Ml/d.

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

Scenario	MC P70 Ml/d	MC P80 Ml/d	MC P90 Ml/d	MC P95 Ml/d
DYAA	4.7	5.4	6.7	8.7
DYCP	5.0	5.5	6.4	7.3
DYMDO	3.5	4	4.6	5.2

The P90 DYAA outage value is 3.5% of 1 in 200 year DYAA DO and P90 DYCP outage is 2.7% of 1 in 200 year DYCP DO.

We tested the impacts of the new Havant Thicket reservoir, and 1-in-500 year drought DO conditions on outage allowance, and found that neither are material to the outage allowance.

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.

5.2 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.