REVISED DRAFT WATER RESOURCES MANAGEMENT PLAN 2024

APPENDIX 4A – BASELINE DEMAND FORECAST

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Overview

The purpose of this document is to outline the technical details and assumptions that underpin the Portsmouth Water (PRT) WRMP24 baseline demand forecast, starting from the outturn base year 2019/20, leading up to the planning base year 2024/25 and extending up to 2099/00. The baseline demand forecast is subsequently used as an input into the WRSE investment modelling.

Document log

Document History

Version Name	Edited by	Date Edited	Description of Edits	Further Comments
PRT_BaselineDemandDocumentation_v1.1	MS	09/12/2020	Document creation	
PRT_BaselineDemandDocumentation_v1.2	MS	15/12/2020	Updated BL leakage and climate change approach.	
PRT_BaselineDemandDocumentation_v1.3	MS	16/12/2020	Updated baseline options approach	
PRT_BaselineDemandDocumentation_v1.4	MS	23/02/2021	Minor update to population and demand normalisation.	
PRT_BaselineDemandDocumentation_v1.5	MS	23/03/2021	Added section on uncertainty	
PRT_BaselineDemandDocumentation_v1.6	SC	28/8/2023	Updates since draft WRMP24	

Review History

Version Name	Internal/External	Reviewed by	Date Reviewed	Comments
PRT_BaselineDemandDocumentation_v1.1	External	Jacobs	11/12/2020	Shared with Jacobs
PRT_BaselineDemandDocumentation_v1.5	Internal	Portsmouth Water	28/5/2023	

Contents

Technical Documentation

1. PRT Demand Model

1.1. All separate components of the baseline demand model are controlled in a single spreadsheet named *DemandModel_WRMP24_v[VERSION.NO].xlsx.*

1.2. The spreadsheet model is used to determine the base year componenent outputs for a given scenario, returning the forecasted componenets out to 2099/00.

1.3. The model consists of the following core tabs:

Table 1 Spreadsheet Model Tab Descriptions

Tab name	Description
controlLog	History of edits and reviews for each model version
modelParameters	Used for scenario selection according to defined WRSE outputs. The tab also contains the key assumptions and parameters for the model.
baseYearCalc	Converts the 2021/22 base year demand component actuals according to the selected scenario. This includes and adjustment to leakage, and matches household demand to the climatic scenario.
optionsModel_AMP7	Applies assumptions of the AMP7 demand reduction strategy from 2019/20 to 2024/25.
nhhModel	Takes the raw Artesia non-household demand forecasts as inputs and converts them to net differences to apply to the base year. The tab is also used to produce the non-household property and population forecast
hhModel	The model controls the flow of properties and population between the three customer segments; Unmeasured, Meter Optants and New Properties. The tab also applies the PRT Variable Flow (VF) methodology, driving volume changes in the household customer base.
usplModel	Produces a forecast of Supply-Pipe Leakage given the expected growth in household properties.
demandForecast	Takes the model outputs from the preceding model tabs and applies the differences to the base year. The model also provides supporting metrics for a given scenario.
wrseTemplate	Applies relevant formatting to the demand forecast , outputting the data in in the format requested by WRSE.
demandDashboard	Provides summary plots of the outputs for a given scenario, comparing the results to those produced for WRMP19.

2. Base Year Calculation

2.1. The base year for the demand forecast is 2021/22. Accordingly, the output components from the 2021/22 Water Balance MLE are used. Notably, the base year uses the updated methodologies for calculating PCC and leakage. This differs from the WRMP19 submission, which uses only ‘new’ methodology leakage.

2.2. In order to adjust the outturn base year to the climatic scenarios, provided at a DI level, the components must also be adjusted accordingly. Adjustments are made solely to the household customer base. In order to make this adjustment, the residual DI is allocated using an MLE type process using (*Volume * Uplift)* which are in turn used to proportionally allocate the residual. An uplift factor of 0.2 and 0.3 are used for the measured and unmeasured groups, respectively. These factors are based on outputs of the ‘Water demand insights from summer 2018’ club project, produced by Artesia.

baseYearCalc

Takes the base year sub-components of demand and converts these

Selected Scenario	DYAA (1 in 20)	<- Adjust using modelParameter Sheet
Target DI	182.24	
Outturn DI	177.2	
Residual	5.1	

Base Year 2021-22

	DEMAND			Outturn	Leakage Adj	Lkg Adj Outturn	Weather Factors	Weather Factor Adj	Weather Allocation %	Weather Allocation #	Rebased Balance
11_{AR}	Distribution input (in reporting year)	Ml/d	2dp	177.18		177.18					182.24
	Consumption										
23_{AR}	Measured non household - consumption	Ml/d	2dp	29.05		29.05	0	0.0	0%	0	29.05
24_{AR}	Unmeasured non household - consumption	Ml/d	2dp	0.61		0.61	0	0.0	0%	0	0.61
25_{AR}	Measured household - consumption	Ml/d	2dp	31.95		31.95	0.2	6.4	20%	1.01	32.96
26_{AR}	Unmeasured household - consumption	Ml/d	2dp	85.50		85.50	0.3	25.7	80%	4.05	89.55
29_{AR}	Measured household - pcc	l/h/d	0dp	144.61		144.61					149.20
30_{AR}	Unmeasured household - pcc	l/h/d	0dp	167.02		167.02					174.92
31_{AR}	Average household - pcc	l/h/d	0dp	160.30		160.30					167.17
32_{AR}	Water taken unbilled	Ml/d	2dp	2.62		2.62	0	0.0	0%	0	2.62
33_{AR}	Distribution system operational use	Ml/d	2dp	0.52		0.52	0	0.0	0%	0	0.52
	Leakage										
34_{AR}	Measured non household - uspl	Ml/d	2dp	0.60		0.60	0	0.0	0%	0	0.60
35_{AR}	Unmeasured non-household - uspl	Ml/d	2dp	0.05		0.05	0	0.0	0%	0	0.05
36_{AR}	Measured household - uspl	Ml/d	2dp	5.07		5.07	0	0.0	0%	0	5.07
37_{AR}	Unmeasured household - uspl	Ml/d	2dp	7.11		7.11	0	0.0	0%	0	7.11
38_{AR}	Void properties - uspl	Ml/d	2dp	0.40		0.40	0	0.0	0%	0	0.40
39_{AR}	Distribution Losses	Ml/d	2dp	13.70		13.70	0	0.0	0%	0	13.70
40_{AR}	Total leakage	Ml/d	2dp	26.93		26.93	0	0.0	0%	0	26.93

Figure 1 Example Base Year Adjustment

3. Climatic Scenarios

3.1. Four climatic scenarios were required for the WRSE submission: NYAA, NYCP, DYAA, DYCP.

3.2. The dry year (DY) scenarios defined as 1-in-20 year for Portsmouth Water (the point preceding the implementation of TUBs).

3.3. To derive demand at the different return periods, PRT has utilised both outturn data and stochastically generated DI data. In principle, the outturn data is used to produce an estimate of the Normal Year (NY) which is well understood. The stochastic data is then used to explore rarer events which are limited in the historic 20-year record.

3.4. The starting point is to generate the best view of what the NYAA and NYCP is in 2021/22. To do this, an STL seasonal decomposition is used to de-trend the data. The data is then annualised and ranked. The median value of the series provides normal year estimation. The estimated NYAA DI is 177.6 Ml/d, close to the outturn figure of 177.2 Ml/d.

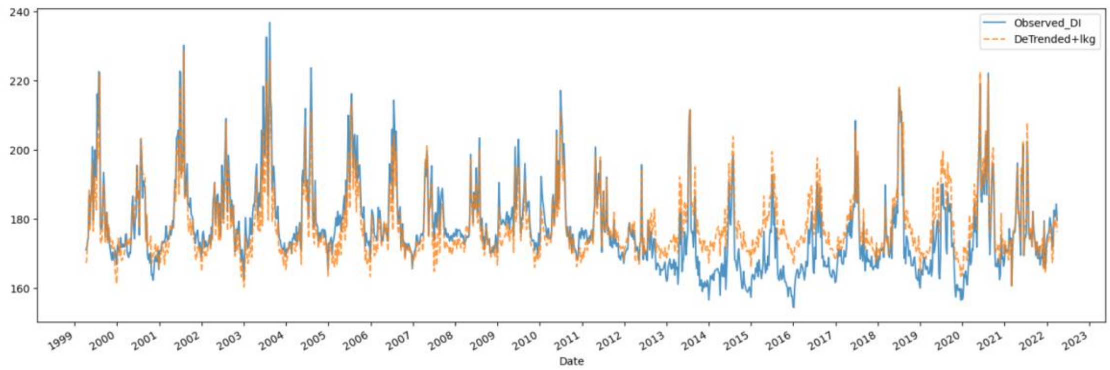

Figure 2 Calculating the NYAA by detrending the historic series. The NYAA is the medial annual average and annual maximum week

3.5. In order to produce all other scenarios, excluding the NYAA, PRT makes use of the daily stochastic DI outputs produced by WRc. The raw simulated DI is first converted to factors by normalising to the median DI across all years and stochastic runs. These factors can then be used as multipliers to the already derived NYAA and NYCP to generate annual DI annual averages (AA) and annual weekly maximums (CP). The n^{th} percentile is then used to represent DI for a given scenario.

3.6. WRc with the Artesia have produced two sets of output stochastic DI reflecting two types 'Series 2' and 'Series 3'. For PRT, both models perform well against the historical series though Series 3 is both recommended by Artesia, and, closely fits the histori series

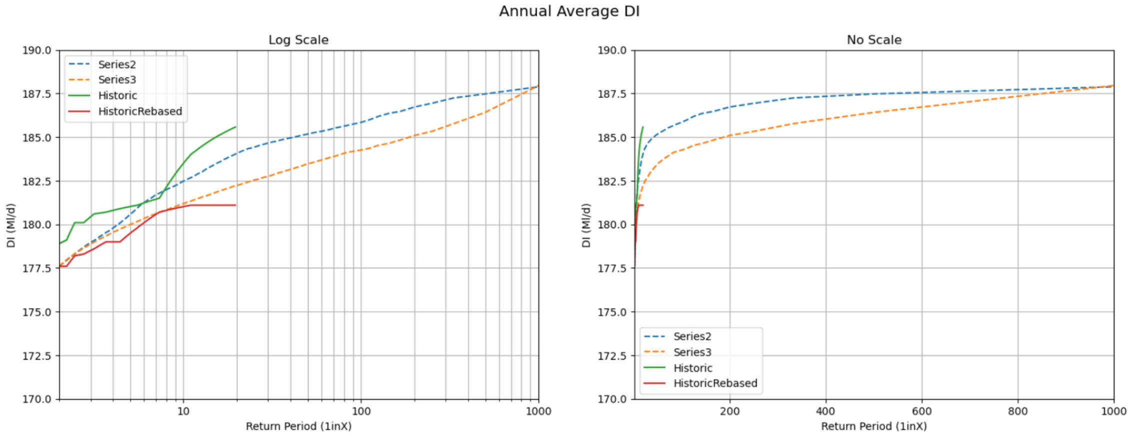

Figure 3 Stochastic DI against the historic record. Note that the 'HistoricRebased' is the de-trended DI series

4. Properties & Population

4.1. Eight properties and population scenarios were uploaded to the WRSE model: BL_H_Plan, Compl_5Y, H_Need, Max, Median, Min_10%, ONS18, Oxcam1a. PRT has used the 'WRSE VICUS Forecasts - February 2023' source data provided by Edge.

4.2. All forecasts are derived using the Edge Analytics Bottom-Up (BU) forecasts which allocate local plan growth according to potential housing development sites – rather than Top-Down, which allocated growth according to existing levels of growth.

4.3. The Max, Median, Min_10% are specific to each company. As the PRT household demand model volume growth is driven by both population and property growth, these scenarios are selected based on an analysis of ML/d impact in 2099/00.

WRSE Scenario	Edge Forecast
Max	Housing-Need-H
Median	Completions-5Y-P
Min	ONS-18-Low-L

Figure 4 Selected forecasts for Max, Median, Min scenarios

4.4. As the Edge base year estimates vary between scenarios and the PRT outturn reported figures, all forecasts are adjusted to outturn reported base year. This is achieved by taking the growth associated with each forecast and applying the net increase in each year.

4.5. All household property growth occurs in the measured group, as all new properties are measured.

4.6. Household population growth is not directly allocated to the measured customer base as this type of growth can occur across the unmeasured and measured population. Instead, the population is assigned according to a controlled logic in the PRT population and property model. Each new property is always assumed to be occupied with the estimated new property occupancy for a given year in the forecast. Suppose in any year the new properties cannot be filled with the new population as there is an excess of housing. In that case, the population is taken from the unmeasured and existing measured groups proportionally. Likewise, if there is an excess of the population beyond that met by new housing, then the surplus population is allocated proportionally.

4.7. All new Non-Household growth is assumed to occur to the measured Non-household group only. This approach is applied as the unmeasured Non-household group is small and remained stable for many years.

5. Household Demand

5.1. For WRMP19, PRT moved away from micro-component modelling previously used in WRMP14 in favour of the 'Variable Flow' (VF) method proposed in the 'WRMP19 Methods – Household Consumption Forecasting' guidance. This decision was taken as the assumptions underpinning the micro-component model were deemed to be outdated. The VF method allows a more explicit exploration of the factors impacting demand and the uncertainty surrounding the model assumptions. Like micro-components, the method is deemed to be suitable for WRZs with moderate-low levels of concern. For WRMP24, the method is applied again with updated assumptions.

5.2. The household demand splits the household customer base into three groups. Unmeasured Properties, New Properties and Meter Optants. New Properties are those customers with properties built after 2004 while Meter Optants are properties that have historically opted for a meter.

5.3. The core drivers of volume in the VF model are Population, Properties and Climate Change. The model also includes impact for options implemented in the period 2020/21-2024/25 which are subsequently derived in the 'Baseline Options' section.

5.4. Typically in water resource planning, new volumes associated with growth are assigned to either new properties or new persons. One weakness of this approach is that it does not fully recognise the impact of occupancy on consumption, i.e. if average occupancy increases, then homes become more efficient and vice versa. The PRT VF model attempts to capture occupancy impacts by assigning volumes to both properties and persons. Customer movements can then drive volume factors according to the outputs of the properties and population model.

5.5. In order to derive the volume factors, a linear regression model was developed using company-specific data. The model uses customer type and occupancy to predict PHC volumes. The result is coefficients that split the PHC volume impacts for persons and households. The coefficients are presented below. As an illustration, a single new property with an average occupancy of 2.2 would lead to an increased volume of 91.2 + (72.4*2.2)=250.5 l/d. Likewise, the availability of new housing would cause a reduction in the unmeasured population and a relative increase in the New Property group. For each person, this would have an overall volume impact of (+72.4) +(-94.4)=-18.8 l/d.

Pop & Prop	Properties (l/prop/d)	Population (l/pers/d)
New Property	91.2	72.4
Measured (Meter Optant)	N/A	85.9
Unmeasured	N/A	94.4

Figure 5 Aggregated coefficients for population and property movements

5.6. The PRT climate change impact is based on the outputs of the UKWIR 'Impact of Climate Change on Water Demand Project' (2012), applying the look-up table of factors in Appendix 6. PRT has implemented the factors used for the South East using the 'Thames' outputs. The factors cover a range of scenarios from p10 to p90, the p50 figures are used as the central scenario. The raw factors extend to 2040, therefore the remaining years have been extrapolated using the Excel ETS forecast function, applied using Log(year) as inputs. The raw factors also use a 2012 base, to adjust to the WRMP24 base, the net difference is taken from 2021-22 onwards. The factors applied differ according to the climatic scenario i.e. Annual Avererage and Critical Period. An MDO set of forecasts are also produced, but are not utilised as a scenario for WRSE. In order to convert the factors to Ml/d impacts, the factors are multiplied by the base year total household consumption, which also varies according to the relevant climatic scenario. The total Ml/d impact of climate change in each year is then split between the Unmeasured and Measured groups proportionally, according to the split of households for a given year.

5.7. In theory, some fall in per customer demand is expected without company intervention, driven by replacement of old, less efficient, water-using devices. In practice, PRT has seen a continual increase in PCC for several years. This may suggest that this impact is being offset by other factors, for example, changes in customer behaviour. As these impacts cannot be robustly estimated, no reduction for water efficiency is assumed for the central scenario. Instead, ranges will be explored as part of the uncertainty analysis.

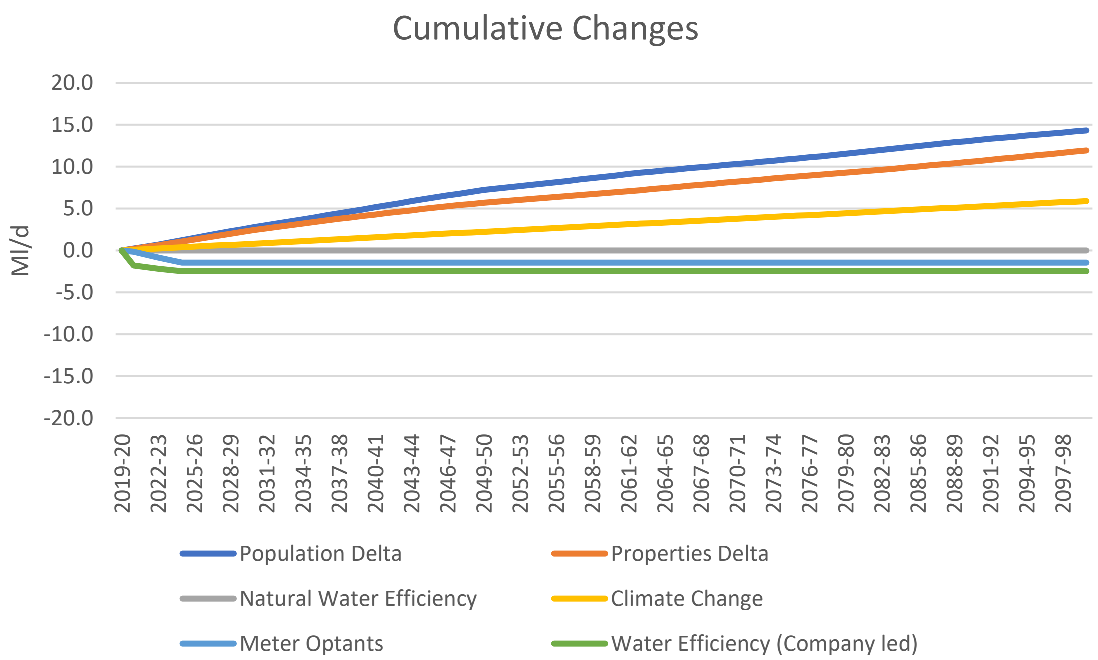

Figure 6 Example VF cumulative Ml/d impacts for NYAA

6. Non-Household Demand

6.1. Artesia has created four core forecasts with associated uncertainty scenarios: Baseline, Low, Central, High.

6.2. The Central scenario has been adopted for the main scenario.

6.3. As each of the scenarios has different starting points in the base year, all the forecasts have been adjusted to the 2021/22 outturn. This is achieved by taking the cumulative change from the base of each forecast, applying it to the 2021/22 actuals.

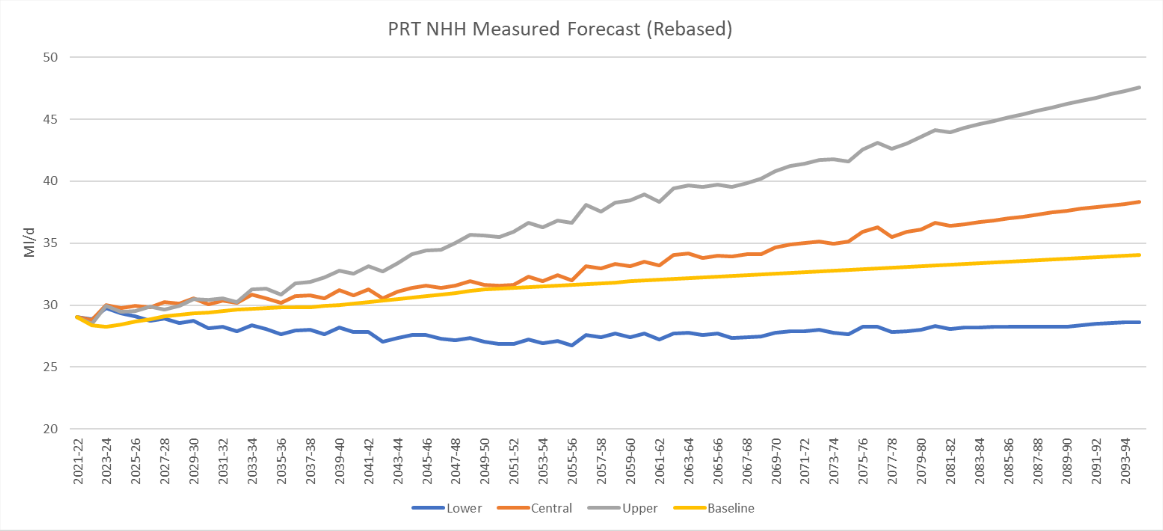

Figure 7 Non-household volume forecasts

7. Leakage

7.1. The draft Environment Agency guidance suggests that leakage in the baseline forecast should be flat. *Leakage in your baseline should remain static from the start of your plan to the end of the planning period. If there is significant growth planned in a resource zone you should discuss and agree your approach with regulators*".

7.2. In practice, given no additional company effort, the baseline leakage might be expected to rise as the length of the network, and, the number of supply pipe connections increase with growth. In alignment with the guidance, however, all leakage is kept flat over the entirety of the period.

8. Minor Components

8.1. Water taken unbilled and Distribution system operational use are kept constant over the entirety of the planning period, held at 2021/22 levels.

9. Baseline Options

9.1. Baseline options for metering, leakage and water efficiency are included in the period leading up to 2024/25. These are based on our most up-to-date view of the estimated outturn for AMP7.

9.2. The options applied in the period to 2024/25 are those intended during the AMP with lower reductions than the assumptions used in WRMP24.

9.3. Option impacts are scaled from the Normal Year NYAA scenario to the given climatic condition according to the relevant uplift in total household consumption.

Appendix

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                            OLS Regression Results
==============================================================================
Dep. Variable:                    PHC   R-squared:                       0.532
Model:                            OLS   Adj. R-squared:                  0.532
Method:                 Least Squares   F-statistic:                 2.473e+04
Date:                Mon, 07 Sep 2020   Prob (F-statistic):               0.00
Time:                        14:25:42   Log-Likelihood:            -7.9225e+05
No. Observations:              130447   AIC:                         1.585e+06
Df Residuals:                  130440   BIC:                         1.585e+06
Df Model:                           6
Covariance Type:            nonrobust
================================================================================================================
                                                coef    std err          t      P>|t|      [0.025      0.975]
----------------------------------------------------------------------------------------------------------------
Intercept                                    63.1889      0.934     67.620      0.000      61.357      65.020
C(meterStatus)[T.Unmetered]                  15.0782      6.567      2.296      0.022       2.207      27.949
C(buildStatus)[T.Property>2006]              28.0375      1.147     24.447      0.000      25.790      30.285
Occupancy                                    85.9360      0.399    215.513      0.000      85.154      86.718
C(meterStatus)[T.Unmetered]:Occupancy         8.4102      2.462      3.417      0.001       3.585      13.235
C(buildStatus)[T.Property>2006]:Occupancy   -13.6761      0.492    -27.825      0.000     -14.639     -12.713
dryYear                                       3.1113      0.586      5.313      0.000       1.963       4.259
==============================================================================
Omnibus:                    12748.266   Durbin-Watson:                   1.231
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            20718.303
Skew:                           0.715   Prob(JB):                         0.00
Kurtosis:                       4.330   Cond. No.                         74.2
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Figure 8 Measured Household PHC Regression Model