South West Water Draft Water Resources Management Plan 2024

Outage Assessment Report

South West Water

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Quality information

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1. Introduction

1.1 Background

South West Water (SWW) is required to submit an Outage Allowance (OA) assessment to the Environment Agency (EA) and the Office of Water Services (OFWAT) every five years as part of its draft Water Resources Management Plan (dWRMP) 2024 submission. SWW has included Bournemouth Water (BW) in its WRMP since 2019, making this the second Periodic Review in which BW has been included in SWW plans.

Outage is defined as 'short-term losses of supply and source vulnerability'. 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.

AECOM has calculated a suitable outage allowance for SWW to incorporate within the supply/demand balance for the Water Resources Management Plans (WRMP) in 2024 from the outage data in the financial year 2020-2021. A summary of the results is given in Table 1, and is discussed further in Sections 3 and 4.

Table 1: WRMP24 Outage Allowance for SWW

Water Resource Zone (WRZ)	Assumed Outage (Ml/d)
Colliford	0.23
Roadford	2.11
Wimbleball	3.66
Bournemouth	0.99
SWW Total	6.68

The values for each Water Resource Zone (WRZ) were derived from Monte Carlo simulations to combine probability distributions of outage duration with outage magnitude and frequency for each sourceworks (a combination of sources from which treated water is pumped into supply). These were also split into outage category. Outage allowance values were selected from the combined probability distributions at the 95th percentile (i.e. 95% of occurrences will be equal to or less than the assumed outage value).

A de minimis value of 1 Ml/d has previously been applied to WRZs where few outage events are identified. As this analysis utilised data from the FY20-21, the de minimis value was not applied, although this would only have significantly affected the Colliford WRZ. However, it should be noted that this has allowed the analysis to be influenced more significantly by the environmental conditions endured during the analysis period than would normally be the case.

This analysis was completed in accordance with the Environment Agency's Water Resources Planning Guideline (WRPG) and the supporting guidance in the UKWIR WR27 DO report (2012).

1.2 Current Report Objectives

AECOM has been commissioned to undertake the re-assessment of the OA for SWW's dWRMP2024 (and including BW OA for the second time).

The aim of the outage assessment is to calculate probability distributions of allowable outage for each outage category, sourceworks 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 SWW sourceworks output data and identify all events that may be classified as an outage;
- Categorise events according to cause, magnitude and duration of outage;
- Identify events which may be classified as legitimate outage events;
- Develop suitable probability distributions to represent allowable outage for each sourceworks based on event magnitudes, durations and frequencies observed in the data set; and
- Combine the individual probability distributions into WRZ distributions 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 modelling assumptions and summarises the results of the assessment, and Section 4 provides conclusions and recommendations.

2. Outage assessment methodology

AECOM and SWW have adopted the standard method for the calculation of outage allowance, developed by UKWIR in 1995 and recommended by the Environment Agency (EA) in their WRMP19 methods paper[1]. The full methodology is outlined in UKWIR's 'Outage Allowances for Water Resource Planning: Operating Methodology'[2].

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 WRZ allowable outage for all sourceworks 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.

The approach undertaken for the WRMP19, and continued for this assessment, was to analyse four WRZs covering the original three within the SWW company area in addition to the Bournemouth Water company area.

Key outage categories (causes for a temporary or short-term losses of supply) were identified both from the recommended categories outlined in the UKWIR report and from data provided by SWW. The outage categories adopted for this analysis are listed in Table 2.

Table 2: Outage Categories

Name	Description
Power failure	Temporary loss in power resulting in reduced output or complete works shutdown
Plant failure	Failure in the treatment process resulting in reduced output or complete works shutdown not caused by a power failure
Turbidity	Source water turbidity resulting in reduced output or complete works shutdown
Plant failure following power failure	Failure of the treatment works caused directly by a power failure
Source Pollution	Pollution of water source requiring a cessation of supply

[1] Environment Agency, 2016, *WRMP 2019 Methods – Risk Based Planning.* UKWIR. *(https://ukwir.org/146387?object=151120)*
[2] UKWIR, 1995, *Outage Allowances for Water Resource Planning*. UKWIR. *(https://ukwir.org/eng/reports/95-WR-01-3/67188/Outage-Allowances-For-Water-Resource-Planning)*

2.1 Analysis of recorded data

The outage analysis has been completed using data from SWW. A summary of the methodology and results is given here in the next section. The full listing of all data provided to AECOM is attached to this report.

The data provided has included a series of spreadsheets containing sourceworks output data and reservoir storage levels for a four-year period 2017-2021 inclusive for SWW. Outage has been defined as *when output of a sourceworks falls to 30% below the 30-day running average AND the strategic reservoir in the WRZ is less than 90% full)*. This approach is similar to the approach taken in WRMP14 and WRMP19 as it takes into account daily variations or seasonal output fluctuations in output which are less than 30% and unlikely to be legitimate outages that reduce the DO.

Initial data sorting was carried out in Microsoft Excel. Daily source output data was provided by SWW and a 30-day running average was calculated for each output. Outages meeting the criteria of causing a drop of more than 30% in source output **and** where the WRZ strategic reservoir was below 90% capacity were identified.

Events that occurred when the reservoir was equal to or greater than 90% full were removed as these are not defined as an outage. It should be noted that Bournemouth WRZ does not have a strategic reservoir therefore all events identified causing at least a 30% reduction in output were considered to be outages.

The final list of outages was summarised in Excel to enable analysis to be undertaken to determine a range of conclusions. This included which outage event was most prevalent (at the site level, WRZ level or company level), which time of the year most outages were experienced, and which site experienced the most outages etc.

2.2 Determination of Legitimate Outage

SWW has discounted all outages when the strategic reservoir in the WRZ is above 90% full. This is because a drop in WTW output at times of high storage usually reflects operational decisions to optimise the use of sources within a WRZ and minimise the cost of production. This has meant that factors such as the impact of autumn leaf fall, which occurs when reservoirs are recovering, and can affect the river quality, pipe and pump efficiency, and hence sourceworks output, have largely been discounted as the strategic reservoirs tend to be more than 90% full during this period. It should be noted that if the reservoir is less than 90% full, then the reduction in output has been counted as an outage and this would likely be the case during drought years.

There were several instances where an operational decision was made to switch off/reduce output from a sourceworks due to limited demand or to balance the network requirements. Although these were initially recorded within the outage database as a planned outage due to an “Operational decision”, they were not considered as outage events within the outage assessment. This is because while they are planned events, they do not result from a requirement to maintain sourceworks asset serviceability, and do not represent an unavoidable loss of deployable output. Ultimately these operational decisions would not have been made if the water was needed, and so these were operational choices rather than outages.

Additional outage events were included at Dotton boreholes to account for the boreholes flooding on occasion. The duration and frequency of these outages have been selected using 2012-2016 data. The frequency of this event between 2012 and 2016 was 3.2 events per year and the duration of each event was between 2 and 26 days. These variables were retained during the analysis summarised in this report.

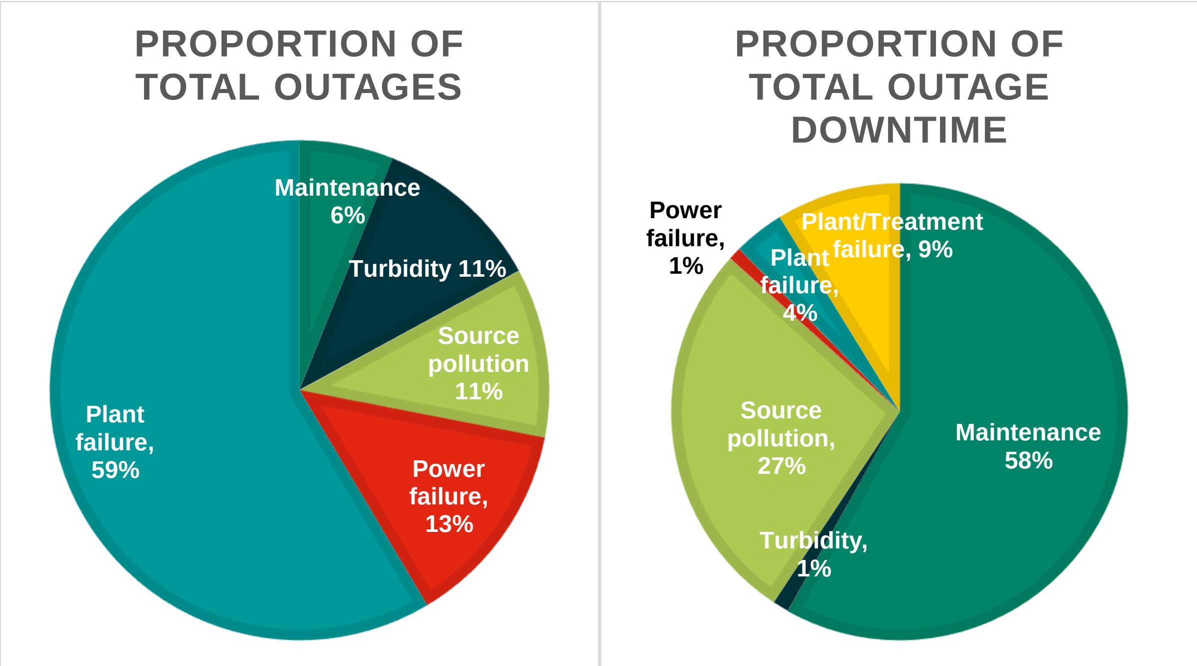
The output at Crownhill and Mayfair was combined, as Mayfair was brought online partway through the year when Crownhill was decommissioned. There was a period of crossover, but this has been reflected in the DO and running 30-day averages where relevant.

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 as not all recorded outages resulted in a 100% loss of DO. Where no outage events were identified at a source works in the 2020-2021 data, a minimum of 1 event lasting 1 day has been applied over a four-year time period (a frequency of 0.25 outages/year). The outage assessment is therefore conservative.

2.3 Summary of Legitimate Outage Events

Following the process described above, a total of 82 legitimate outage events were identified, which lasted a total of 155 days from the period April 2020 to the end of March 2021 across the SWW operating area (BW included). Of these 82 legitimate outage events, 5 events (lasting 90 days) were planned events while 77 events lasting a total of 65 days were unplanned. Figure 1 below shows the distribution of various causes of outage in terms of their frequency and duration across all the WRZs for the analysis period.

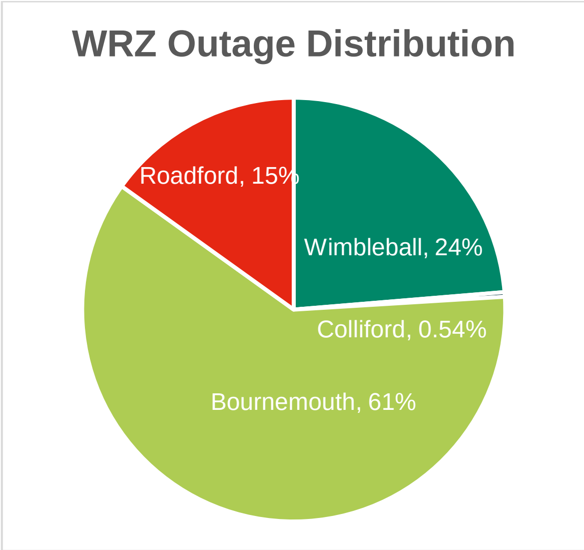
Figure 1: Proportion of overall number and duration of outages by cause across all WRZs for the period 2020 - 2021



Most known outages were a result of plant failure. All outages were identified and categorised, which is due to the improvements made by SWW in their logging and monitoring systems (previous WRMPs have required manual categorisation).

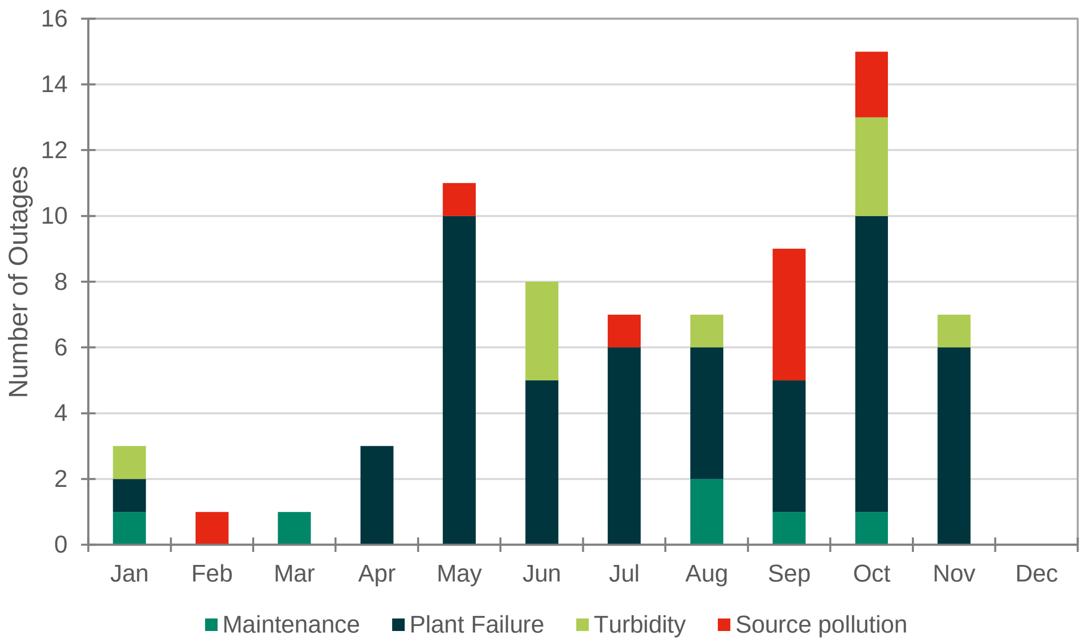
The Bournemouth WRZ experienced the longest duration of outages, which contributed to more than half of the total outage downtime, as shown in Figure 2. A key reason for this is that this WRZ does not have a strategic reservoir, and therefore there is a higher potential for outages to occur if using the same method for other SWW WRZs.

Figure 2: Outage distribution by WRZ, 2020 - 2021



The seasonal distribution of the outages is illustrated in Figure 4, which indicates that a greater proportion of outages occur from June to December than from January to May. This is the case even if planned maintenance is not considered. The reason for this seasonal distribution could be due to the cyclical nature of the reservoir levels, which are usually above 90% from December to April, which results in the discounting of a number of outages that would otherwise be included.

Figure 3: Annual distribution of all legitimate outages across all WRZs, 2020 - 2021



While all outages were able to be categorised, generic categories of planned and unplanned outages were used for the probabilistic modelling to increase the accuracy of the risk simulations (by way of reflecting that the nature of planned outages means that a loss in DO can be planned for in advance).

3. Probabilistic modelling assumptions and results

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

3.1 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 sourceworks (this is likely to be conservative);
- DO has been calculated as the WAFU – AMP7 Outage, and then spread across the source works in proportion to the treatment works capacity as a percentage of the total WRZ treatment capacity;
- Where no outage events have been identified at a source works in the 2020-2021 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); and,
- AMP7 Average DOs for Bournemouth have been used.

3.2 Assessment of results

The results of the probabilistic assessment are summarised in Table 3, and in further detail in Appendix A.

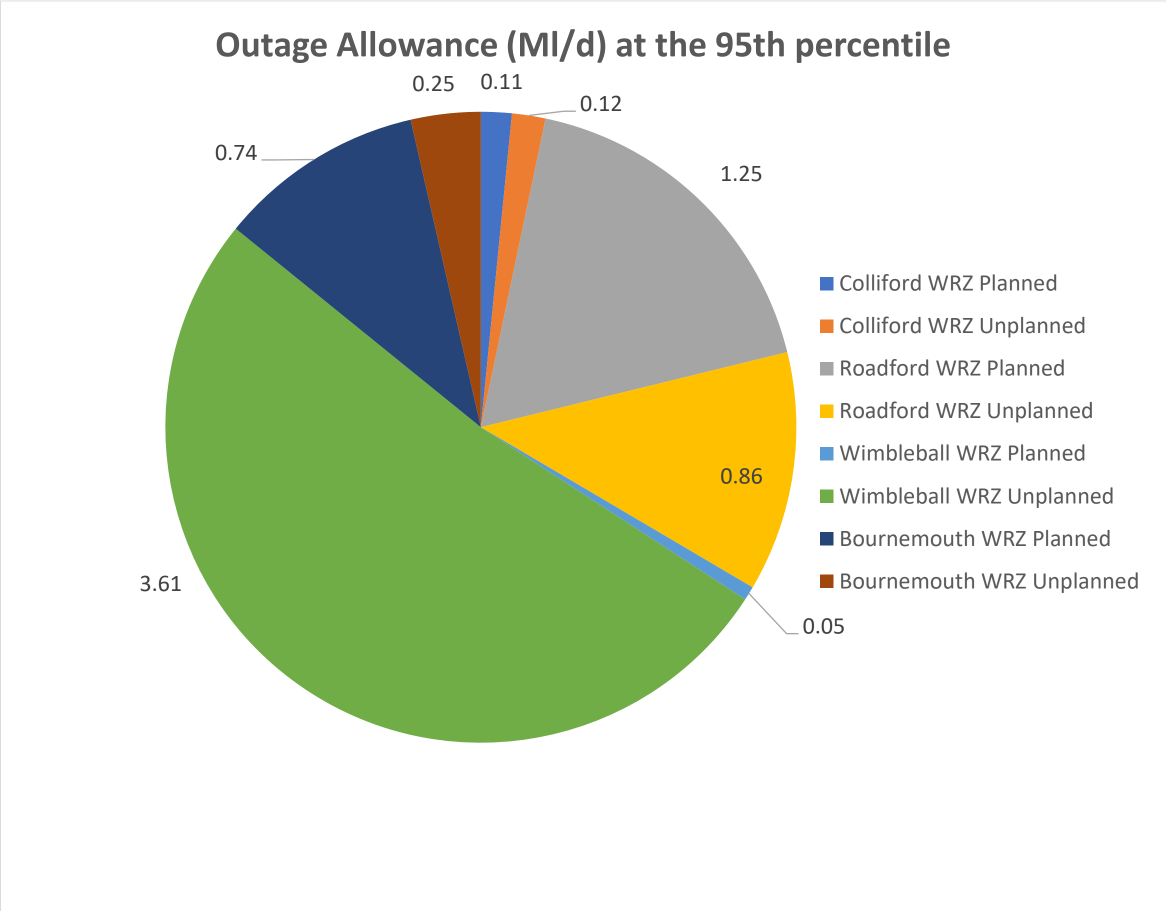
Table 3: SWW Outage Allowance

Zone	50%	75%	80%	90%	95%
Colliford	0.23	0.23	0.23	0.23	0.23
Roadford	1.82	1.95	1.98	2.06	2.11
Wimbleball	1.73	2.56	2.76	3.29	3.66
Bournemouth	0.94	0.96	0.97	0.98	0.99
SWW Total	4.74	5.58	5.77	6.30	6.68

The outage values to be taken forward into South West Water's supply/demand balance analysis for dWRMP 2024 are based on the 95th percentile, i.e. the values with a 5% risk of exceedance. The outage allowance value adopted is therefore 6.68 Ml/d. It should be noted that the outage allowance values by WRZ in Table 3 do not sum to the company total outage allowance values. This is because the "Risk Output" function of @Risk was used to sum the outage at each site to produce a WRZ outage allowance. By using @Risk to sum the outage at each WRZ, the sums are done in each iteration (a total of 10,000 iterations are run) of the model, as the probabilistic nature of the Monte Carlo simulation allows for the fact that outage events in all WRZ's do not occur simultaneously in each step of the iteration. Simply summing the percentiles at the end would not allow for this and would therefore produce a higher outage allowance. By using @Risk to determine the WRZ outage allowance in this way, it is possible to produce probability distribution graphs which illustrate the range of values that are likely to occur.

The results by individual WRZs also provide an indication of their relative contributions to the combined company total values. Figure 4 shows the main contributory factors to the company's outage allowance. As can be seen in Figure 4, Wimbleball WRZ unplanned events contribute the most to the total outage allowance. This is in line with the data analysed, which shows that while Bournemouth had the longest event in terms of duration (Ampress), Wimbleball had the largest number of outages which averaged at a longer duration. Part of the reason for this is the presence of the Dotton boreholes in the Wimbleball WRZ, which comprise of 14 individual boreholes supplying a single output, and so increasing the opportunity for outages. The second largest contributor to the total outage allowance is Roadford WRZ unplanned outages followed by Bournemouth WRZ planned events.

Figure 4: Relative Contributions of Outage Categories to the Total Outage Allowance



In order to understand how each sourceworks contributes to the outage allowance, a summary of the allowance for each sourceworks is shown in the files attached with this report. These values have been selected from the allowable outage distribution for each individual sourceworks within the Monte Carlo simulation and the level of accuracy quoted (i.e. three decimal places) is an output from the probabilistic model. Again, it should be noted that the outage values by sourceworks do not sum to the company total outage allowance due to the probabilistic or randomised nature of the Monte Carlo simulation.

4. Appendix A - @RISK Results Summary

Output	Colliford WRZ Total Planned	Colliford WRZ Total Unplanned	Colliford WRZ Total Total	Roadford WRZ Total Planned	Roadford WRZ Total Unplanned	Roadford WRZ Total Total	Wimbleball WRZ Total Planned	Wimbleball WRZ Total Unplanned	Wimbleball WRZ Total Total	Bournemouth WRZ Total Planned	Bournemouth WRZ Total Unplanned	Bournemouth WRZ Total Total	Company Outage Planned	Company Outage Unplanned	Company Outage Total
Statistic															
Minimum	0.11	0.12	0.23	1.25	0.27	1.53	0.05	0.23	0.29	0.74	0.15	0.89	2.16	0.98	3.14
Maximum	0.11	0.12	0.23	1.25	1.03	2.29	0.05	4.57	4.63	0.74	0.27	1.02	2.16	5.75	7.90
Mean	0.11	0.12	0.23	1.25	0.59	1.84	0.05	1.83	1.89	0.74	0.20	0.94	2.16	2.74	4.90
Mode	0.11	0.12	0.23	1.25	0.50	1.76	0.05	0.92	0.98	0.74	0.18	0.92	2.16	1.72	3.88
Std. Deviation	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.94	0.94	0.00	0.03	0.03	0.00	0.96	0.96
Variance	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.89	0.89	0.00	0.00	0.00	0.00	0.92	0.92
Skewness	0.00	0.00	0.00	0.00	0.44	0.44	0.00	0.55	0.55	0.00	0.46	0.46	0.00	0.53	0.53
Kurtosis	0.00	0.00	0.00	0.00	2.45	2.45	2.40	2.41	2.41	0.00	2.40	2.40	2.40	2.44	2.44
Percentiles															
1%	0.11	0.12	0.23	1.25	0.33	1.59	0.05	0.43	0.49	0.74	0.15	0.90	2.16	1.24	3.40
2.5%	0.11	0.12	0.23	1.25	0.35	1.61	0.05	0.51	0.56	0.74	0.16	0.90	2.16	1.35	3.51
5%	0.11	0.12	0.23	1.25	0.38	1.63	0.05	0.59	0.64	0.74	0.16	0.90	2.16	1.45	3.61
10%	0.11	0.12	0.23	1.25	0.41	1.66	0.05	0.71	0.77	0.74	0.17	0.91	2.16	1.60	3.76
20%	0.11	0.12	0.23	1.25	0.45	1.71	0.05	0.93	0.98	0.74	0.17	0.92	2.16	1.84	4.00
25%	0.11	0.12	0.23	1.25	0.47	1.73	0.05	1.05	1.10	0.74	0.18	0.92	2.16	1.95	4.11
50%	0.11	0.12	0.23	1.25	0.57	1.82	0.05	1.67	1.73	0.74	0.20	0.94	2.16	2.58	4.74
75%	0.11	0.12	0.23	1.25	0.69	1.95	0.05	2.50	2.56	0.74	0.22	0.96	2.16	3.42	5.58
80%	0.11	0.12	0.23	1.25	0.72	1.98	0.05	2.71	2.76	0.74	0.22	0.97	2.16	3.61	5.77
90%	0.11	0.12	0.23	1.25	0.81	2.06	0.05	3.23	3.29	0.74	0.24	0.98	2.16	4.14	6.30
95%	0.11	0.12	0.23	1.25	0.86	2.11	0.05	3.61	3.66	0.74	0.25	0.99	2.16	4.52	6.68
97.5%	0.11	0.12	0.23	1.25	0.90	2.16	0.05	3.86	3.92	0.74	0.26	1.00	2.16	4.78	6.94
99%	0.11	0.12	0.23	1.25	0.94	2.19	0.05	4.09	4.14	0.74	0.26	1.01	2.16	5.02	7.18

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