Jersey Water
for Island life

APPENDIX H:
Decision-making approach

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1. Introduction

This appendix describes the decision-making approach for our Water Resources and Drought Management Plan (WRDMP). The decision-making approach is a core component of the WRDMP, and the methods outlined in this document interlink with several aspects of the overall process as illustrated in Figure 1-1

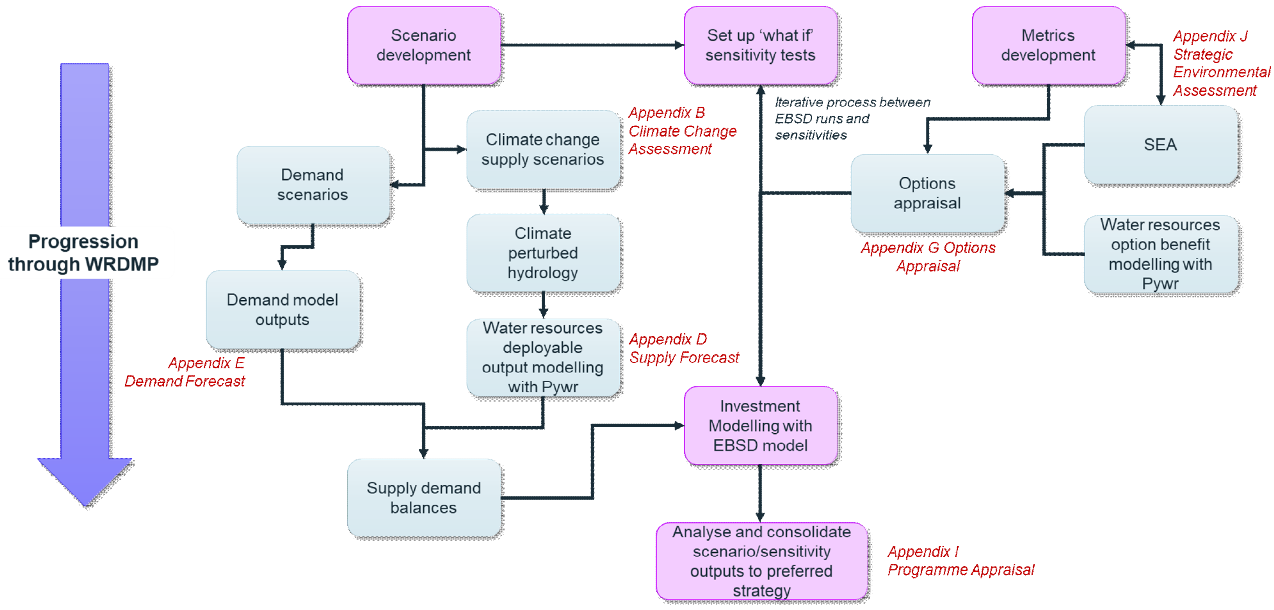

Figure 1-1 - Flow chart illustrating where the approaches covered in this Appendix (pink boxes) link with other aspects of the process. Areas covered by alternative Appendices are identified by the red text.

Jersey Water face several challenges to ensuring an ongoing secure supply in the long term. These include uncertainty around the impact of environmental and societal changes (such as climate change and population change) as well as uncertainty in the data used to assess the availability of supply and the options to increase supply or reduce demand in the future. Scenarios are used to explore the risks associated with different future uncertainties (see Section 3), while specific metrics have been developed to allow comparison of different investment programmes and to explain the additional value each may deliver (see Section 2). Increasing our level of drought resilience (one of our resilience metrics) is a driver of our plan and we have developed an approach that allows Jersey Water to explore the indicative cost impact and risk impact of moving to different levels of drought resilience (i.e. 1 in 100-year versus a 1 in 500-year type of drought event).

This appendix is structured as follows:

- The approach to best-value planning, including a summary of objectives and metrics
- The approach to scenario development and modelling
- An overview of the investment model itself, including model operation and processing steps.

2. Best Value Planning

The latest best practice guidelines for water companies in England and Wales require companies to develop a 'best-value' plan rather than simply the least cost plan[1]. The planning guidelines state that a best value plan "considers factors alongside economic cost and seeks to achieve an outcome that increases the overall benefit to customers, the wider environment and overall society".

Delivering an effective best-value plan therefore requires careful selection and formulation of the objectives and metrics against which *value* can be measured. Figure 2-1 illustrates the framework against which we have developed the metrics. The high-level objectives have been taken from Jersey Water's five key business strategy pillars (Figure 2-2) and the value criteria and metrics formulated under these (see Section 2.1).

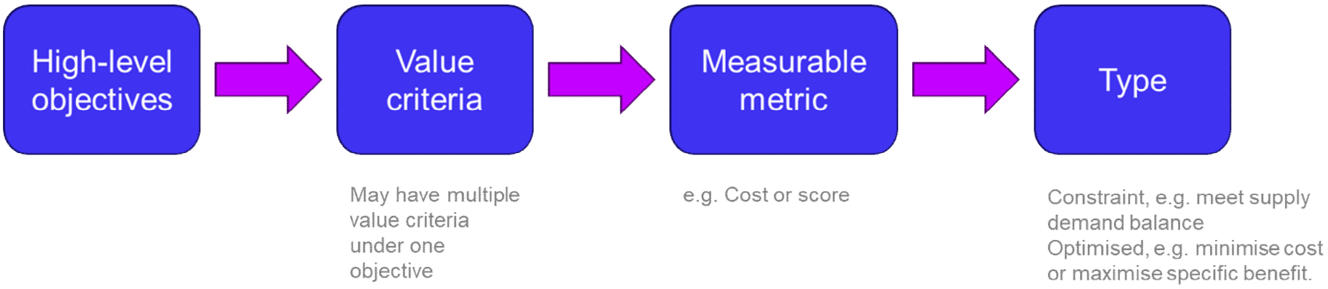

Figure 2-1 - Framework for developing metrics for best value planning

Value criteria are the set of criteria that represent our high level objectives, each of these have one or more associated metrics that define how we will measure additional value. Metrics are the measurable indices that are used within the decision-making process to indicate how a portfolio of options may provide 'best-value'. Metrics scores are ideally assigned to the individual options within the investment model and aggregated together to understand total plan performance. The type of metric defines how it is included in and influences the decision making and this is outlined in further detail in Section **2.1.1**.

2.1 Objectives, value criteria and metrics

Jersey Water have five key pillars to their current business strategy, and we have mapped these core objectives to associated value criteria which each have a set of associated metrics that are used to measure the additional value delivered. This ensures that the WRDMP is aligned with Jersey Water's core business strategy.

[1] Water Resource Planning Guidelines, April 2023

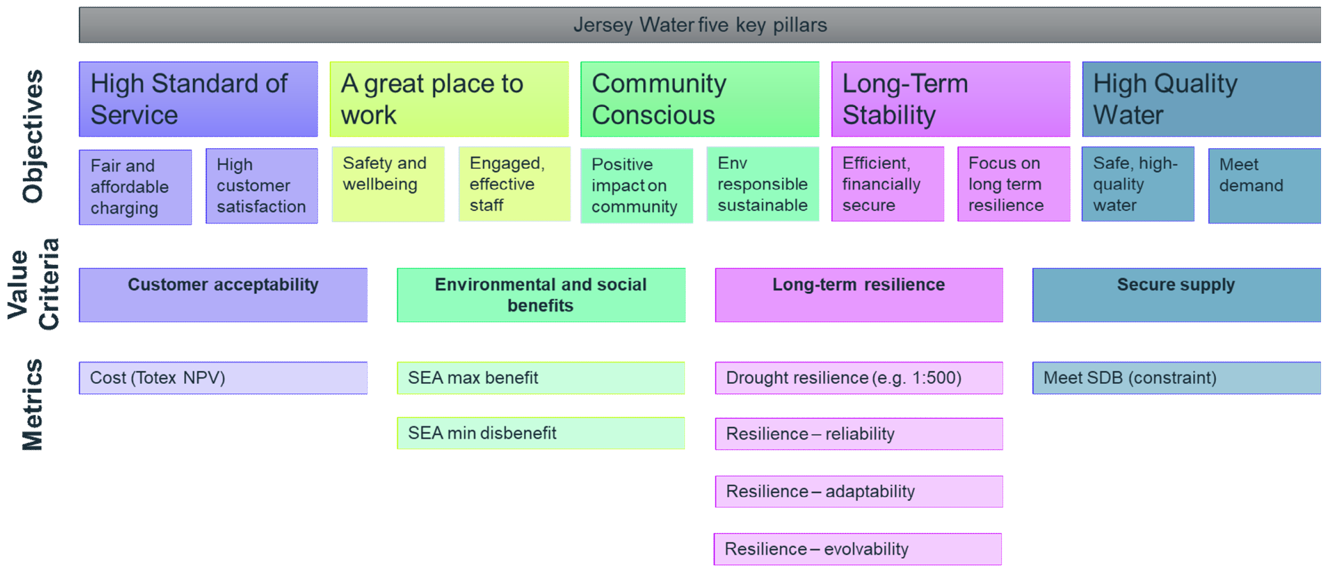

Figure 2-2 - Value criteria and metrics aligned to Jersey Water's five strategic objectives

2.1.1 Summary of metrics

The metrics are used to compare different investment programmes and to explain the additional value each may deliver. Each programme comprises a series of options and represents a different version of what the plan could look like. Some of the metrics have been identified as things that Jersey Water 'must do'. These are implemented as *constraints* within the investment model, for instance, meeting the supply demand balance. Other metrics are used to measure the different levels of additional value added under different plans. These are identified as *optimised* metrics. Cost is an example of an optimised metric. Section 4.5 outlines how the metrics are included within the investment modelling optimisation to generate the best value plans.

All the metrics used in the best value appraisal are calculated using information that is evaluated at the option-level. Table 2-1 details the type, units, and calculation steps for each of the metrics.

Table 2-1 – Type and calculation steps for each of the metrics

Value Criteria	Metric	Type	Calculation steps	Unit
Customer acceptability	Cost – NPC TOTEX	Optimised	Costs developed for each option during options appraisal. Financing costs, annuitised CAPEX, fixed OPEX and variable OPEX accounted for within investment model to generate total net present cost (NPC).	£
Environmental and social benefits	SEA max benefit	Optimised	Developed for each option as part of the SEA assessment.	Score
	SEA min disbenefit	Optimised	Developed for each option as part of the SEA assessment.	Score
Long term resilience	Drought resilience	Constraint	Water Resource model used to understand supply at the agreed drought level (e.g. 1 in 500-year return period drought event)	Ml/d
	Resilience – reliability	Optimised	Combined scores from separate resilience sub-metric assessment (see Table 2-2).	Score

Value Criteria	Metric	Type	Calculation steps	Unit
	Resilience – adaptability	Optimised	(Optimisation aims to maximise score to maximise resilience).	Score
	Resilience – evolvability	Optimised		Score
Secure supply	Meet Supply Demand Balance	Constraint	Supply Demand Balance projection for each year of the planning period, under varying future scenarios from demand model, water resource DO assessment and supply forecast	Ml/d

2.1.2 Level of drought resilience

The drought resilience metric defines the level of drought risk that we want to plan for within the plan. The latest UK Water Resource Planning Guidelines require water companies to plan for a 1 in 500-year level of resilience by at least 2039. While Jersey Water are not required to achieve this level of drought resilience, they are committed to providing a long-term reliable supply across the island and so the approach has assumed a target of 1 in 500 year drought resilience with the ability to understand this in terms of strategy and cost implications.

The investment modelling has therefore been carried out to test both 1 in 500 and 1 in 200 as the critical drought event level, with flexibility to adjust when in the planning period this condition will be met.

2.1.3 Resilience of the plan

To make sure the preferred plan is resilient to future shocks and stresses, both foreseen and unforeseen, a resilience framework comprising three resilience metrics each with three separate sub-metrics has been defined. These are developed to assess a range of different resilience attributes covering reliability, adaptability and evolvability under each option. (Note that this resilience framework is in addition to the drought resilience metric). This approach has been based on that applied by Water Resources South East for WRMP24 which utilises resilience attributes and characteristics akin to the Cabinet Office's five R's of redundancy, resistance, reliability, response and recovery. The approach adapts the indices developed by Botlz and Brown (2019) to a water resources planning context resulting in three basic indices of *reliability, adaptability and evolvability*.

Table 2-2 details each of the sub-metrics that make up the three resilience indices alongside the main hazard these represent and the scoring approach. Each sub-metric is initially given a score from 1 to 5 that is then converted to a scaled score based on option benefit as follows:

$$Value = score * Mld\ benefit$$

The scaled sub-metric values are summed within each of the resilience metrics to result in three resilience indices (each of these three are then optimised in the investment model).

Table 2-2 – Resilience sub-metrics and details

Resilience metric	Sub-metric	Main hazard	Type	Scoring approach
Reliability	Uncertainty of option supply demand benefit	Drought / societal	Semi-quantitative	5-point score supported by analysis of modelled DO variation. (1=notably more DO uncertainty, 5=notably less DO uncertainty)
	Risk of failure of option due to physical and water quality hazards		Subjective	Relative risk of loss of service due to a physically based shock event likely to occur when availability of water resource is already stressed. 5-point scale relative to current 'typical' exposure and vulnerability of available options (1=notably more risk, 3=typical, 5=notably less risk).
	Risk of failure due to societal hazards	Societal	Subjective	Relative risk of loss of service due to a societal shock event likely to occur when availability of water resource is already stressed. 5-point scale relative to current 'typical' exposure and vulnerability of available options (1=notably more risk, 3=typical, 5=notably less risk).
Adaptability	Expected time to failure	Drought	Quantitative	Calculated as the mean time from resource state = 100% to resource state failure under critical events. Percentage change is calculated across the same set of events and converted to a relative 5-point scale.
	Operational complexity	All hazards	Subjective	Score relative to current 'typical' situation (1=notably complex, 3=typical, 5=notably less complex). Score should be based on aspects such as reliance on multiple institutions to operate, connectivity and the ability to move water around the network, experience of operation and other factors.
	Contributes to system connectivity	All hazards	Subjective	Scoring will generally be either neutral or positive (+2) to indicate where benefit is gained through greater system connectivity.
Evolvability	Scalability and modularity of option	Planning hazards	Subjective	Score based on the overall flexibility of the option. A score of 1 represents an initiative that can only realistically be a single size with no flexibility (e.g. reservoir). A score of 5 represents an option that can be implemented on a fully staged, modular, and extendable basis.
	Intervention lead times	Planning hazards	Quantitative	Total planning and construction time for the option. Lead times are evaluated and separated into 5 equal sized bands for the 5-point score. (1 = longer lead times, 5 = shorter lead times)

Resilience metric	Sub-metric	Main hazard	Type	Scoring approach
	Uncertainty in planning / delivery process	Planning and societal hazards	Subjective	Score ranging from no uncertainty (=5) through to likely uncertainty and challenge (=3) to schemes that rely on new forms of cooperation between conflicting institutions (=1).

2.1.3.1 Option resilience scores

Table 2-3 shows the final resilience metrics calculated for each of the feasible options. As the scores are scaled by Ml/d benefit this shows that options with a larger DO benefit have an associated larger resilience benefit (e.g. La Rosiere desalination plant extension and Bellozanne water reuse plant).

Table 2-3 – Final resilience scores

Option code	Option name	Option type	Reliability	Adaptability	Evolvability
S101	New stream abstraction (Fernlands)	New abstraction	1.1	1.0	1.3
S103i	New storage reservoir option Trinity reservoir (lowest cost range).	Reservoir	16.3	10.9	6.8
S103ii	New storage reservoir option Trinity reservoir (lowest cost, with budget split).	Reservoir	16.3	10.9	6.8
S24b_1200	Expansion of Val de la Mare reservoir (new dam) - 1200Ml	Reservoir	40.9	30.7	13.6
S24b_750	Expansion of Val de la Mare reservoir (new dam) - 750Ml	Reservoir	28.5	21.4	14.3
S24b_450	Expansion of Val de la Mare reservoir (new dam) - 450Ml	Reservoir	17.3	13.0	5.8
S15d	New groundwater abstraction: d. Pont Marquet	New abstraction	4.9	2.5	4.9
S9i	La Rosière desalination plant extension - Phase 1	Desalination	48.6	32.4	59.4
S18	Bellozanne indirect treated effluent water reuse scheme	Water reuse	44.9	33.7	33.7
S14	Raw water infrastructure system enhancements (West-East Transfer)	Asset enhancement	5.3	5.3	3.5
S-B1	Supply measures - Basket 1: Catchment Measures (S1, S2, S3)	Catchment management	0.1	0.0	0.1
S-B2	Supply measures - Basket 2: Treatment enhancement to target PFAS contaminated sources (S114, S6)	Asset enhancement	7.0	3.9	7.0
D-LMS	Leakage Management Software 1	Leakage Management	2.2	1.2	3.1
D-APM	Leakage Advanced Pressure Management	Leakage Management	1.1	0.6	1.9
D-MRS1	Leakage Mains Renewal	Leakage Management	0.5	0.5	0.9

D-MRS2	Leakage Mains Renewal 2	Leakage Management	0.5	0.5	0.9
D-MRS3	Leakage Mains Renewal 3	Leakage Management	0.5	0.5	0.9
D-AT	Leakage Additional Technician	Leakage Management	0.7	0.7	1.1
D-AL	Leakage AI Accoustic Logging	Leakage Management	0.7	0.3	1.3
D-B11	Demand Basket 1 - Smart metering phase 1	Metering	1.3	0.6	2.4
D-B12	Demand Basket 1 - Smart metering phase 2	Metering	1.3	0.6	2.4
D-B3	Demand Basket 3 - planning regulation	Water Efficiency	0.0	0.0	0.1

2.1.4 Maximising Environmental and Social benefits

We have carried out an SEA of the feasible options identified during the Options Appraisal. The SEA considers numerous environmental and social factors as detailed in Table 2-4. Each option is assessed against the topics in the table and given a residual impact (categorised into significant or insignificant) to represent the residual positive and residual negative impacts associated with both construction and operation of the scheme.

Table 2-4 – SEA topics and objectives

Topic	Objective
Biodiversity	To protect and enhance biodiversity, vulnerable habitats and habitat connectivity and achieve biodiversity net gain.
Soil	To protect and enhance the functionality, quantity and quality of soils and geologically designated sites.
Water	To protect and enhance the quantity and quality of surface, groundwater, estuarine and coastal waterbodies and water dependent habitats.
Air	To reduce and minimise air and noise emissions.
Greenhouse Gas Emissions	To achieve the government of Jerseys target of becoming a carbon-neutral jurisdiction by 2030.
Climate Factors	To reduce vulnerability of built infrastructure to climate change risks and hazards.
Climate Factors	To reduce or manage flood risk, taking climate change into account.
Landscape	To conserve, protect and enhance landscape, townscape and seascape character and visual amenity.
Cultural heritage	To conserve, protect and enhance, Jersey's historic environment and heritage assets, including archaeological remains.
Population and human health	To maintain and enhance the health and wellbeing of the local community, including economic and social wellbeing
Population and human health	To maintain and enhance tourism and recreation.
Material Assets	To minimise resource use and waste production.

Material Assets	To avoid negative effects on built assets / infrastructure.

The impact assessments are intended to be considered individually in terms of the value and significance of each factor. However, in practice a pragmatic approach has been adopted to allow these assessments to contribute towards the modelled decision-making by converting them into a single summed impact score that can be combined for each option. The approach has also applied a weighting factor of 2 to impacts deemed 'significant' prior to summing across all the factors. This achieves a total positive and total negative impact associated with both construction and operation. As with CAPEX costs the residual construction impacts are applied within the model just during the construction period and the residual operation impacts are applied as an annual benefit or disbenefit once the scheme starts delivering DO benefit.

2.1.4.1 Option SEA scores

Table 2-5 shows the final SEA metrics for each of the feasible options,, as outlined above these are taken directly from the SEA assessment with 'significant' impacts weighted by a factor of two. This shows that the demand management options perform well from an environmental and social perspective, as do catchment measures. The two PFAS targeted actions (to install a new borehole at Pont Marquet and carried out enhanced PFAS treatment at source) as well as Bellozanne water reuse have a total negative impact score with a total negative construction and operation score.

Table 2-5 – Final SEA scores

Option code	Option name	Option type	Total construction	Total operation
S101	New stream abstraction (Fernlands)	New abstraction	-17.0	2.0
S103i	New storage reservoir option Trinity reservoir (lowest cost range).	Reservoir	-39.0	16.0
S103ii	New storage reservoir option Trinity reservoir (lowest cost, with budget split).	Reservoir	-39.0	16.0
S24b_1200	Expansion of Val de la Mare reservoir (new dam) - 1200Ml	Reservoir	-23.0	7.0
S24b_750	Expansion of Val de la Mare reservoir (new dam) - 750Ml	Reservoir	-23.0	7.0
S24b_450	Expansion of Val de la Mare reservoir (new dam) - 450Ml	Reservoir	-26.0	1.0
S15d	New groundwater abstraction: d. Pont Marquet	New abstraction	-18.0	-1.0
S9i	La Rosière desalination plant extension - Phase 1	Desalination	-11.0	1.0
S18	Bellozanne indirect treated effluent water reuse scheme	Water reuse	-23.0	-1.0
S14	Raw water infrastructure system enhancements (West-East Transfer)	Asset enhancement	-14.0	1.0
S-B1	Supply measures - Basket 1: Catchment Measures (S1, S2, S3)	Catchment management		31.0
S-B2	Supply measures - Basket 2: Treatment enhancement to target PFAS contaminated sources (S114, S6)	Asset enhancement	-12.0	-5.0

D-LMS	Leakage Management Software 1	Leakage Management	-8.0	16.0
D-APM	Leakage Advanced Pressure Management	Leakage Management	-8.0	16.0
D-MRS1	Leakage Mains Renewal	Leakage Management	-8.0	16.0
D-MRS2	Leakage Mains Renewal 2	Leakage Management	-8.0	16.0
D-MRS3	Leakage Mains Renewal 3	Leakage Management	-8.0	16.0
D-AT	Leakage Additional Technician	Leakage Management	-8.0	16.0
D-AL	Leakage AI Accoustic Logging	Leakage Management	-8.0	16.0
D-B11	Demand Basket 1 - Smart metering phase 1	Metering		5.0
D-B12	Demand Basket 1 - Smart metering phase 2	Metering		5.0
D-B3	Demand Basket 3 - planning regulation	Water Efficiency		11.0

3. Scenario development

To ensure that a plan is resilient to a range of plausible futures and uncertainties requires understanding of the sources of uncertainty including the uncertainty within the data and analysis steps as well as future uncertainties. Target Headroom is a commonly used approach to deal in part with some of these sources of uncertainty (see Appendix F). While this is a valuable technique to provide an overall allowance for uncertainty in a plan, it is useful to use scenarios to understand how different plausible alternative futures may impact the best-value plan.

It is not possible to predict exactly what will happen in the future and producing a best-value plan that responds to just one future cannot guarantee it will be the optimal strategy if an alternative future occurs. For this WRDMP we have made a distinction between the identification and use of scenarios and sensitivity tests as follows:

- **Scenarios** – describe the interplay of major drivers for change or uncertainty that may have a significant and long-term impact on our ability to have sufficient supplies available to meet demand. For instance, drivers include:
  - Population or demographics – changes in birth and death rates, employment trends or migration policies
  - Societal values – trends in customer priorities or water use behaviour
  - Climate changes – long-term changes in the weather that influences water supply availability and demand for water
- **Sensitivity tests** – explore the impact of specific policies, stresses, shocks or uncertainties (may be termed “what-if” tests). Rather than being designed to cover the range of potential outcomes these are often binary tests such as whether a specific scheme is implemented or not.

Figure 3-1 illustrates the approach to the use of scenarios in producing a robust and adaptive plan.

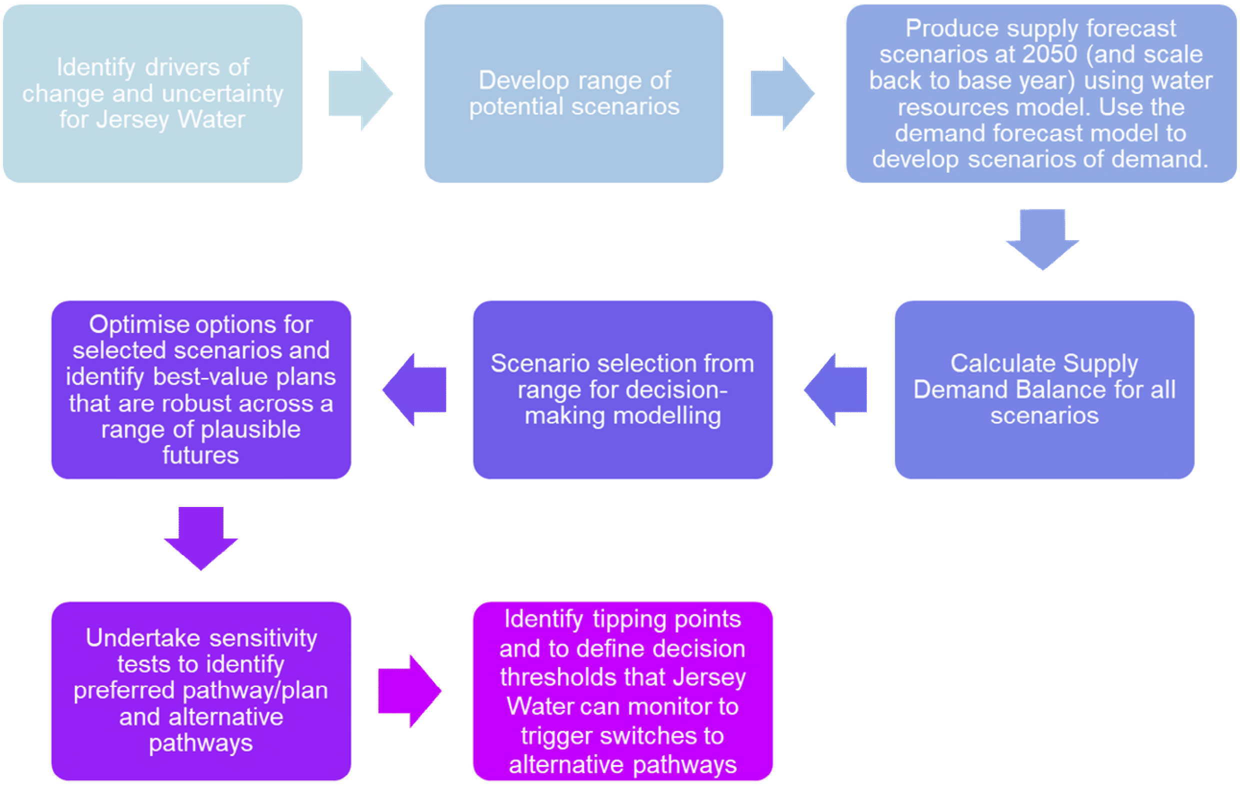

Figure 3-1 – Step-by-step approach to incorporating scenarios in adaptive planning approach

3.1 Scenario framework

Key drivers for change and uncertainty for our system may be factors that impact reliable supply, demand or both (see Appendix A Problem Characterisation). Table 3-1 summarises the key drivers of long-term uncertainty for Jersey. These are accounted for in different ways within the decision-making approach depending on the nature of the uncertainty.

Table 3-1 – Drivers of long-term uncertainty for Jersey and inclusion within decision-making approach. The drivers in blue represent those that form the core scenario framework.

Drivers	Description
Demand uncertainties	
Population and employment	Range of population projection scenarios modelled as part of the demand forecast.
Climate change	Impact of climate change on demand incorporated into the demand forecast
Difference between normal year and dry year demands (NYAA and DYAA)*	Normal and dry year demand forecast and incorporated as planning scenarios within the investment model.
Water-use behaviour change	A small variation in water-use behaviour as compared to base scenario has been incorporated into the Very High and Very Low scenarios.
Supply uncertainties	

Drought risk	Stochastic data used to understand drought risk across our system in terms of the impact this has on the deployable output of Jersey Water's sources. Varying levels of drought return period impacts included within the investment modelling to understand impact on plan.
Climate change	A range of climate projection scenarios are modelled and impact on supply estimated.
Hydrological uncertainty	Uncertainty in the DO assessment is considered a relatively significant component for this plan and this is covered in the Target Headroom value as a cross-cutting uncertainty affecting all possible futures.
PFAS regulation	We have considered the impact of varying levels of PFAS regulation as part of the sensitivity analyses of the preferred plan.

**See Section 4.1 for a description of these planning conditions*

Combinations of future uncertainties can quickly multiply so it is necessary to seek a balance between considering the key drivers and producing outputs that are meaningful and can be readily understood. We have therefore limited the drivers considered in the core scenario framework to the impacts of climate change and population growth.

3.1.1 Supply scenarios

The key supply uncertainties that make up the supply side scenarios are the impacts of drought and climate change on resources. The supply scenarios are produced by modelling changes in rainfall and PET (Potential Evapotranspiration) driven by these factors. Drought risk is explored through the generation and use of stochastic weather data, which provides long time series (≈20,000 years) of weather data based on the statistical characteristics of the historical record, and thus enables exploration and planning against different levels of drought resilience (see Section 2.1.1.1).

The impact of climate change is estimated through the calculation of change factors applied to the baseline stochastic data. The core of this approach is to analyse multiple climate scenarios to ensure that the range of possible climate futures is covered. Therefore, 12 separate sets of climate change factors have been used to produce the 12 supply scenarios.

The supply scenarios therefore represent a combination of climate change forecasts and a wide range of drought events (stochastic weather) including more extreme droughts than have been observed in the historic record but which could plausibly occur.

3.1.2 Demand scenarios

The demand scenarios are produced by altering assumptions within the demand forecast model (see Appendix E).

Population change

Changes in population can have a large impact on the level and pattern of demand. Statistics Jersey produce population forecasts for the island. The latest population projections[2] cover 2023 – 2080 and include five different future scenarios based on different set levels of net migration every year over the projection period. These are:

- -100 net migration: where 100 people leave the island over and above the number that arrive
- Net nil migration
- +325 net migration: where 325 arrive on the island over and above the number that leave
- +700 net migration
- +1000 net migration

Normal and dry year demand

Demand (and supply) can vary significantly between a 'normal' year and a dry year. We allow for the impact that this may have on option utilisation and cost which can affect the best value strategy. The investment modelling therefore includes allowance for changes in demand during a normal year (normal year annual average – NYAA) and dry year (dry year annual average – DYAA).

Water-use behaviour change

The impact of changes in water-use behaviour on demand over time is potentially a significant uncertainty. This can cover changes in water use as a result of, for example, changes driven by changes to water using appliance efficiencies, through housing regulations, per capita consumption (PCC) reduction targets, and the impact of Covid on usage patterns. There is limited new development on Jersey and customers already have relatively low PCC levels, therefore this is not expected to be a significant driver for change for this WRDMP. However, we have included some allowance for water use behavioural change against the existing baseline in the very high and very low demand scenarios. We have also included a sensitivity test looking at the impact of further PCC reductions (down to a PCC of 110 litres per person, per day by 2035 in a dry year).

Climate change

The relationship between water used by customers and climate change is hard to quantify and is not likely to be constant over time. Given the lack of updated science in this area, an estimated constant impact is often used. We have taken a pragmatic approach mapping Low, Medium and High climate impacts to the relevant grouped 12 supply scenarios.

3.2 Adaptive planning

The UK Water Resource Planning Guidelines state that "an adaptive plan is a framework which allows you to consider multiple preferred programmes or options. The adaptive plan should set out how you will make decisions within this framework". To achieve this, future scenarios and uncertainties need to be incorporated in a structured way to understand the impact on the overall WRDMP strategy.

Figure 3-2 illustrates the scenario build up and selection approach to identify five scenarios taken forward for investment modelling. These scenarios were selected to cover the range of plausible supply-demand balance futures across both climate change and population growth uncertainties. These are characterised as follows:

- **Very Benign** – this represents a very low population growth future (<= nil migration) and low climate change impacts

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[2] Published 20 December 2023

- **Benign** – this represents a future with low population (probably around nil net migration) and low to medium climate change impacts
- **Mid-Range** – the mid-range future spans a range of possible combinations that could include high climate change impacts but low population growth, low climate change impacts but high population growth or medium population and climate change impacts
- **Plausible Adverse** – this represents a future with likely high population growth (>= +325 net migration) and medium to high climate change
- **Reasonable Worst** – this represents a future with high population growth (>= +700 net migration) and high climate change impacts

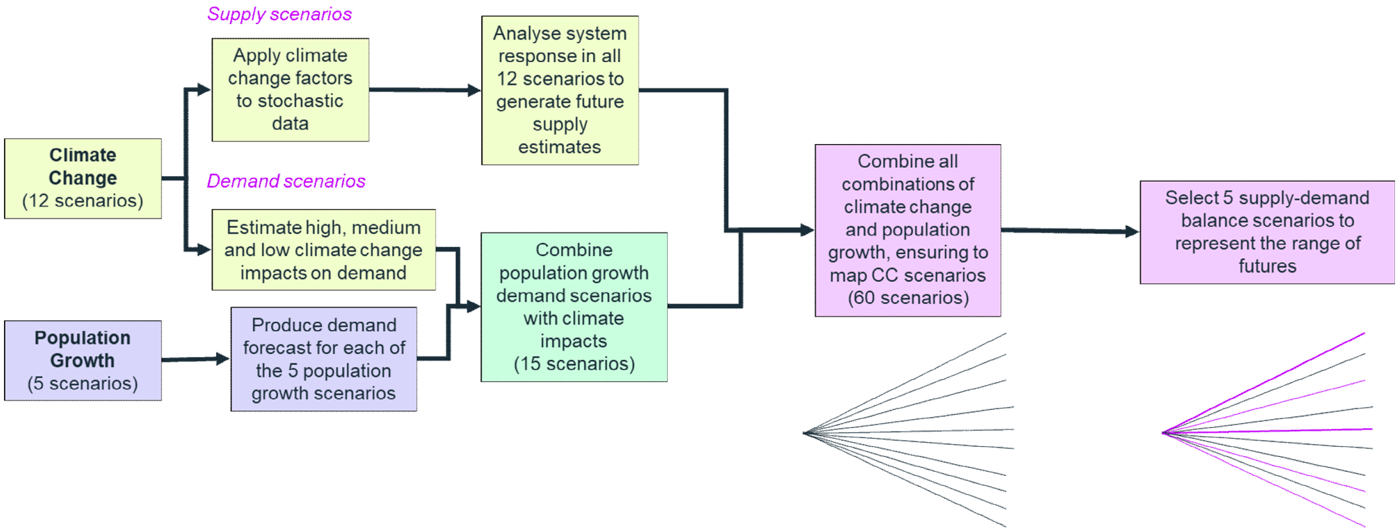

Figure 3-2 – Scenario build up and selection

To develop the adaptive strategy a best-value plan has been produced for each of the five scenarios. We have analysed the outputs of these scenarios to understand the impact of the different futures on the plan and if there are any least regrets options that are selected in all or most of the futures. In addition to this we have also carried out a series of sensitivity tests to understand the impact these may have on our preferred plan.

3.3 Sensitivity tests

We identified a set of sensitivity, or "what-if", tests to analyse specific policies, and to stress-test assumptions and uncertainties that are relevant to our plan. Depending on the sensitivity test the setup of these required either adjustments to constraints within the investment model or, in some cases, preparation of additional model inputs. Table 3-2 details the sensitivity tests that have been carried out.

Table 3-2 – Summary of sensitivity tests

Sensitivity	Reasoning	Mode of application	Additional inputs required?
La Rosiere desalination not available	This is a core part of our strategy, and this test seeks to understand our dependency on this scheme.	Constraint within the investment model.	No.
Bellozanne reuse not available	This looks to understand how sensitive our preferred plan is to change in Bellozanne reuse availability and/or cost.	Constraint within the investment model.	No.
Bellozanne reuse is 10% more expensive		Amend cost within the investment model	No.

Sensitivity	Reasoning	Mode of application	Additional inputs required?
Bellozanne reuse is 10% cheaper			No.
Both La Rosiere desalination and Bellozanne reuse options are not available	Test if there are sufficient options aside from these two large schemes.	Constraint within the investment model.	No.
Pont Marquet not available	Explore sensitivity of preferred plan to variations in the PFAS strategy.	Constraint within the investment model.	No.
Pont Marquet not available and PFAS treatment has a higher cost		Constraint within the investment model and amended cost to PFAS option.	No.
Force in PFAS treatment		Constraint within the investment model.	No.
Force in Trinity reservoir	This option has other benefits aside from purely water resource benefit and this test seeks to understand the impact on our preferred plan if it is chosen.	Constraint within the investment model.	No.
Explore plan sensitivity to cost of Trinity reservoir (e.g. 10% to 60% cheaper)		Amend cost within the investment model	No.
Impact of no Grands Vaux Reservoir or Vallee de Vaux source on the strategy	The proposed flood attenuation scheme would remove the benefit from these locations. This tests the impact and cost this could have on our strategy.	Additional 'dummy' option included in investment model representing SDB write-down.	Yes. Additional water resources modelling carried out to estimate impact on supply.
Impact of meeting Target 110 PCC level by 2035	This explores the benefit on our strategy of seeking to achieve ambitious PCC reductions.	Alternative demand forecast incorporated into SDB. Carried out on reduced set of future scenarios.	Yes. Additional demand forecast modelling carried out for described scenario.
Include draft values for La Gigoulande Quarry	This option was screened out during the options appraisal screening process, however using draft saving and cost values this test seeks to understand if it could be part of the plan, were it to become available as a plausible option.	Additional option included within investment model.	Yes. Additional option information required for La Gigoulande Quarry.

4. Investment model

The investment model has been developed by AtkinsRéalis based on the traditional Economics of Balancing Supply and Demand (EBSD) approach. This essentially uses a mixed integer linear programme (MILP) to understand the mix and schedule of options that will solve the supply demand balance in each year of the planning period for the least cost. In other words, the objective function is set to minimise total net present value.

In these types of models, the objective function could be set up to minimise or maximise any one of the metrics, not just cost. For example, it could be set up to maximise the SEA benefit score. However, the solvers are not able to optimise more than one metric at once. The approach that has been applied for Jersey Water's WRDMP therefore involves carrying out an initial least cost optimisation, recording the total Net Present Value[3] (NPV) cost of this run and setting up a second optimisation with the objective function set to maximise the aggregated benefit score of all other metrics subject to constraining the total NPV cost within a set tolerance of the least cost run. The tolerance factor can be adjusted through trial and error, but we identified that a 10% allowance was appropriate. This approach can be termed **hierarchical optimisation**.

The investment model is built in Python and uses the COIN-OR solver which is an open-source mixed integer solver written in C++.

4.1 Utilisation and planning conditions

Options in the investment model can be categorised into those that could be turned off when they are not required (e.g. desalination) and those that have to be maintained at a certain output. For the former schemes, a 'utilisation factor' is applied to reflect the reduced operations costs that could be obtained by only operating the schemes when they are needed (i.e. during drought conditions).

The investment model includes utilisation within its calculations by operating a simultaneous supply demand balance for more than one planning condition. These planning conditions relate to frequency of occurrence, in other words, 'normal year' versus 'dry year' or drought design event. These are known as the *states of the world* within the model[4]. The optimiser seeks the overall least cost for the plan that allows for the expected amount of time that the system would operate under each planning condition throughout the planning period. If a new scheme does not have to be operated during 'normal' conditions, then the scheme only incurs a proportion of the variable OPEX costs that would be required to meet drought conditions. However, there is also the functionality to include a DO minimum value for an option to represent cases where a plant needs to be kept operational even when not directly needed. Table 4-1 shows the states of the world that have been considered within the investment model alongside the associated utilisation factors. Utilisation factors have been calculated based on the associated return periods/probabilities of each state of the world as shown in Table 4-2.

Table 4-1 - States of the world for the investment model

State of the world	Return Period	Probability	Utilisation factor
Normal year annual average (NYAA)	2	0.5	0.639
Dry year annual average (DYAA)	10	0.1	0.300
Drought	100	0.01	0.055
Drought	500*	0.002	0.006

** We have also carried out separate runs with 200 as the highest drought return period*

[3] Net Present Value refers to a calculation that accounts for decreasing value placed on costs or benefits with time. The standard formula is $NPV = \frac{R_t}{(1+i)^t}$ where R^t is the cost/benefit, i is the discount rate and t is the years from the base year.

[4] States of the world can also include planning conditions related to timing within the year such as summer peak versus annual average, however Jersey Water's planning problem is not driven by peak conditions.

Table 4-2 – Calculation steps for the utilisation factor in example with three states of the world (where X_1 to X_3 represent increasing return periods)

Return Period	Probability	Utilisation factor
X_1	$1 / X_1 = P_1$	$1 - (U_2 + U_3)$
X_2	$1 / X_2 = P_2$	$(P_2 + P_1) / 2 = U_2$
X_3	$1 / X_2 = P_2$	$(P_3 + P_2) / 2 = U_3$

4.2 Discounting

We have followed the best practice guidance in terms of discount rates. The UK Water Resource Planning Guidelines provides the following instructions on discounting costs in the investment model: "You should calculate the net present costs and benefits using the Treasury standard declining long-term discount rate as set out in the HM Treasury 'Green Book'". This defines a discount rate of 3.5% for the first 30 years, 3.0% until year 75 and 2.5% until year 80. Discounting has been applied to both costs and benefits within the investment model prior to undertaking the optimisation.

4.3 Whole life cost appraisal for decision-making

We have applied a whole life cost approach to inform the decision-making process that has incorporated an understanding of the asset deterioration over the long-term and discounting effects. Estimated option CAPEX costs were disaggregated into the contributary costs from each asset life category as follows:

- Instrumentation assets
- Mechanical and electrical assets
- General civil engineering assets
- Pipeline and desalination assets
- Dams / reservoirs assets

Costs arising within each category were multiplied by an 'Annuity Factor' derived from the asset lifespan and a weighted average discount rate of 3.23% across an 80-year period to arrive at a fixed annual equivalent CAPEX cost value, otherwise termed an annuitised CAPEX cost, for use in the decision making.

Option OPEX costs were applied to each year following option implementation either as a fixed cost or variable within each of the modelled states of the world. For variable costs the utilisation factor outlined in Section 4.1 above was used to calculate the total estimated cost.

4.4 Inflation

Option Net Present Cost will be prepared using the 'real' terms cash flow without adjustment for inflation for any planned future expenditure. This is in line with the HM Treasure Green Book 2022 that makes reference to the requirements of using real cash flow without inflation for this purpose.

4.5 Optimisation for best-value planning

The investment model uses the COIN-OR solver to find the optimal solution to the objective function defined by the MILP. To produce the best-value plan that considers the multiple metrics our approach is as follows:

1. Produce an initial optimised plan against least cost
2. Take the least cost value and perform a second optimisation aimed at maximising the aggregated benefit score but within x% of the least cost solution. (For instance, constrain the model to not increase cost by more than 10% from our least cost level).

This approach allows the costs, benefits and trade-offs between the different plans be explored. We have also been able to do additional variations on this to, for example, optimise against a sub-set of the benefits to find the optimal Environmental and Social plan.

4.6 Model operation

4.6.1 Data inputs

The investment model requires several inputs which are listed below:

- Supply demand balances for each future scenario (5 scenarios selected as described in Section 3.1) as well as for each planning condition (such as NYAA, DYAA, as described in Section 4.1),
- Available options, including their costs, benefits, dependencies, construction times, etc., and
- Specific run parameters and constraints such as any additional constraints required as part of sensitivity tests, metrics to optimise, etc.

Excel templates have been used to manage the collation of all input data.

4.6.2 Execution

The model is run in the command line by calling on the Python scripts.

4.6.3 Data outputs

Data outputs consist of Excel spreadsheets with tables detailing option selection and year as well as plan scores against all metrics. Additional processing scripts are used to collate and analyse the outputs to assist with identifying the least regrets options and adaptive pathways.

Timeline visualisations of option selection have also been produced as part of the investment modelling output.