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Optimisation of Supply Demand Balance Model Under Uncertainty

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Research questions

- What are the optimal or near optimal solutions to the Supply Demand Balance Problem under various sources of uncertainty?
- What are the impacts of the chosen uncertainty and risk approaches on decision making?

Motivation

Every five years Water Only Companies (WOC) and Water and Sewage Companies (WaSC) publish their Water Resources Management Plans (WRMP) and Business Plans. Bristol Water uses the following models to deliver their WRMP: Mass Balance Model, MISER model (Water Resource Modelling tool) and Supply-Demand Balance (SDB) model for investment planning.

Various SDB models are employed by companies as decision support tools to enable the optimal selection of capital investment programs and operational strategies. During the PR14 process, any WRMP forecast was based on the simple deterministic forecasts of supply and demand; and the risk was represented by target headroom. PR19 regulator guidance requires the introduction of a new decision support tool that will represent a new approach for risk and uncertainty application.

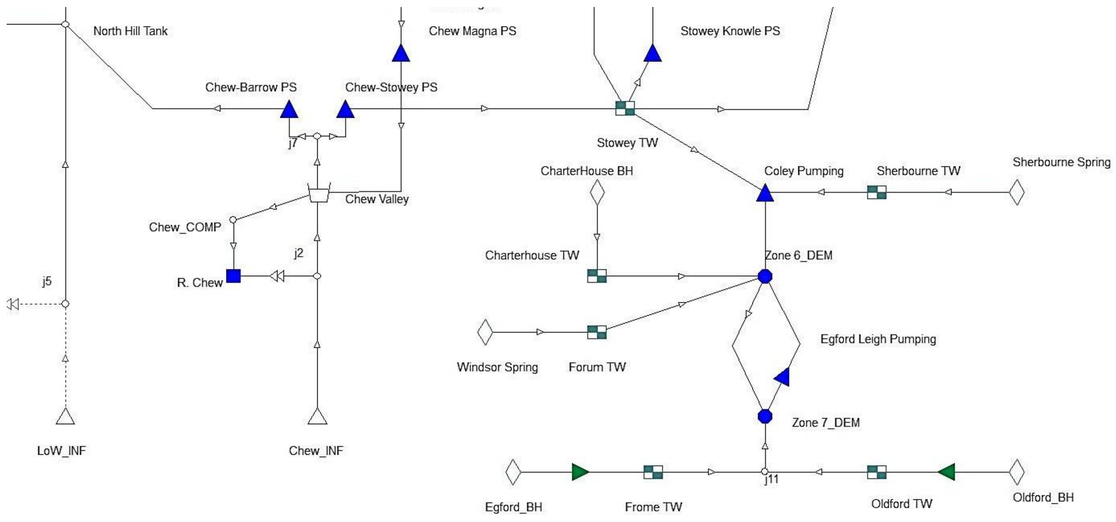

Figure 1. Bristol Water MISER Schematic (South West Area of the System)

Aim and objectives

Aim: To develop a better understanding of supply demand balance problems for water resources management under uncertainty.

Objectives:

1. To develop an SDB model based on the input generated by new risk-based methods.
2. To optimise the model under uncertainty.
3. To investigate the impact of uncertainty on decision-making.
4. To establish how decisions are determined by various adopted strategies, policies and risk.

Uncertainty

Uncertainties affecting water supply system (WSS):

- due to imperfect knowledge about socioeconomic drivers,
- due to climate variability and climate change,
- as a result of changing system dynamics,
- related to regulatory framework or legal aspects.

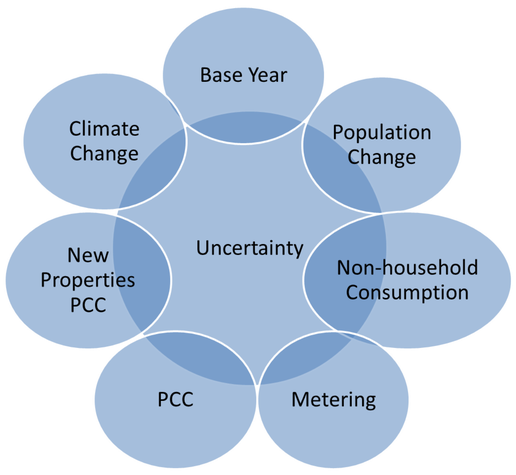

Figure 2. Various sources of uncertainty affecting WSS

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Model

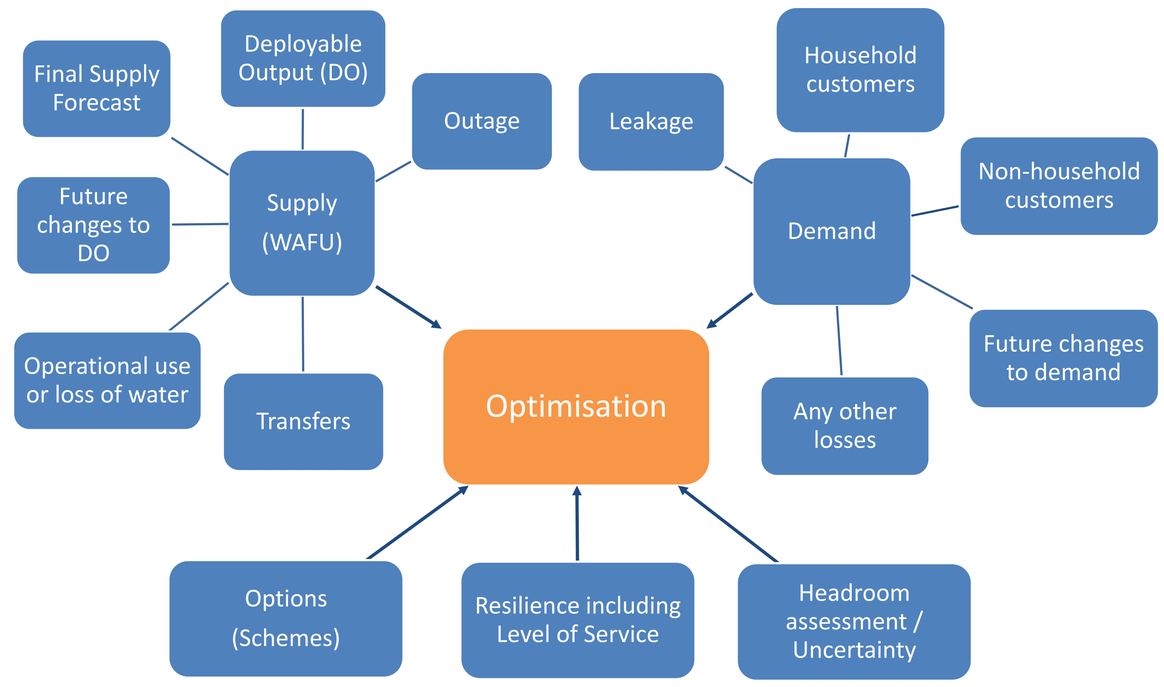

Figure 3. SDB model for Bristol Water WRMP19 submission

Data input and decision variables

The input data to SDB comes from the following assessments: climate change, demand and population forecasting, deployable output, headroom, leakage, option appraisal, outage; and customer preference, by way of customer surveys.

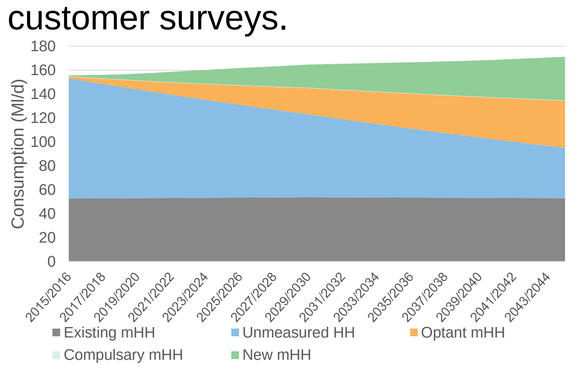

Figure 4. Total household consumption forecast for Bristol Water Operational Area

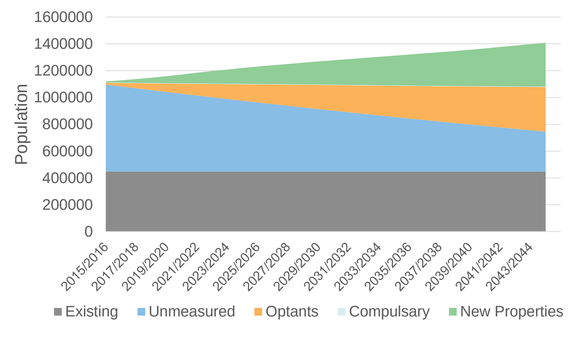

Figure 5. Population forecast for Bristol Water Operational Area

Strategic models used in WRMP19 need to be consistent with the Company Drought Plan, hence any control curves or investment options from the Drought Plan need to be included as an input to SDB modelling. The potential yield, cost and time-to-build variables are captured for each of the investment schemes being considered.

The decision variable is an intervention selected or not selected in any given year, over a 25-year planning horizon.

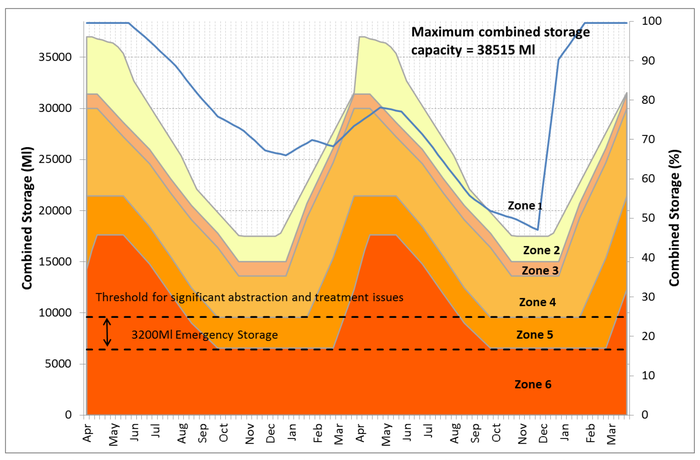

Figure 6. Mass Balance Model output for April 1933 to April 1935, with a demand of 299.70Ml/d

Figure 7. Artist's impression of Cheddar 2 Reservoir – one of the water resources options proposed

Future work

The majority of data for input has been delivered, but requires further data analysis including uncertainty and sensitivity analysis. A simulation model has already been built and optimised in R environment, using genetic algorithm. Multiple model runs will be undertaken shortly, to investigate the impact of adopted policies and strategies on the optimal solution.

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