Gate 2 Submission: Supporting Technical Report

Annex 4: Water Resources Modelling

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Executive Summary

Introduction

The Water Resources Management Plan (WRMP) 2019 sets out Southern Water's response to the water supply challenge in the western region. The response consists of a strategic new supply source, new and increased bulk supplies from neighbouring water companies, demand management, and new strategic transfer pipelines across the region. Southern Water commissioned a water resources modelling study prior to Gate 1 to confirm the impact of licence reductions under various scenarios required for desalination, water recycling and alternative configurations (Havant Thicket). Phase 1 of the water resources modelling study was completed to support the RAPID Gate 1 submission in September 2020.

This document describes the objectives, methodology and results of the second phase, Phase 2, of the water resources modelling study and how its outputs have informed the required capacity of the strategic new supply source. Phase 2, as outlined in the Annex 07 Strategic Modelling report in the Gate 1 submission, builds on the progress completed in Phase 1 using the same water resources modelling approach to support the RAPID Gate 2 submission.

1 in 200-year Drought

Phase 2 of the water resources modelling study was limited to investigating the impact of a 1 in 200-year drought as defined in WRMP19. Limitations in the [redacted] modelling software restrict the ability to investigate 1 in 500-year droughts. Future modelling studies are expected to use the 'Pywr' WRSE regional model and will therefore be better positioned to analyse the impact of a 1-in-500-year drought. Annex 12, Outline Option Evolution Plans, reports on how the Future Needs Assessment has taken the results of the water resources modelling study and reviewed them against the emerging results from WRSE to consider the possible impact of a 1-in-500-year drought up to 2040.

Supply-Demand Balance: Recalculated Residual Deficit

During Gate 2, a supply-demand balance calculation was undertaken to define the effect that supply and demand interventions described in WRMP19 have on the supply-demand deficit. The calculation is used to inform the required capacity of the strategic new supply source (such as a water recycling plant) by calculating the *residual deficit* once all other elements of WRMP19 have been included.

As the water resources modelling study progressed, the water resources model has been further developed and Southern Water's understanding of the elements and assumptions in the supply-demand balance calculation has improved. Key changes to assumptions are the revised approach to calculating process and outage losses (described in the Gate 1 submission) and the inclusion of wastewater treatment works discharges in river flow series data. This led to a change to the magnitude of the residual deficit that informs the water resources modelling study; the *recalculated residual deficit* based on this work was **51 Ml/d** (as of 27th September 2021 – the original Gate 2 date).

Supply-Demand Balance: Future Needs Assessment

During the Gate 2 Interim Update, a review was undertaken to assess expected future need, as part of a Future Needs Assessment. The purpose of the review was to define the most appropriate scenario to be modelled as an input to the engineering design process. A boundary date of 2040 was agreed, as elements becoming relevant beyond this date have a higher degree of uncertainty and therefore could not reliably inform infrastructure capacity specifications. Elements forecast with a high degree of certainty in 2040 were identified and incorporated into the supply-demand balance calculation to produce a revision to the magnitude of the residual deficit. The *revised residual deficit* is **83 Ml/d,** and it is this figure that is considered most appropriate to inform the required capacity of the strategic new source. An additional allowance of 5% for process losses at Otterbourne WSW will need to be included in the capacity of the strategic new source.

The results of the assessment are presented in Section 3 and Section 4 and are summarised below.

Revised Residual Deficit and Strategic New Source Required Capacity

The revised residual deficit informs the required capacity of the strategic new source. Capacities of new sources required to resolve this revised residual deficit have been identified and are described below:

Table 1 - Capacities of new sources

	Option A.1/A.2		Option B.2/B.5		Option B.4		Option D.2	
Residual Deficit	Resolves Deficit?	Required Capacity (Ml/d)	Resolves Deficit?	Required Capacity (Ml/d)	Resolves Deficit?	Required Capacity (Ml/d)	Resolves Deficit?	Required Capacity (Ml/d)
Recalculated 51 Ml/d – excluding process losses	✔	51	✔	51	✔	0	Yes	0
Recalculated 51 Ml/d – including process losses	✔	51	✔	54	✔	0	Yes	0
Revised FNA 83 Ml/d - excluding process losses	-	-	✔	83	✔	25	No	N/A
Revised FNA 83 Ml/d – including process losses	-	-	✔	87	✔	25	No	N/A

1. Background and objectives

The aim of Phase 2 of the water resources modelling study was to aid the design of the wider Water for Life Hampshire solution by informing, in conjunction with the separate hydraulic network modelling study, the optimal configuration of assets to resolve the supply-demand deficit. Ultimately the two combined studies have helped to inform the size and configuration of infrastructure and non-infrastructure assets to be constructed.

The water resources model informs the capacity of the SRO at a strategic level in terms of the volume of water required per day, and the hydraulic model informs how the water is to be transferred at an operational level through the new transmission network to demand centres.

The hydraulic modelling study is described within the Network Infrastructure section of Annex 1 Desalination, Annex 2 Water Recycling and Annex 3 Havant Thicket. Phase 2 of the water resources modelling study builds on the progress completed in Phase 1, which informed the RAPID Gate 1 submission, using the same water resources modelling approach to support the RAPID Gate 2 submission. Phase 2 continued to use the Southern Water water resources model that was configured for Phase 1, using [redacted] water resources modelling software.

Several different options were modelled as part of Phase 2 of the water resources modelling study:

- A.1, A.2 Desalination (75 Ml/d, 61 Ml/d) to Testwood WSW
- B.2 Recycling (61 Ml/d) to Otterbourne WSW
- B.4 Recycling to Otterbourne WSW via Havant Thicket (Havant Thicket / Water Recycling Plant conjunctive use)
- B.5 Recycling (75 Ml/d) to Otterbourne WSW
- D.2 Havant Thicket alternative use (direct raw water transfer).

Study Boundaries

The Phase 2 of the water resources modelling study was limited to investigating elements and boundaries defined in WRMP19. The study focused on the impact of a drought with a return period of 1-in-200-years and includes two scenarios of daily operation and severe drought operation. No intermediate droughts have been investigated.

The WRSE regional water resources modelling studies will incorporate impact of a drought with return period of 1-in-500-years, but limitations in the [redacted] model have restricted the ability to include such a scenario in Phase 2 with adequate accuracy. [redacted] is limited to 2000-year time-series data which reduces the confidence level associated with modelling 1-in-500-year droughts.

Some of these drought impacts are also included in Environmental Destination scenarios explored by WRSE modelling (i.e. the reduction from ED is the same and not additive). We know that the WRP capacity can be increased to accommodate future deficits. WRSE modelling is the proper first step to consider the best regional response to these impacts that need to be addressed in 2040. It is anticipated that future modelling studies will align more closely with WRSE regional modelling to include Portsmouth Water and to investigate the impact of scenarios and boundaries identified in WRMP24 and will be better positioned to analyse the impact of a 1-in-500-year drought.

The FNA, summarised in Annex 12, has taken the results of this Phase 2, 1-in-200-year drought water resource modelling work, and reviewed against the emerging results from WRSE for both Southern Water and Portsmouth Water to consider the possible impact of a 1-in-500-year drought up to 2040.

The proposed Thames Water to Southern Water transfer has not been included in the Phase 2 water resources modelling study, as it will not be available before 2040 and therefore is not a viable option for addressing the deficit during the period to 2040. It is anticipated that this will be explored further in future WRSE/WRMP24 water resources modelling studies to mitigate deficits beyond 2040.

Key processes in Phase 2 of the water resources modelling study included:

- *Alignment of water resources model structure with hydraulic network model*

Demand centres were aligned in the two models (the water resources mode and the hydraulic network model) so that their total demands were equivalent in any discrete zone. Regional transfers between zones were aligned in both models. Both models were expanded to include Andover and the Isle of Wight.

- *Alignment with WRSE model*

New water resource models are being developed for the whole of the South East for WRSE in order to optioneer the preferred strategy for the Regional Plan. Phase 2 of the water resources modelling study shows alignment with these regional models as far as practicable and appropriate, as it was desirable for the model to align as closely as practicable to the WRSE models. The project team liaised with WRSE regarding model configuration to ensure consistency.

- *SRO capacity analysis*

Analysis was undertaken as part of Phase 2 of the water resources modelling study to inform the capacity of the strategic new source required to resolve the supply-demand deficit, according to the supply and demand interventions described in WRMP19. The results are presented in Section 3.

2. Methodology

2.1. Process Undertaken

2.1.1. Phase 2 Water Resources Model Development

An independent review of the Phase 1 model, which informed the RAPID Gate 1 submission, was carried out by an external consultant and concluded that the model was operating as expected and no further changes were necessary. The assumed costs which are used to enforce the order in which sources are utilised were updated to better reflect up to date operational reality. Abstraction Licence information was taken from existing licences and remains unchanged from the information used in WRMP19. Source DOs, sustainability reductions, and climate change impacts were taken from the supply-demand balance (SDB) spreadsheet (this defines the supply and demand elements used in WRMP19 and calculates the regional deficit/surplus). Process losses and outage allowances for each source were taken from the SDB spreadsheet.

The Isle of Wight WRZ was copied and joined with the Western Area model to simulate the operation of the Isle of Wight in combination with the Hampshire zones.

Following a review of the Phase 2 water resources model abstraction impact factors used to quantify how much impact a groundwater abstraction has on neighbouring watercourses; a subsequent examination of the whole water balance was undertaken. An important component of this was the inclusion of wastewater treatment works discharges to river flows. Discharges had not been included in previous modelling of the Southern Water Western Area and were not included in the Phase 2 water resources model, which had been based on the earlier water resources modelling studies. To be consistent with the approach taken for WRSE regional modelling the model was updated to include discharges. The impact of this change is described in Section 3.

In Phase 1 of the water resources modelling study, the MDO demands were applied as an average demand to which the established annual demand profiles were applied. For Phase 2, the representation of demand has been improved by calculating an appropriate weighted average that offers the best fit over both MDO and PDO periods. For Phase 2, the model has been updated to better reflect the operational considerations of maintaining water treatment process streams, transfers, and pipelines. As such, transfers and SRO sources were given minimum operating flows.

2.2. Method

The Phase 2 water resources model makes use of a series of 2000-year stochastic-generated flow time series developed to allow the assessment of droughts more extreme than those recorded in the historical record. The method uses the 2000-year stochastic data to test the system under a full range of realistic hydrological conditions. However, to examine system behaviour in detail it is useful to look at outputs during individual drought years. These events are discussed below.

2.2.1. Individual Droughts

The dynamic nature of the model means that deficit values differ as the system reacts to changes in model inputs. This means that different model runs will produce different 1-in-200-year droughts, and it is therefore time consuming to confirm such a result in an iterative “trial and error” modelling process as the 2000-year model runs take several days to complete. The 1-in-200-year drought can only be confirmed once the model run is complete and the 10 worst deficits have been identified (the 10th-worst being the 1-in-200-year drought in a 2000-year series).

However, within the 2000-year stochastic time series there are a number individual droughts with characteristics that reflect a return period of around 1-in-200-years. These individual droughts can be used to inspect results more rapidly for events representing a 1-in-200-year drought without having to undertake a full 2000-year model run. Four such individual events were selected from the 2000-year record, based on their drought characteristics which align most closely to a 1-in-200-year drought. Details of these are shown in Table 2.

Table 2 - Modelled drought events representing a 1-in-200-year drought

Year	WRMP19 DO (Ml/d)	**WRMP19 DO Return Period**	River Test Min Flow (Ml/d)	**River Test Min Flow Return Period**	River Itchen Min Flow (Ml/d)	**River Itchen Min Flow Return Period**	24-month Rainfall Deficit (mm)	**24-month Rainfall Return Period**
3543	25.2	**1 in 200**	326.8	**1 in 125**	82.0	**1 in 167**	-149	**1 in 149**
4315	28.6	**1 in 182**	303.4	**1 in 250**	81.9	**1 in 182**	-574	**1 in 204**
4644	35.1	**1 in 143**	309.6	**1 in 182**	82.3	**1 in 143**	-683	**1 in 1694**
3168	24.7	**1 in 222**	329.5	**1 in 118**	86.0	**1 in 77**	-531	**1 in 103**

2.2.2. Residual Deficit

WRMP19 has determined maximum deficits in a 1-in-200-year drought during peak demand and minimum deployable output conditions. The Preferred Strategy in WRMP19 includes several interventions, which incrementally reduce the supply-demand deficit. These are shown in Table 3 and summarised in Figure 1. The WRMP19 Preferred Strategy is composed of a major strategic source, transfer elements such as a Portsmouth Water bulk supply and a South West Water transfer. On the demand side, the Preferred Strategy includes a major programme of demand reductions through measures such as leakage reduction and the SW water efficiency programme, Target 100 (T100), targeting a 100 l/d per capita consumption.

A supply-demand balance calculation identifies the effect that supply and demand interventions described in WRMP19 have on the supply-demand deficit. The calculation is used to inform the required capacity of the strategic new supply source by calculating the residual deficit once all other elements of WRMP19 have been included. The design capacity of the SRO in the Preferred Strategy in WRMP19 is 75 Ml/d, and this is defined as the WRMP19 design capacity residual deficit. This has been rounded up from the supply-demand balance residual deficit of 72 Ml/d to align with the WRMP19 preferred option and to better align with an anticipated modular approach to SRO design.

Table 3 - WRMP19 elements [1]

Baseline Ml/d MDO drought scenario, 10th percentile scenario			
Supply	Deployable Output		134
	Losses (-ve)	Sustainability Reductions	62
		Climate change	-2
		Outage allowance	6

[1] The data are a summarised version of those presented in Annex 2 of the Gate 1 submission.

		Process Losses	11
	Baseline Supply		57
Transfers		Existing transfers	5
Demand		Demand	218
Baseline supply-demand balance Ml/d			**-156**
Non-SRO Interventions Ml/d			
Demand Reduction	T100		7
	Metering		0
	Leakage reduction		11
	TUBs/NEUs		1
Catchment Management	River Test catchment		1
	River Itchen catchment		3
Bulk Transfer Schemes	PW World's End		9
	PW Havant Thicket		21
	South West Knapp Mill		20
New Supply Schemes	East Woodhay		1
	Sandown Water Recycling		9
Total Non-SRO Interventions Ml/d			**84**
Supply-Demand Balance Residual Deficit Ml/d			72
WRMP19 Design Capacity Residual Deficit Ml/d			**75**

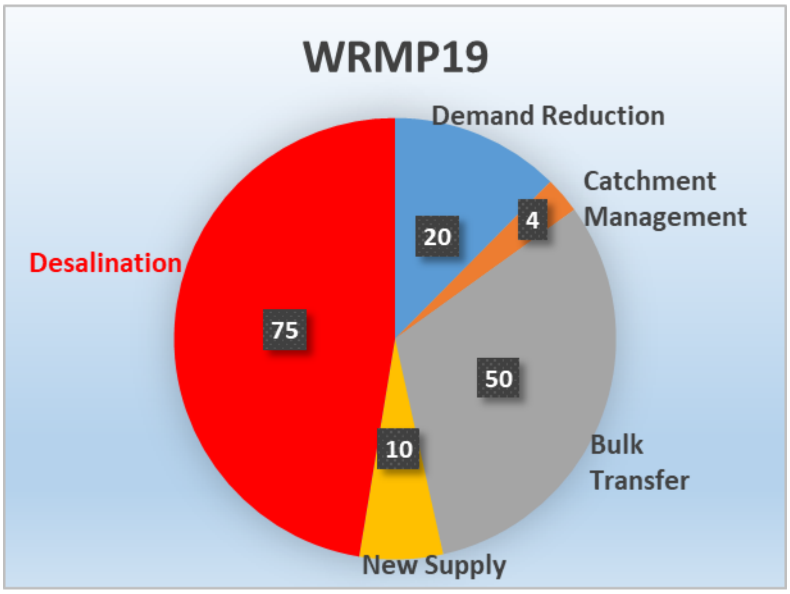

Figure 1 - Graphical summary of key elements contributing to the WRMP19 solution (values in Ml/d)

2.3. Assurance

To better ensure that modelling results were correctly representative throughout the study, an independent “rolling review” was undertaken by an external consultant as 2nd line assurance. The more immediate nature of the review taking place as modelling continued enabled the timely application of any amendments to the process as the modelling study developed, rather than a retrospective review once the study was complete and results already embedded in the project outputs. This enabled the earlier sharing of key modelling outputs with other WfLH teams and Portsmouth Water as the results are considered to have a high level of confidence. A separate, retrospective review of the modelling report (including the modelling approach and outputs) has also been undertaken. Neither review recommended any significant amendments.

3. Initial Results as of 27th September 2021

The results of Phase 2 of the water resources modelling study indicate a change to the magnitude of the residual deficit that informs the required capacity of the strategic new supply source. These changes are presented in Figure 2 and explained below. A description of the options modelled is provided in Table 4.

Table 4 - Summary of modelled Options

Option	Capacity (Ml/d)	Description	Comment
A.1	75	[redacted]	Modelled jointly with Option A.2
A.2	61		Modelled jointly with Option A.1
B.2	61		Modelled jointly with Option B.5
B.4	n/a		
B.5	75		Modelled jointly with Option B.2
D.2	n/a		

3.1. Supply-Demand Balance and Residual Deficit

Results are presented in Figure 2.

3.1.1. WRMP19 Residual Deficit

WRMP 19 includes a scenario generator and uses a form of Monte Carlo analysis to consider the wide range of uncertainties in the assumptions of the WRMP. The solutions from the 10th centile of the resulting distribution are used to form the basis of the WRMP Preferred Strategy. This implies that WRMP19 has built in risk mitigation by choosing a supply-demand balance more extreme than in the 50th centile.[2] This resulted in the SDB identifying a WRMP19 design capacity residual deficit of 75 Ml/d.

3.1.2. WfLH Phase 1 Modelling Residual Deficit

WRMP19 assumed that some plant at any time will not be available due to outage and process losses. Projections for process losses and outage were based on the performance of the existing asset base and were not linked to changes in the source yields resulting from sustainability reductions. When checked against the SDB, Southern Water found that this approach resulted in some source yields being written down to zero due to sustainability reductions, but outage and process losses still being applied in the SDB. Southern Water therefore decided to adjust the impacts of process losses and outage in proportion to the reduction in yield due to sustainability reductions. As a result, it was calculated through the Phase 1 work that the residual deficit was 61 Ml/d.[3] This was communicated in the Gate 1 submission in September 2020, within Annex 2 WRMP and Supply Demand Balance Risk Assessment.

3.1.3. WfLH Phase 2 Modelling Recalculated Residual Deficit

As explained in Section 2.1.1 the Phase 2 water resources model was amended to include wastewater treatment works discharges to rivers, to align with WRSE methodology. It was found that the previous methodology overstated the residual deficit, implying that any solution design based on this would be over-conservative, and that the recalculated residual deficit was 51 Ml/d.

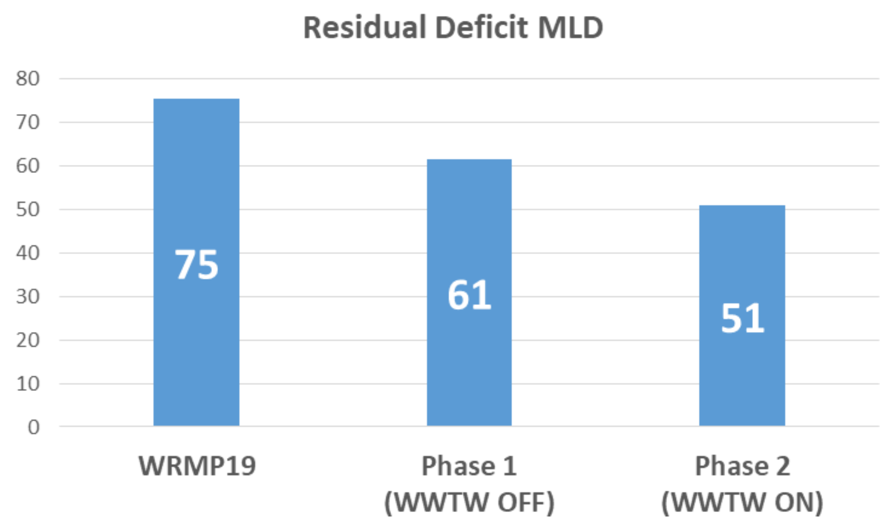

Figure 2 - Modelled Residual Supply-Demand Deficits (Ml/d)

[2] See Annex 2 of the Gate 1 submission, section 5.1 for a description of this approach.
[3] This value is the same as that described in Annex 2 of the Gate 1 submission.

3.2. Initial New Source Capacities

All results presented have been modelled using the WfLH Phase 2 Modelling Residual Deficit supply-demand balance assumption as described in Section 2. The model includes all deficit reduction impacts from demand management and supply augmentation schemes described in WRMP19.

3.2.1. Option A.1 and A.2

Approach

Option A was modelled as shown in Figure 3. The options represent the use of a new desalination plant, which would supply potable water to Southern Water's distribution network at Testwood WSW. The options simulate supply from the desalination plant at varying plant capacities; A.1 was modelled at a capacity of 75 Ml/d and A.2 at a capacity of 61 Ml/d.

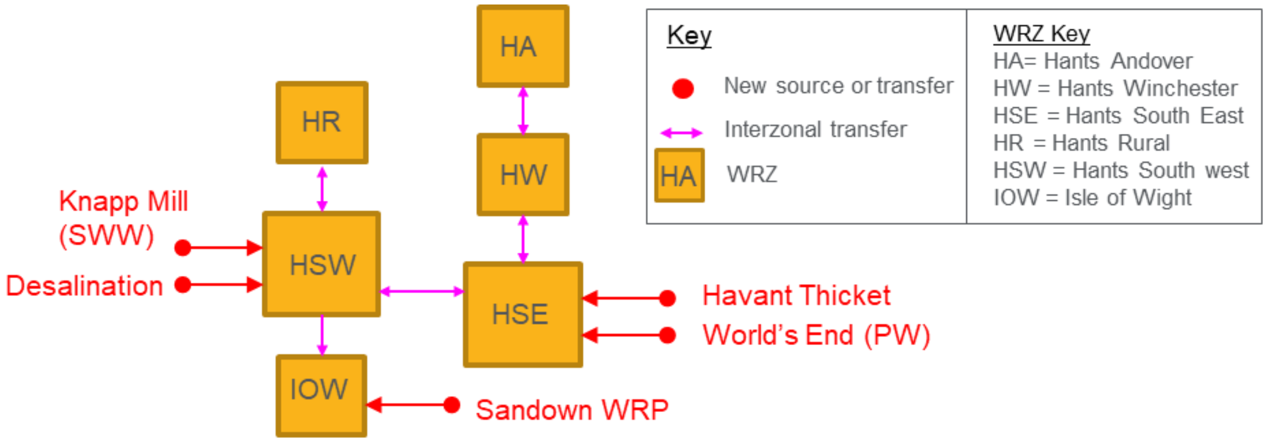

Figure 3 - Option A model schematic

Results

The results are shown in Figure 4. The graph shows new source outputs and transfer flows for different drought return periods throughout the 2000-year model run. The source outputs and transfer flows run at their respective sweetening flows or minimum operational outputs during normal operating scenarios, with the World's End transfer becoming operational slightly ahead of a 1-in-5-year drought, Gater's Mill transfer becoming operational slightly ahead of a 1-in-20-year drought, and the Knapp Mill and Havant Thicket bulk supplies becoming operational before a 1-in-50-year drought. The new SRO (desalination plant) becomes operational between a 1-in-50- and 1-in-100-year drought and reaches an output of approximately 50 Ml/d at a 1-in-200-year drought. The model results therefore indicate that a SRO of capacity 51 Ml/d would resolve the supply-demand deficit in a 1-in-200-year drought scenario.

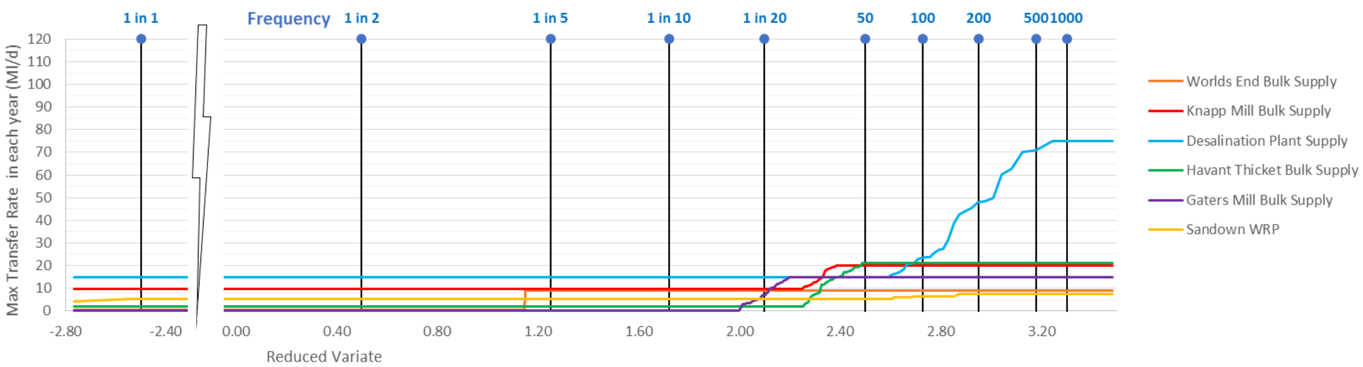

Figure 4 - Option A.1 model output showing maximum annual rates of supply for drought return periods

3.2.2. Option B.2 and B.5

Approach

Options B.2 and B.5 were modelled as shown in Figure 5. The options represent the use of a proposed new wastewater recycling plant, which would supply water to Southern Water at Otterbourne Water Supply Works (WSW) from Southern Water's [redacted]. The options simulate supply from the WRP at varying plant capacities; B.2 was modelled at a capacity of 61 Ml/d and B.5 at a capacity of 75.0 Ml/d.

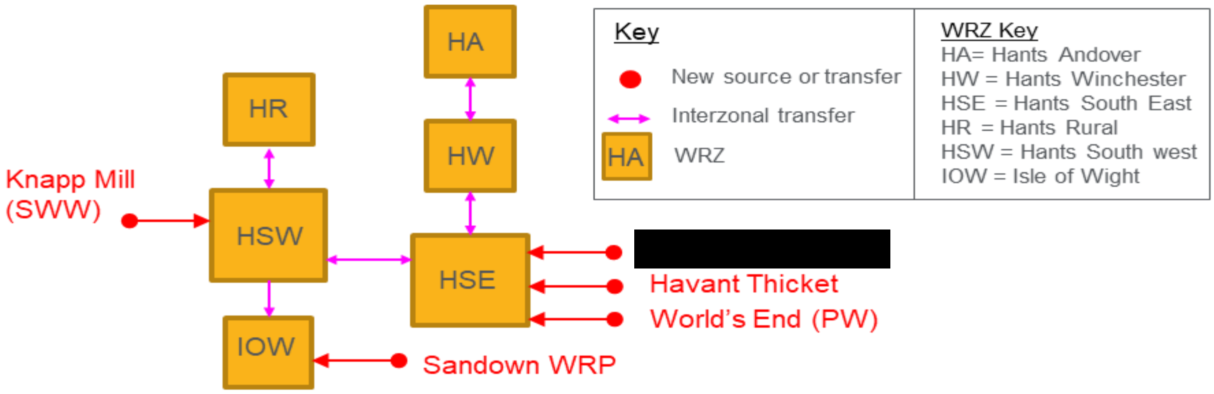

Figure 5 - Option B.2 and B.5 model schematic

Results

The results are shown in Figure 6. The graph shows new source outputs and transfer flows for different drought return periods throughout the 2000-year model run. The source outputs and transfer flows run at their respective sweetening flows or minimum operational outputs during normal operating scenarios, with the World's End transfer becoming operational slightly ahead of a 1-in-5-year drought, Gater's Mill transfer becoming operational slightly ahead of a 1-in-20-year drought, and the Knapp Mill and Havant Thicket bulk supplies becoming operational Between a 1-in-20- and a 1-in-50-year drought. The new SRO ([redacted]) becomes operational between a 1-in-50 and 1-in-100-year drought and reaches an output of approximately 50 Ml/d at a 1-in-200-year drought. The model results therefore indicate that a SRO of capacity 51 Ml/d would resolve the supply-demand deficit in a 1-in-200-year drought scenario.

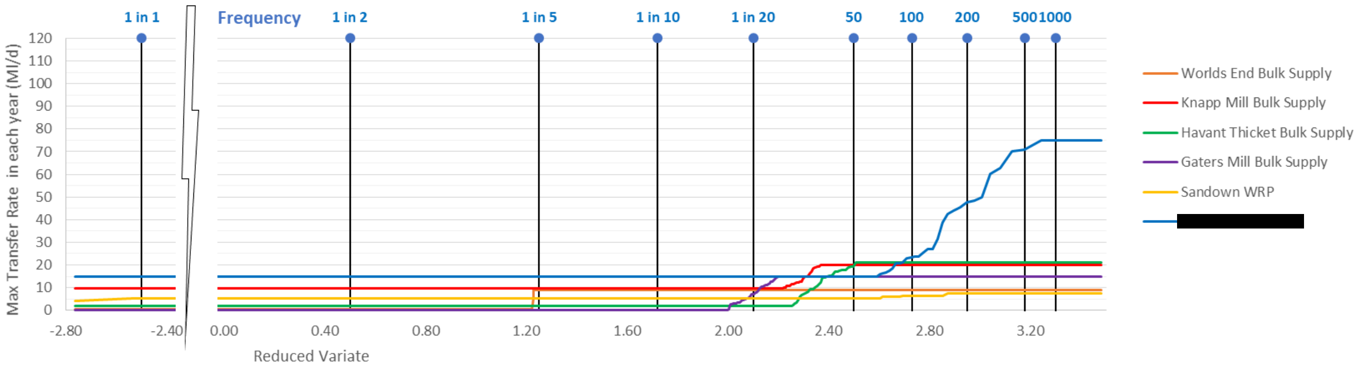

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Figure 6 Option B.5 model output showing maximum annual rates of supply for drought return periods

3.2.3. Option B.4

Option B.4 utilises a WRP to transfer water to Otterbourne WSW via Havant Thicket reservoir, with the WRP refilling the reservoir to recharge the used volume. As such it is to be used in conjunction with the storage in Havant Thicket reservoir, which is also refilled by [redacted] Modelling results for Option D.2 show that the available storage in Havant Thicket reservoir is itself adequate to resolve the recalculated residual deficit without further transfer from the WRP. Therefore using the Phase 2 recalculated residual deficit supply-demand balance assumption described in Section 2, Option B.4 aligns with Option D.2 as no further resource capacity is required from the WRP.

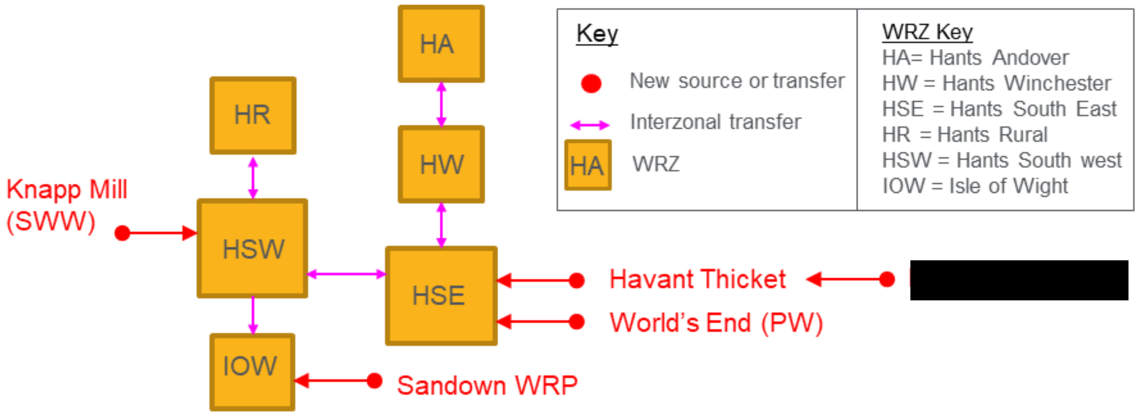

Figure 7 - Option B.4 model schematic

Option B.4 – Gate 2 Design Capacity

Section 3.2.4 describes how Option B.4 can resolve the supply-demand deficit without the need for a WRP. However, this result is dependent on the inclusion of wastewater treatment works discharges to river flows as described in Section 3 – a methodology that differs from that used to inform the RAPID Gate 1 submission. Southern Water's submission for Gate 1 stated that the capacity WRP required for Option B.4 was 61 Ml/d, as no benefit was taken from the storage within Havant Thicket, and the Phase 2 water resource study modelling has shown that this capacity is not required. To align with the methodology used to inform the RAPID Gate 1 submission (i.e. excluding wastewater treatment discharges to river flows), initial modelling was undertaken, with WWTW discharges turned off, to determine the RAPID Gate 2 WRP design capacity, which was set at 15 Ml/d for the April 2021 design freeze. Results of this modelling are presented in Figure 8 and Figure 9. Figure 8 shows how the solution resolves the deficit for a 1 in 200-year drought and Figure 9 shows that storage volumes in Havant Thicket remain above the minimum level (zero on the graph), indicating that the solution successfully resolves the 1 in 200-year drought deficit.

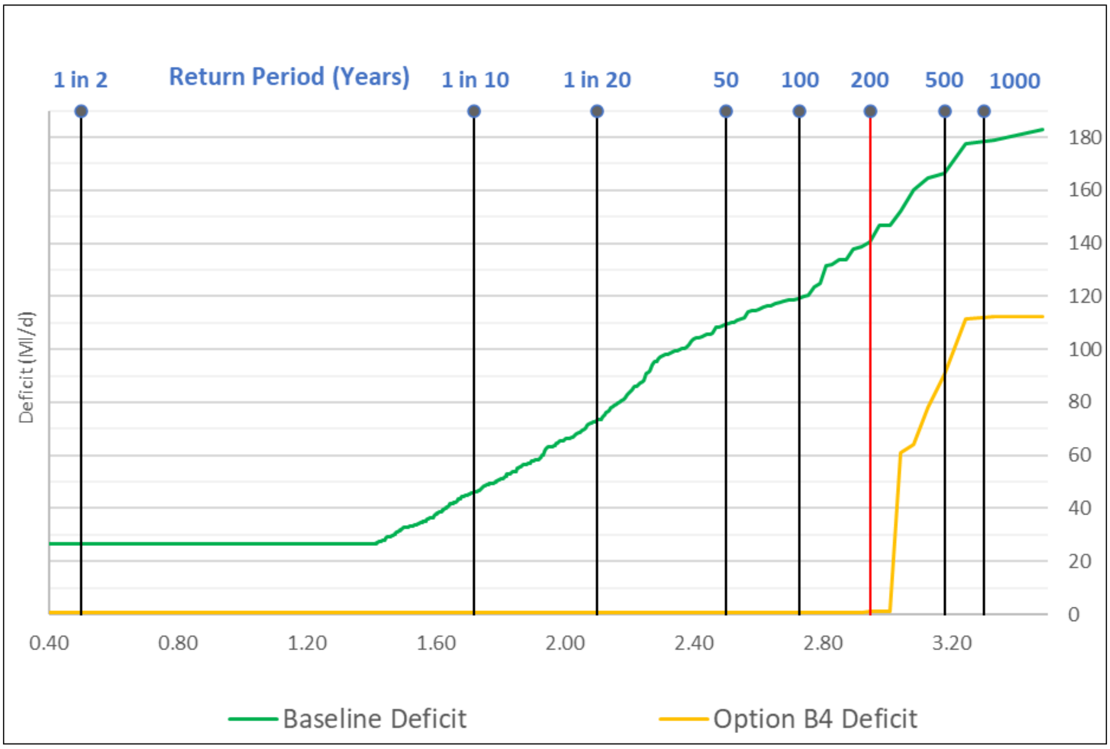

Figure 8 - Option B.4 15 Ml/d (WWTW Off) design capacity model deficits output for different drought return periods

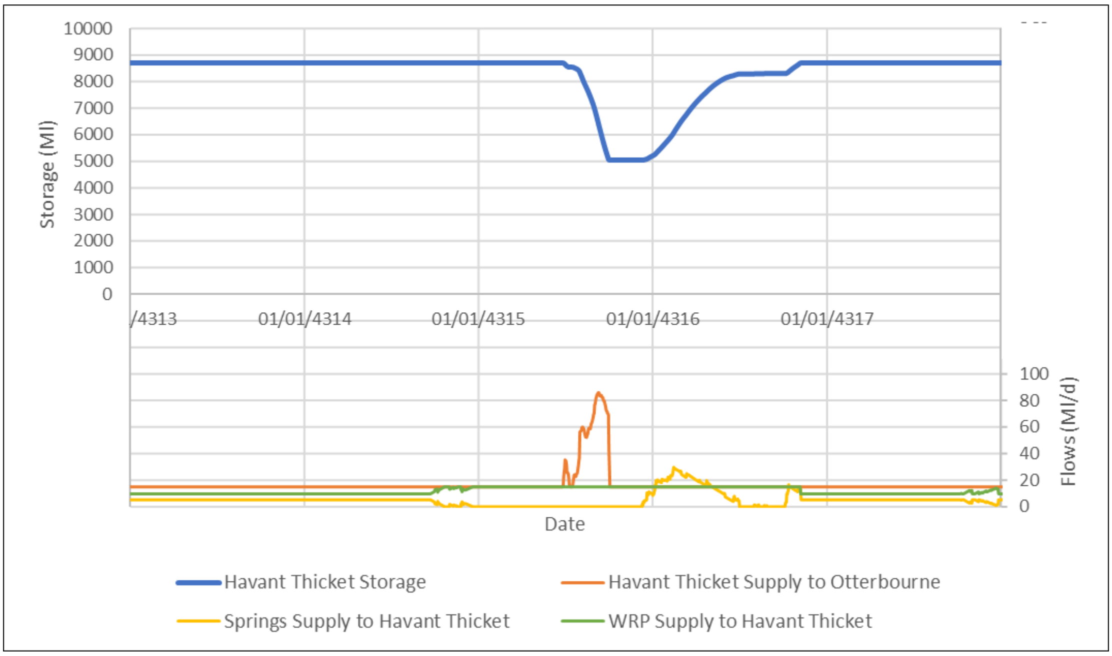

Figure 9 Option B.4 15 Ml/d (WWTW Off) – Havant Thicket storage and utilisation in a 1 in 200-year representative drought (drought year 4315)

3.2.4. Option D.2

Approach

Full utilisation of Havant Thicket reservoir is simulated in Option D.2, with a maximum available reservoir capacity of 8700 Ml (this maintains a minimum required level of water in the reservoir). The model was set-up as shown in Figure 10. As a modelling simplification the Havant Thicket Bulk Supply was disabled in this scenario and all Havant Thicket source water transferred directly to Otterbourne WSW as raw water. This is not likely to be the final preferred network configuration but this modelling change has no effect on water resources. A sweetening flow of 4.7 Ml/d was applied between Havant Thicket and Otterbourne WSW.

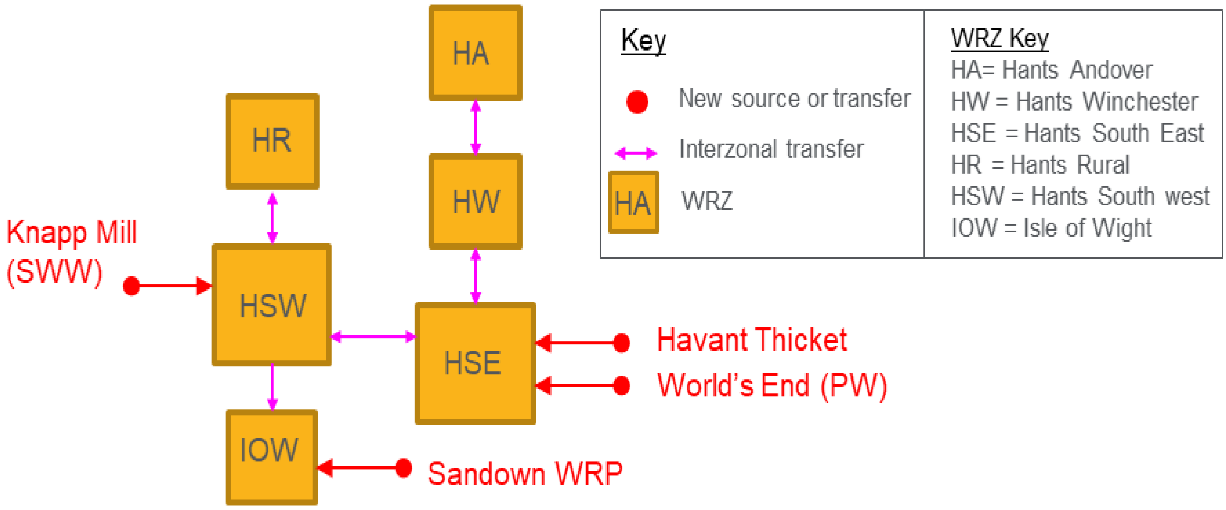

Figure 10 - Option D.2 model schematic

Results

The results are shown in Figure 10. The graph shows new source outputs and transfer flows for different drought return periods throughout the 2000-year model run. The source outputs and transfer flows run at their respective sweetening flows or minimum operational outputs during normal operating scenarios, with the World's End transfer becoming operational slightly ahead of a 1-in-5-year drought, Gater's Mill transfer becoming operational slightly ahead of a 1-in-10-year drought, and the Knapp Mill transfer becoming operational slightly ahead of a 1-in-20-year drought. The Havant Thicket bulk supply transfer becomes operational slightly after a 1-in-20-year drought and reaches an output of approximately 72 Ml/d at a 1-in-200-year drought. This equates to a Havant Thicket transfer of 21 Ml/d (this is included in all options as an element of WRMP19 as the "Havant Thicket Bulk Supply") in addition to that of 51 Ml/d in alignment with the recalculated residual deficit figure. For simplicity, these transfers were modelled as one as they both had the same Southern Water receiving point at Otterbourne WSW. The model results therefore indicate that a strategic new transfer source of capacity 51 Ml/d would resolve the supply-demand deficit in a 1-in-200-year drought scenario.

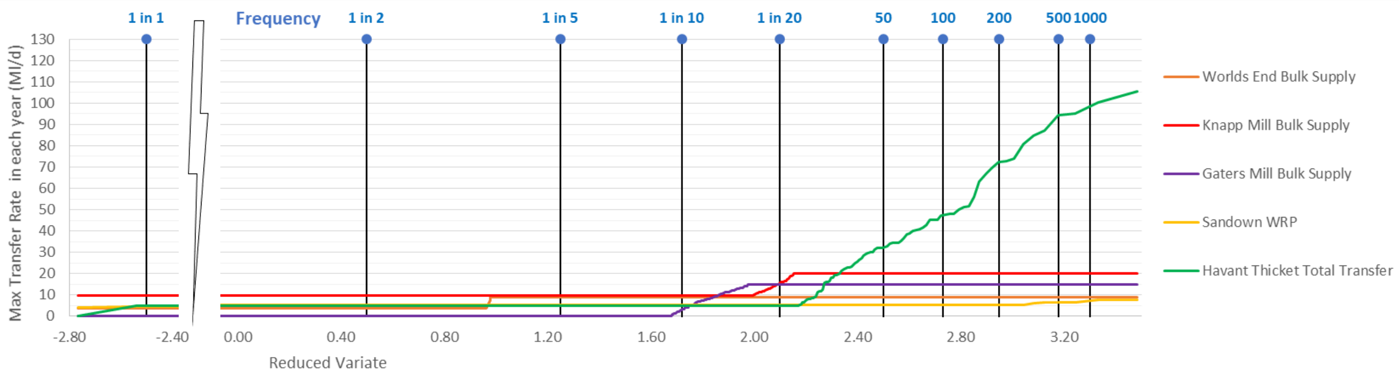

Figure 11 - Option D2 model output showing maximum annual rates of supply for drought return periods

Figure 12**Error! Reference source not found.** shows how the Havant Thicket winter storage reservoir and raw water transfer reacts to each of the four individual drought events identified (representing a 1-in-200-year drought) and shows how much the reservoir storage is drawn down. The graph shows that none of the drought events breach the minimum storage level in the reservoir (zero on the graph), indicating that the reservoir has adequate capacity to resolve the residual supply-demand deficit during a 1-in-200-year drought.

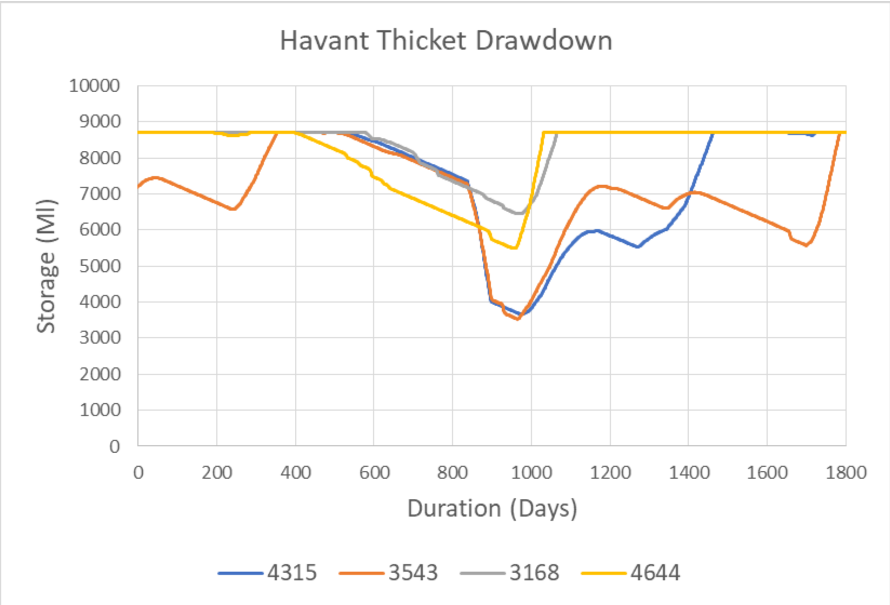

Figure 12 - Drawdown of Havant Thicket reservoir during individual drought events (representing a 1-in-200-year drought). The storage volume represents total storage available for use.

3.2.5. Water Resource Benefit

Table 5 - Water Resource Benefit

Option	Benefit (Deployable Output) Ml/d	Comment
A.1	75	
A.2	61	
B.2	61	
B.4	n/a	See note below
B.5	75	
D.2	n/a	See note below

Table 5**Error! Reference source not found.** presents the water resource benefit of each option, this being defined as the water into distribution after the application of any losses due to process etc. Options B.2 and B.5 represent the volume of potable water available for use at the output from Otterbourne WSW, having been transferred to the WSW as raw water prior to process losses, and Options A.1 and A.2 represent the volume of water at the output of the desalination plant as potable water after any losses due to the plant processes. Options B.4 and D.2, however, cannot be represented in the same way due to the characteristics of the [redacted] model. The water available for use is determined by dynamic relationship of the drawdown of water stored in Havant Thicket impounding reservoir against time (the duration of the drought event). The [redacted] model is demand-driven, which means the volume of water drawn from the reservoir is limited by the amount of residual demand needing to be met, and a maximum possible volume available for use cannot be measured. Instead, the model confirms that the volumes being drawn from the reservoir are adequate to meet the residual demand in the scenario being modelled and therefore resolve the supply-demand deficit.

3.3. Utilisation – 51 Ml/d Residual Deficit

An analysis was undertaken to identify the frequency of use of the proposed new SRO for the recalculated residual deficit of 51 Ml/d, and figures for maximum daily supply, annual days of operation and total volume transferred annually are presented below. Results for Options A.1 and A.2 are identical and are presented together, as are results for Options B.2 and B.5.

3.3.1. Option A.1/A.2

Table 6 - Option A.1/A.2 utilisation

Drought Return Period (years)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)
1	15	0	5475
2	15	0	5475
5	15	0	5490
10	15	0	5490
20	15	0	5490
50	15	0	5490
100	24	16	5537
200	48	49	6275

Commentary on Option A.1/A.2 Results

During normal daily operation the asset will operate on a minimum flow of 15 Ml/d. As drought severity increases the asset will be called upon to output increased volumes, with the desalination plant starting to operate above its minimum flow during a drought with an approximate return period of 65 years. During a drought with a return period of 100 years the plant will operate above minimum flow for 16 days in a 365-day period, and in a 1-in-200-year drought the plant will be operating at or near its full capacity for 49 days in a 365-day period.

3.3.2. Option B.2/B.5

Table 7 - Option B.2/B.5 utilisation

Drought Return Period (years)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)
1	15	**0**	**5475**
2	15	**0**	**5475**
5	**15**	**0**	**5490**
10	**15**	**0**	**5490**
20	**15**	**0**	**5490**
50	**15**	**0**	**5490**
100	**24**	**16**	**5537**
200	**48**	**49**	**6275**

Commentary on Option B.2/B.5 Results

During normal daily operation the asset will operate on a minimum flow of 15 Ml/d. As drought severity increases the asset will be called upon to output increased volumes, with the water recycling plant starting to operate above its minimum flow during a drought with an approximate return period of 65 years. During a drought with a return period of 100 years the asset will operate above minimum flow for 16 days in a 365-day period, and in a 1-in-200-year drought the asset will be operating at or near its full capacity for 49 days in a 365-day period.

3.3.3. Options B.4 and D.2

As described in section 3.2.3 Option B.4 does not require a WRP to meet the recalculated residual deficit, and therefore the option is identical to Option D.2. Results for both are presented below. For modelling simplicity Options B.4 and D.2 were modelled with a single raw water transfer from Havant Thicket to Otterbourne WSW, which included the WRMP19 Portsmouth Water 21 Ml/d Havant Thicket bulk transfer. In other options this is modelled as a separate transfer. The results below exclude the 21 Ml/d transfer (i.e. the equivalent flow and volume have been removed from the values) to allow a like-for-like comparison with Options A.1/A.2 and Options B.2/B.5.

Table 8 - Option B.4/D.2 utilisation

Drought Return Period (years)	Maximum Daily Supply (Ml/d) Exc. 21 Ml/d potable transfer	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml) Exc. 21 Ml/d potable transfer
1	5	0	1715
2	5	0	1715
5	5	0	1720
10	5	0	1720
20	5	0	1720
50	11	27	1144
100	27	52	1271
200	51	100	2844

Commentary on Option D.2 Results

During normal daily operation the transfer from Havant Thicket to Otterbourne WSW will be 5 Ml/d. As drought severity increases the transfer will increase during a drought with an approximate return period of 23 years. During a drought with a return period of 100 years the transfer will operate above minimum flow for 52 days in a 365-day period, and in a 1-in-200-year drought the transfer will be operating above minimum flow for 100 days in a 365-day period.

3.3.4. Bulk Transfers

An analysis has been undertaken to identify the frequency of use for bulk transfer imports. The results are shown in Table 9. The results are consistent for all options.

Table 9 - Bulk transfer imports utilisation (*sweetening flow)

	PW Havant Thicket Potable Transfer			SWW Knapp Mill Transfer			PW World's End Transfer		
Drought Return Period (years)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)
1	2*	0	693	9.5*	n/a	3477	0.4*	0	146
2	2*	0	693	9.5*	n/a	3477	0.4*	0	146
5	2*	0	695	9.5*	n/a	3477	9	30	404
10	2*	0	695	9.5*	n/a	3477	9	68	731
20	2*	0	695	9.5*	n/a	3477	9	157	1496
50	21	21	849	20	n/a	3579	9	282	2571
100	21	43	1304	20	n/a	3825	9	315	2855
200	21	86	2017	20	n/a	4162	9	353	3182

The Havant Thicket potable water transfer becomes operational (above daily sweetening flow) during a drought with an approximate return period of 28 years and is operational for 86 days per year during a 1-in-200-year drought. The South West Water Knapp Mill transfer becomes operational (above daily sweetening flows) during a drought with an approximate return period of 28 years; data for annual days' operation were not available from the model results. The Portsmouth Water World's End transfer becomes operational (above daily sweetening flow) during a drought with an approximate return period of 4 years and is operational for 353 days per year during a 1-in-200-year drought.

3.4. Residual Supply-Demand Deficit

3.4.1. Recalculated Residual Deficit

Section 3.1 described how the residual deficit had been recalculated at 51 Ml/d. The modelling results show that to resolve the recalculated residual deficit in this scenario, the new source capacity required for Option B.4 is zero. These results are presented in Figure 13.

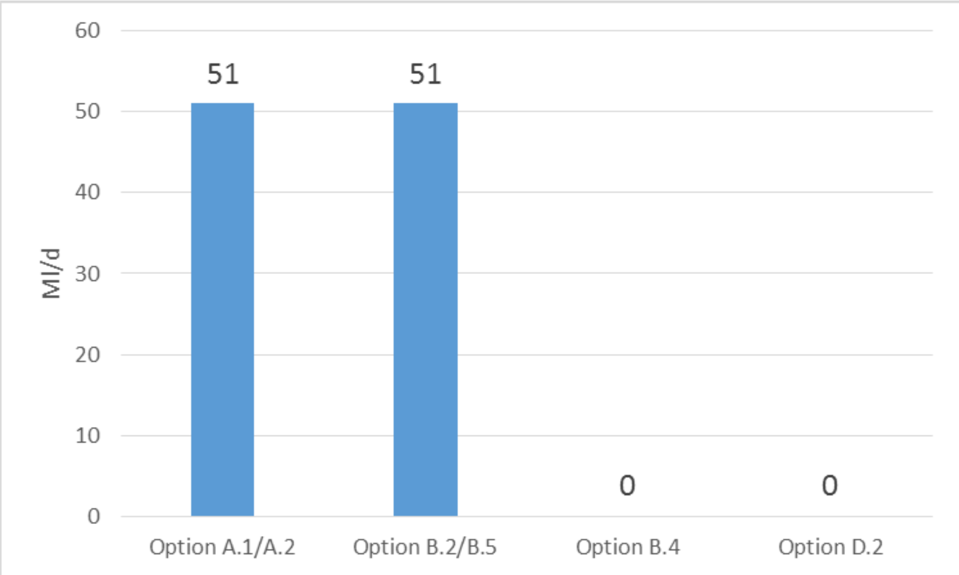

Figure 13 - New strategic supply source capacity (in addition to Havant Thicket reservoir) required for 51 Ml/d recalculated residual deficit

Figure 13 shows the capacity of the new source required to resolve the recalculated residual deficit of 51 Ml/d for different options. Options A.1/A.2 and B.2/B.5 each require a new source of capacity of 51 Ml/d. Options B.4 and D.2 are effectively identical under this scenario as Option B.4 does not require the WRP to resolve the residual deficit; the deficit is resolved using the raw water stored in Havant Thicket impounding reservoir.

4. Future Needs Assessment

4.1. Revised Residual Deficit - Future Needs Assessment

Following Southern Water's Interim Update, a review was undertaken to assess the risks to the required capacity of the new source as part of a Future Needs Assessment. The outcome of the review was to define the most appropriate scenario to be modelled as an input to the engineering design process to such elements as the capacity of the strategic new source, the raw water transmission pipeline and potable water transmission grid downstream from Otterbourne WSW. The design capacity of these elements requires defining to enable the engineering design process to remain on program.

A small working group was formed of strategy managers and SMEs covering aspects of water resources and supply-demand balance such as demand strategy, water resources planning, water strategy planning and risk management. This group identified elements in the supply-demand balance calculation with a relatively high degree of certainty of change within a visible timeframe. A boundary date of 2040 was agreed as elements becoming relevant beyond this date have a higher degree of uncertainty and therefore could not reliably inform infrastructure capacity specifications.

Elements considered during the review included:

- Outputs from current WRSE modelling
- WRMP24 development and the 1-in-500-year drought scenario
- The proposed Thames Water to Southern Water transfer
- Potential future exports from Havant Thicket to Portsmouth Water
- The environmental forecast and potential future sustainability reductions
- Outputs from the current CSMG study
- Outage allowance
- Bulk Transfer Imports.

The outcome of the review concluded:

<u>WRSE/WRMP24</u>

- Recent WRSE runs (1-in-100-year) are returning the Havant Thicket reservoir to Otterbourne WSW transfer at ~ 70 Ml/d, in line with the WfLH B.4 option. 1-in-500-year runs are returning the Havant Thicket reservoir to Otterbourne WSW transfer at ~ 40Ml/d with additional input from the TW transfer. Both 1-in-500-year scenario and TW transfer will be implemented after 2040 and are excluded from the SRO modelling.

<u>Thames Water to Southern Water Transfer</u>

- The Thames Water transfer will be implemented after 2040 and was excluded from the SRO modelling. A connection from the transfer will be included in network optimisation modelling to enable transmission infrastructure to be sized for future use.

<u>Exports to Portsmouth Water</u>

- Potential demand off Havant Thicket to Portsmouth Water Hoads Hill due to future sustainability reductions is uncertain and wasn't included in the SRO modelling. Its implementation is likely to be post 2040.
- Abstraction from [redacted] might potentially be restricted in a drought and outputs from groundwater modelling to estimate this restriction, and any consequent potential abstraction that Portsmouth Water might require to substitute it, will be included in the new source capacity sizing.

<u>CSMG</u>

- CSMG results have been excluded due to uncertainty on the outcome of the study and, in particular, the timing of when any subsequent changes in restrictions will be introduced. The CSMG study is ongoing and not yet complete. When more certainty is defined the outputs of the CSMG study will be included in a later water resources modelling study.

Environmental Forecast and Sustainability Reductions

- Revised values were defined by the Water Resource Planner and derived from current WRSE scenarios. The values have considered WRMP19 assumptions, the sensitivity scenarios investigated during the water resources modelling study, current WINEP study and the longer Environmental Destination where relevant.

Outage Allowance

- In Phase 1 of the water resources modelling study "double counting" of outage losses was identified where some sources were written down in output even though they were shut down, and this was addressed as explained in Section 3.1.2. It was decided to review this approach for the Future Needs Assessment to better align with current WRSE modelling methodology and retain the overall regional WRMP19 outage loss allocated across all sources. This will impact the deficit calculated in the SDB. The approach to process losses remains unchanged.

Bulk Transfer Imports

- The supply-demand balance elements considered to be at most risk were the bulk transfers from South West Water and Portsmouth Water (Knapp Mill and World's End respectively). Transfers from South West Water Knapp Mill were assumed to be zero and from Portsmouth Water World's End assumed to be 4.5 Ml/d (50% of the transfer included in WRMP19).

From these results, a risk-based *Future Needs Assessment residual deficit* value was calculated as part of the Future Needs Assessment (FNA). It is this revised residual deficit value that best informs the required capacity of the strategic new source.

Table 10 - Summary of risk-based revised residual deficit in Ml/d (summed figures have been rounded)

		WRMP19	Gate 1	Gate 2 Re-calculation	Gate 2 FNA Revision
Supply	Deployable Output	134	134	147	147
	Sustainability Reductions & Climate Change	-61	-61	-61	-69
	Outage Allowance & Process Losses	-16	-5	-7	-8
	Inter-company Transfers	5	5	5	5
	Baseline Supply	**62**	**73**	**84**	**75**
Demand	**Baseline Demand**	**218**	**218**	**218**	**218**
Baseline Supply-Demand Deficit		**156**	**145**	**134**	**143**
WRMP19 Elements	Demand & Catchment Management	24	24	24	24
	Bulk Transfers	50	50	50	26
	Supply Schemes	10	10	10	10
	Total WRMP19 Elements	**84**	**84**	**84**	**59**
RESIDUAL DEFICIT		**73**	**61**	**51**	**83**

Table 10**Error! Reference source not found.** shows the progression of understanding of the magnitude of the residual deficit through the different phases of the water resources modelling study and the effect of supply-demand risks on it. Baseline supply is the sum of all the supply elements, with reductions of source outputs shown as negative values, and the baseline supply-demand deficit is the difference between baseline supply and baseline demand. The residual deficit is calculated by subtracting the total of the WRMP19 elements from the baseline supply-demand deficit. The figures in the table exhibit some differences due to rounding. WRMP19 identified the need for an SRO of capacity 75 Ml/d based on a residual deficit of 73 Ml/d, and during water resources modelling for the Gate 1 submission outage and process losses were revised, as described in Section 3.1.2, resulting in a redefined residual deficit of 61 Ml/d. Further modelling for the Gate 2 submission identified WWTW discharges had not been enabled, as described in Section 3.1.3, which resulted in an increase in deployable output and a recalculated residual deficit of 51 Ml/d. A further review of the supply-demand deficit for the Gate 2 Future Needs Assessment, described above, included changes to sustainability reductions and bulk transfer imports and resulted in a revised residual deficit of 83 Ml/d, and it is this value that informs the required capacity of the strategic new source.

4.2. New Source Capacities – Future Needs Assessment

4.2.1. Modelling Methodology – Exports to Portsmouth Water

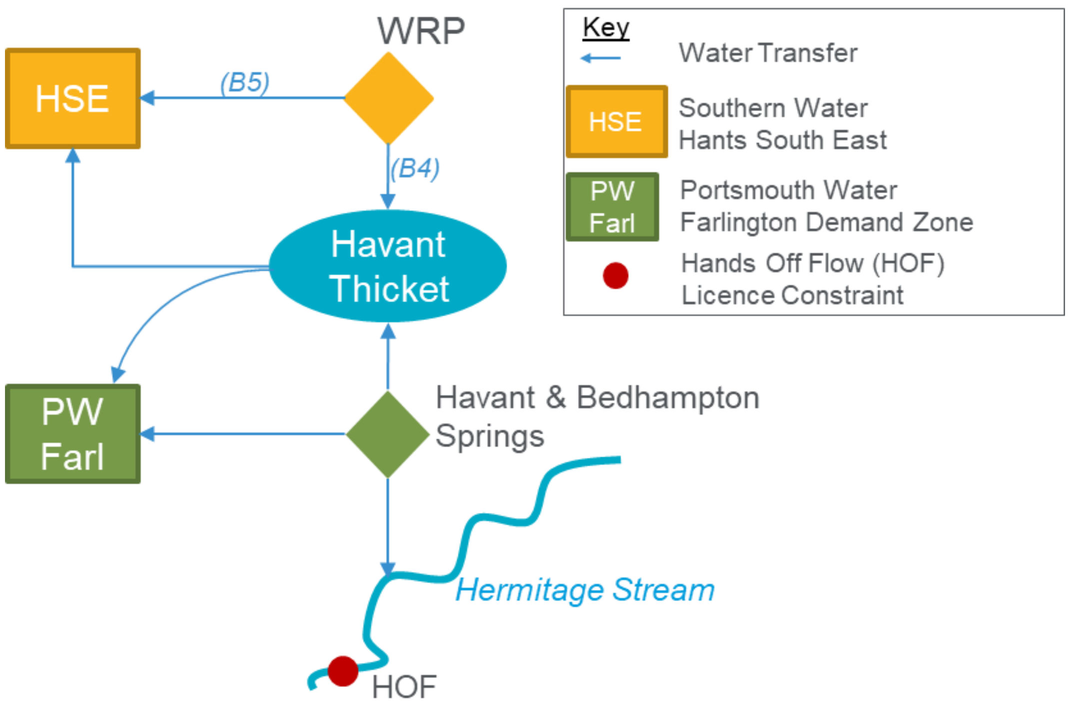

Figure 14 - Future Needs Assessment model schematic for exports to Portsmouth Water

The [redacted] flows were assessed using a 2000-year sequence (modelled previously in a separate study) imported into the [redacted] water resources model. The existing hands-off flow (HOF) licence constraint of 70 l/s was implemented at Brockhampton Mill Lake on Hermitage Stream, and maximum daily and annual licence amounts were applied to the '[redacted] Licence' abstraction group, which covers both the existing abstraction to Portsmouth Water's [redacted] and the proposed abstraction to fill Havant Thicket Reservoir. Transfer to [redacted] is given first priority on the available water from the springs and, if any resource is left over, within the licence constraints, it is used to fill the Havant Thicket reservoir. A demand value equal to the average works output for 2015 was used to represent the demand in [redacted].

Modelling was undertaken to investigate how any potential transfer might impact storage volumes in Havant Thicket reservoir. The potential transfer will affect the capacity of the strategic new source. The model was configured to attempt to meet any deficit at [redacted] that cannot be met by the springs by providing additional resource from Havant Thicket reservoir. Priorities have been set such that [redacted] has highest priority on any available water, then the 21 Ml/d bulk supply to Southern Water via [redacted] and Gater's Mill WSW, then (for Option B.4) the proposed additional use of Havant Thicket by Southern Water via Otterbourne WSW.

The inclusion of a supply-demand deficit modelling at [redacted] identifies an emerging need to be investigated in future studies by Southern Water in liaison with Portsmouth Water. Detailed understanding of the impact of this emerging need has not yet been developed and the assumed solution to it (further abstraction from Havant Thicket), as well as its magnitude, might change. All scenarios modelled and reported in this section include the local supply-demand deficit at [redacted].

4.2.2. Option B.4

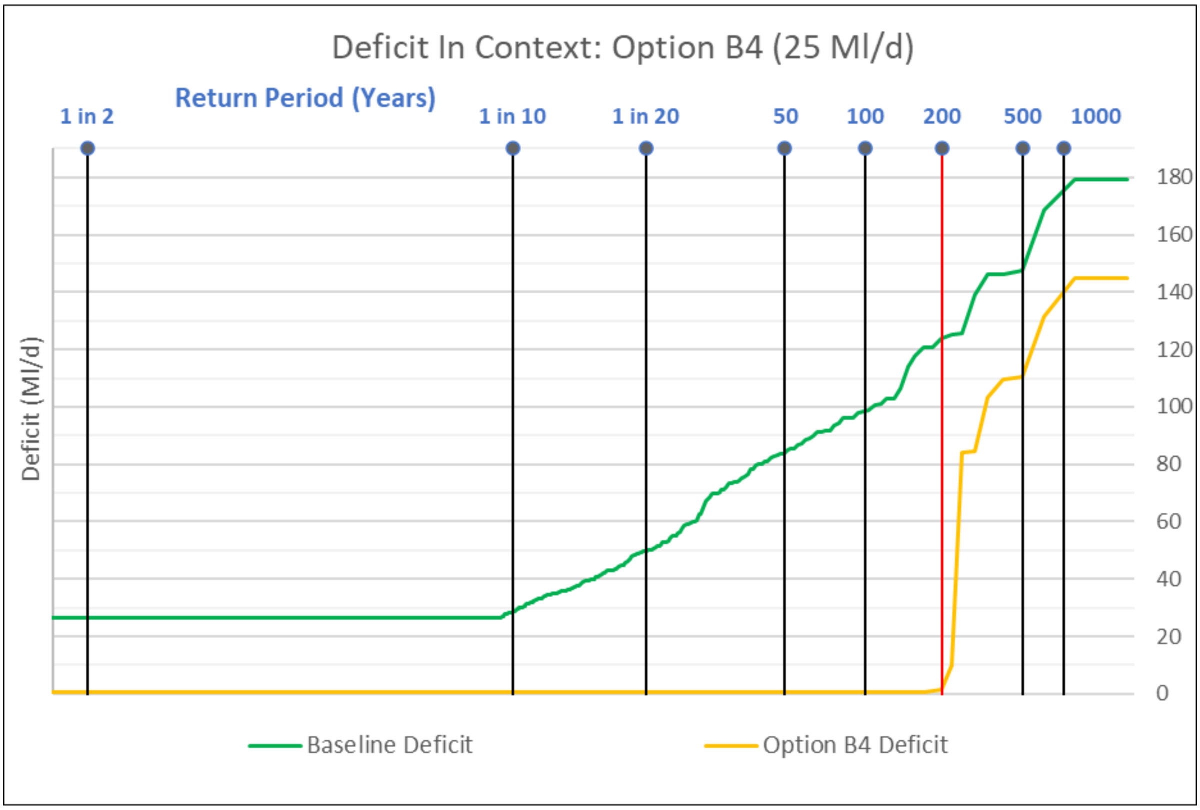

Figure 15 - Option B.4 deficit modelling results

Figure 15 shows the modelled deficits for the baseline option and Option B.4 (capacity 25 Ml/d) for a representative 1-in-200-year drought (drought 4315). The baseline graph represents the deficit without any WRMP19 elements introduced and differs from the static SDB deficit due to the dynamic nature of the model. The Option B4 Deficit graph in Figure 15 represents the impact of WRMP19 elements in addition to the proposed strategic new source combined with Havant Thicket winter storage reservoir. The modelled deficit in Option B.4 for a 1-in-200-year drought is less than 1 Ml/d which, allowing for modelling anomalies, indicates that this option resolves the supply-demand balance deficit for the Future Needs Assessment scenario. The required transfer capacity from Havant Thicket reservoir to Otterbourne WSW will be 87 Ml/d to resolve the revised residual deficit of 83 Ml/d (this includes an allowance for process losses at Otterbourne WSW).

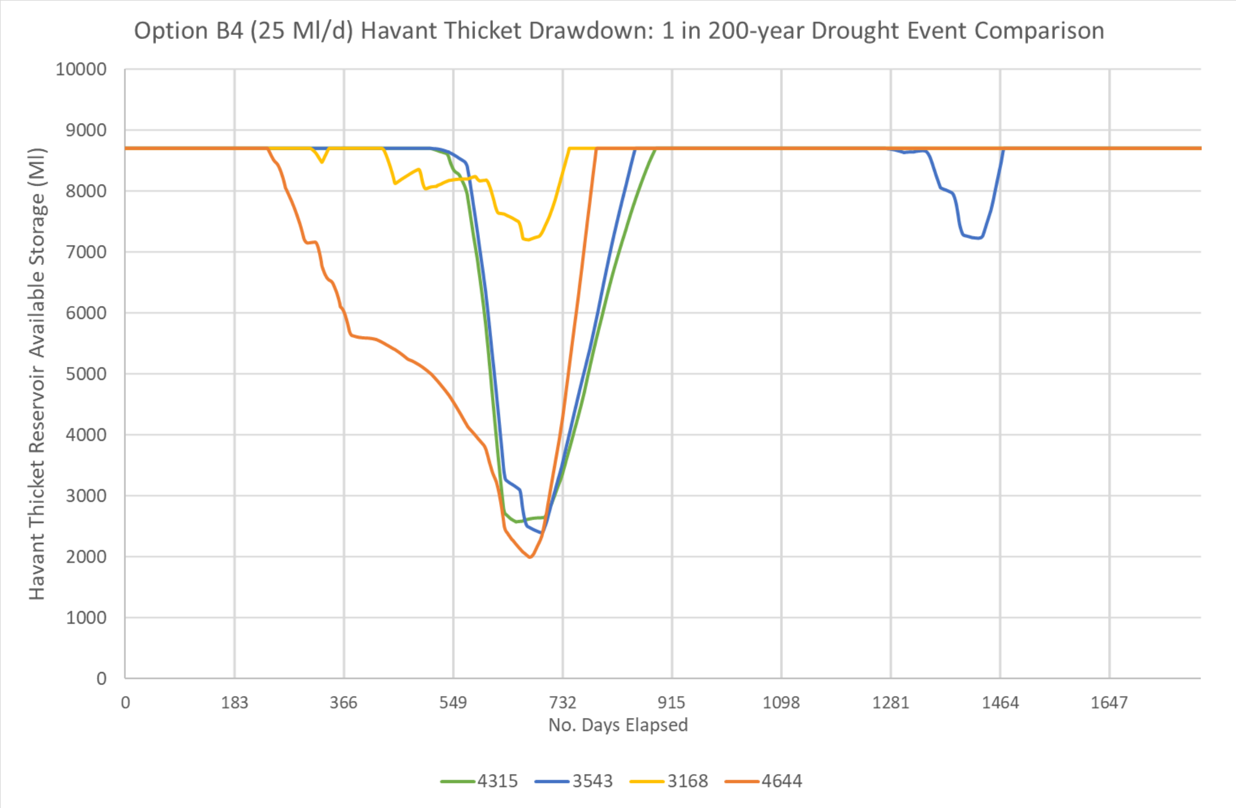

Figure 16 - Havant Thicket drawdown for Option B.4

Figure 16 shows how Havant Thicket reservoir is drawn down in the individual droughts representing a 1-in-200-year drought, described in Section 2.2.1, for Option B.4 (capacity 25 Ml/d). In all four drought events the reservoir remains above its minimum level (shown as zero on the graph), indicating that Option B.4 satisfactorily resolves the 1-in-200-year drought supply-demand balance deficit for the Future Needs Assessment scenario.

4.2.3. Option B.5

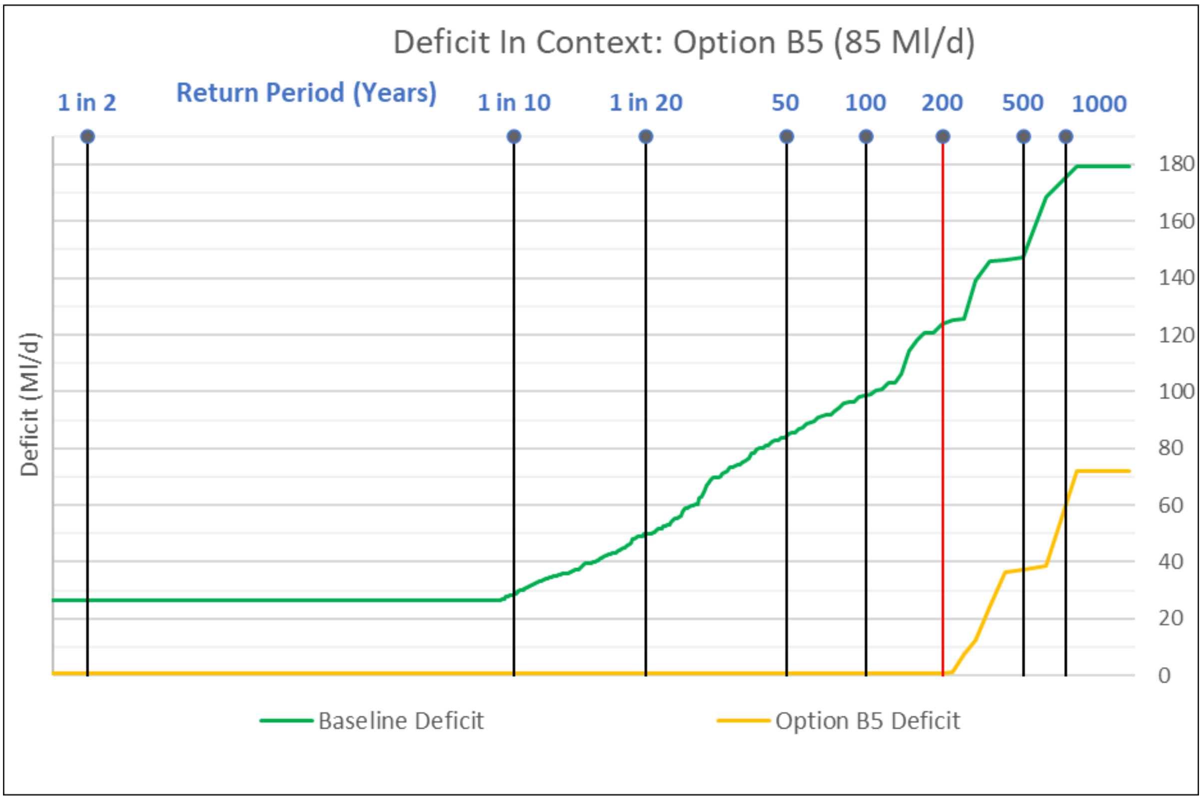

Figure 17 - Option B.5 deficit modelling results

Figure 17 shows the modelled deficits for the baseline option and Option B.5 for a representative 1-in-200-year drought (drought 4315). The baseline graph represents the deficit without any WRMP19 elements introduced and differs from the static SDB deficit due to the dynamic nature of the model. The Option B5 Deficit graph in Figure 17 represents the impact of WRMP19 elements in addition to the proposed strategic new source. The modelled deficit in Option B.5 for a 1-in-200-year drought is less than 1 Ml/d which, allowing for modelling anomalies, indicates that this option resolves the supply-demand balance deficit for the Future Needs Assessment scenario.

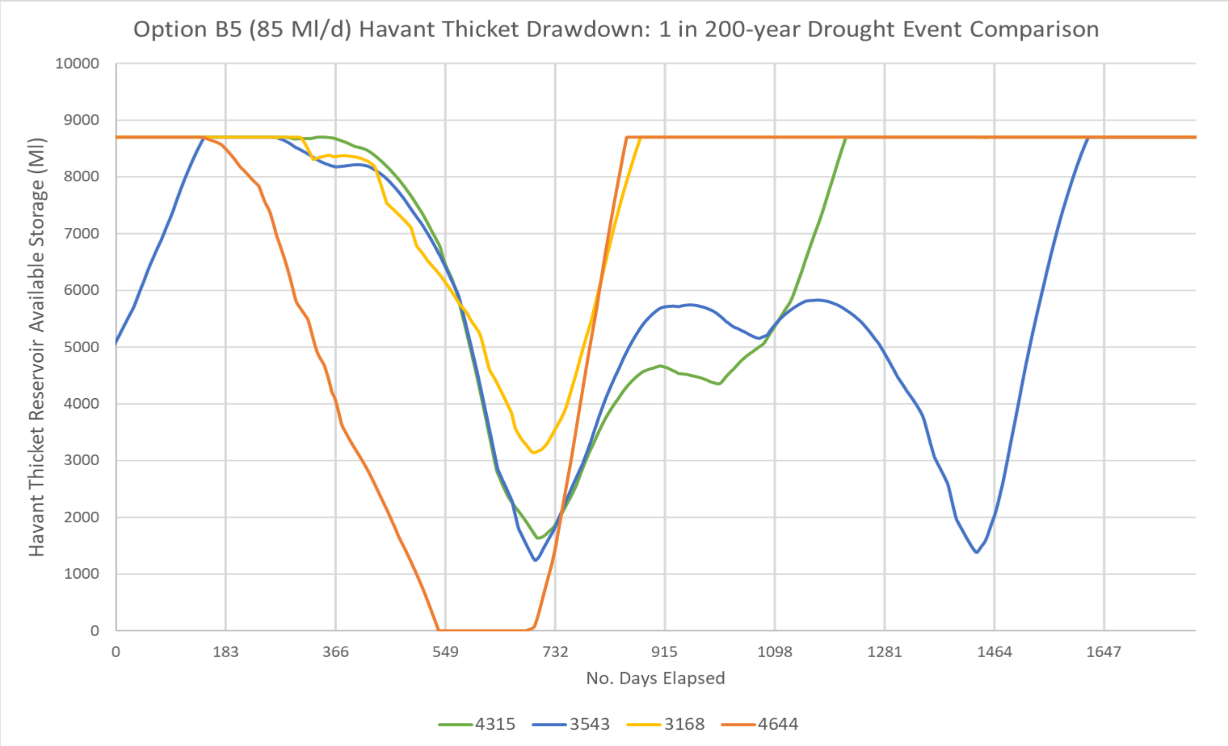

Figure 18 - Havant Thicket drawdown for Option B.5

Figure 18 shows how Havant Thicket reservoir is drawn down in the individual droughts representing a 1-in-200-year drought, described in Section 2.2.1, for Option B.5 (capacity 85 Ml/d). In three drought events the reservoir remains above its minimum level (shown as zero on the graph), suggesting that Option B.5 satisfactorily resolves the 1-in-200-year drought supply-demand balance deficit for the Future Needs Assessment scenario. However in drought 4644 the reservoir drains below its minimum level, indicating that the deficit is not resolved as inadequate resources remain available in Havant Thicket reservoir. Drought 4644 differs from the other representative droughts as its rainfall deficit and return periods are significantly more extreme, as shown in Figure 19. The significant (and unusual) characteristic is its very long period without rainfall, and it is this characteristic that renders it of interest to the Water Resources Modelling study. The aspect most significantly impacting on the drawdown in Havant Thicket reservoir is the modelled abstraction from Havant Thicket supplying the [redacted] demand zone in Portsmouth Water (see Section 4.2.1), as the very long period of rainfall deficit impacts the flows on [redacted] which breaches its Hands-off Flow (HoF) limit. [redacted] is fed from the [redacted] which is the groundwater source supplying Havant Thicket reservoir, resulting in a reduction the inlet flows available to Havant Thicket reservoir over an extended period that consequently results in the drawdown of the available storage.

Figure 19**Error! Reference source not found.** presents drawdown and transfer results from drought 4644 and shows transfers from the WRP to Otterbourne to be of short duration, and also shows the long duration between the start of the transfer to [redacted] and the start of the refilling by the springs supply; it is this long period without recharge from the springs that causes the drawdown of Havant Thicket reservoir, and this is itself caused by the exceptionally long period without rainfall that characterises drought 4644. In this respect, drought 4644 is not typical of a 1-in-200-year drought, which are of shorter duration.

It can be seen in Figure 19 that the Springs Supply to Havant Thicket reservoir exceeds the scheme's design constraint of 40 Ml/d, resulting in a quicker than feasible refill of the reservoir. This has not been observed in other representative drought year results, for which the reservoir refill rates results remain valid. It is proposed that further investigation is undertaken into this emerging need identified in the Future Needs Assessment, in partnership with Portsmouth Water, to better understand the risks of deficit in the [redacted] zone and to develop interventions to mitigate these risks.

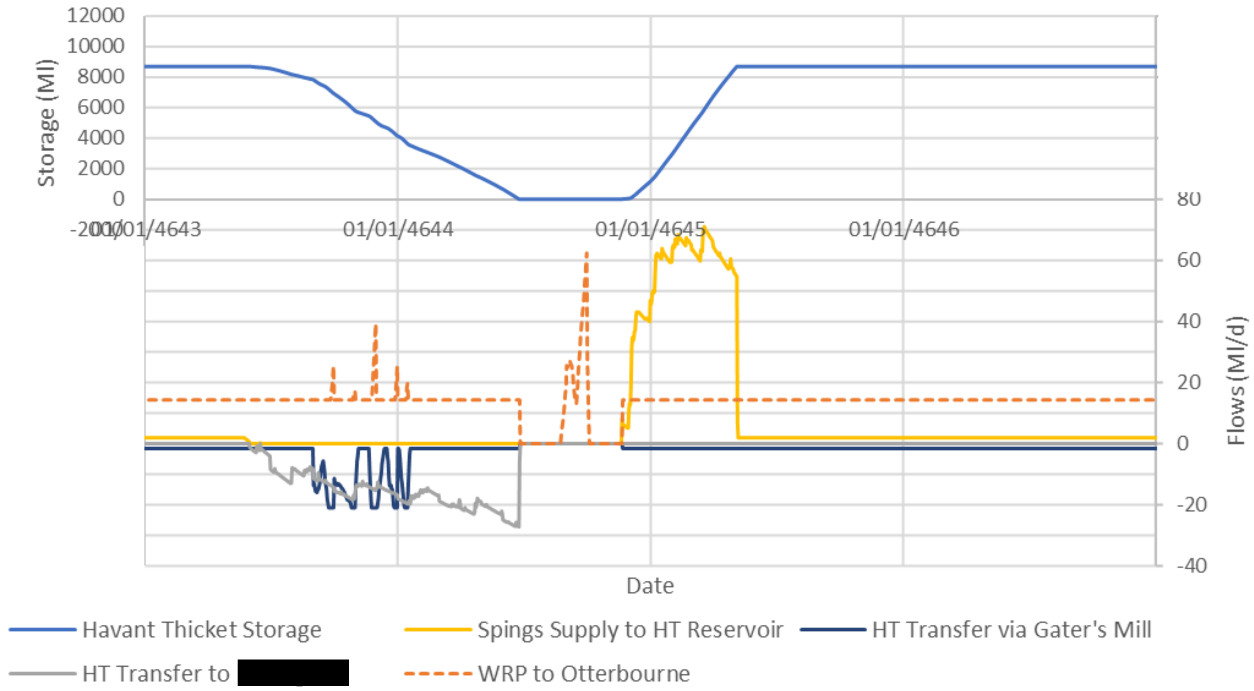

Figure 19 - Havant Thicket Reservoir – Option B.5 Storage and Utilisation for Drought 4644

Table 11 - Drought 4644 characteristics

Year	WRMP19 DO (Ml/d)	WRMP19 DO Return Period	River Test Min Flow (Ml/d)	River Test Min Flow Return Period	River Itchen Min Flow (Ml/d)	River Itchen Min Flow Return Period	24-month Rainfall Deficit (mm)	24-month Rainfall Return Period
3543	25.2	**1 in 200**	326.8	**1 in 125**	82.0	**1 in 167**	-149	**1 in 149**
4315	28.6	**1 in 182**	303.4	**1 in 250**	81.9	**1 in 182**	-574	**1 in 204**
4644	35.1	**1 in 143**	309.6	**1 in 182**	82.3	**1 in 143**	-683	**1 in 1694**
3168	24.7	**1 in 222**	329.5	**1 in 118**	86.0	**1 in 77**	-531	**1 in 103**

4.3. Utilisation – Future Needs Assessment

An analysis was undertaken to identify the frequency of use of the proposed strategic new source for the revised Future Needs Assessment residual deficit of 83 Ml/d, and figures for maximum daily supply, annual days of operation and total volume transferred annually are presented below. Section 4.3.3 explains how drought return periods differ for each parameter, and why figures across different parameters might not align exactly for a given drought return period.

4.3.1. Option B.4

Table 12 - Option B.4 utilisation (*minimum flow)

	Havant Thicket to Otterbourne WSW			WRP Operation		
Drought Return Period (years)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)
1	8*	0	2920	8*	0	3030
2	8*	0	2920	8*	0	3030
5	8*	0	2928	10	14	3050
10	8*	0	2928	23	119	3698
20	8*	0	2928	25	184	4823
50	38	26	3234	25	270	6258
100	54	52	3821	25	341	7665
200	73	85	6087	25	365	9125

The normal daily transfer from Havant Thicket to Otterbourne WSW (and the WRP operation) was modelled at 8 Ml/d, based on the assumption that the WRP would run at a minimum output equal to one third of its capacity (this assumption might change during design progression). As drought severity increases the Havant Thicket to Otterbourne WSW transfer will increase during a drought with an approximate return period of 21 years. During a drought with a return period of 100 years the transfer will operate above minimum flow for 52 days in a 365-day period, and in a 1-in-200-year drought the transfer will be operating above minimum flow for 85 days in a 365-day period.

Table 13 - Option B.4 Havant Thicket to Farlington utilisation

	Havant Thicket to Farlington Demand Zone (Portsmouth Water)		
Drought Return Period (years)	Maximum Daily Supply (Ml/d)	Annual Days Operation	Annual Volume Transferred (Ml)
1	0	0	0
2	0	0	0
5	0	0	0
10	6	91	246
20	11	161	950
50	16	221	2002
100	19	282	3164
200	26	330	4694

Error! Reference source not found. Table 13 shows the utilisation of the potential export to Portsmouth Water's [redacted] demand zone when the impact of a drought on the [redacted] is included in the model. The frequency of use is higher than the planned transfer from Havant Thicket to Otterbourne WSW, reflecting the frequency of drought impact on the output of the [redacted]. In a 1-in-200-year drought the export would be operational 330 days in a 365-day period and would transfer 4694 Ml of water from Havant Thicket reservoir.

Table 14 - Option B.4 Bulk transfer imports utilisation (* minimum flow)

	PW Havant Thicket Potable Transfer			PW World's End Transfer		
Drought Return Period (years)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)
1	1.6*	0	583	0.4*	0	146
2	1.6*	0	583	0.4*	0	146
5	1.6*	0	584	4.5	42	314
10	1.6*	0	584	4.5	119	631
20	19	18	744	4.5	220	1048
50	21	56	1403	4.5	310	1417
100	21	80	1788	4.5	345	1561
200	21	109	2447	4.5	364	1638

An analysis has been undertaken to identify the frequency of use for bulk transfer imports, and the results are shown in Table 14**Error! Reference source not found.**. The Havant Thicket potable water transfer becomes operational (above daily sweetening flow) during a drought with an approximate return period of 11 years and is operational for 109 days per year during a 1-in-200-year drought. The Portsmouth Water World's End transfer becomes operational (above daily sweetening flow) during a drought with an approximate return period of 3 years and is operational for 364 days per year during a 1-in-200-year drought.

4.3.2. Option B.5

Table 15 - Option B.5 utilisation (* minimum flow)

	WRP to Otterbourne WSW		
Drought Return Period (years)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)
1	15*	0	475
2	15*	0	5475
5	15*	0	5490
10	15*	0	5490
20	15*	0	5490
50	37	17	5621
100	54	39	6074
200	79	84	8201

During normal daily operation the asset will operate on a minimum flow of 15 Ml/d. As drought severity increases the asset will be called upon to output increased volumes, with the water recycling plant starting to operate above its minimum flow during a drought with an approximate return period of 28 years. During a drought with a return period of 100 years the asset will operate above minimum flow for 39 days in a 365-day period, and in a 1-in-200-year drought the asset will be operating at or near its full capacity for 84 days in a 365-day period.

Table 16 - Option B.5 Havant Thicket to [redacted] utilisation

	B.5 Havant Thicket to [redacted] Demand Zone (Portsmouth Water)		
Drought Return Period (years)	**Maximum Daily Supply (Ml/d)**	**Annual Days Operation**	**Annual Volume Transferred (Ml)**
1	0	0	0
2	0	0	0
5	0	0	0
10	6	88	225
20	11	155	903
50	16	213	1953
100	19	249	2716
200	27	289	3657

Table 16**Error! Reference source not found.** shows the utilisation of the potential export to Portsmouth Water's [redacted] demand zone when the impact of a drought on the [redacted] is included in the model. The frequency of use is higher than the planned transfer from Havant Thicket to Otterbourne WSW, reflecting the frequency of drought impact on the output of the [redacted]. In a 1-in-200-year drought the export would be operational 289 days in a 365-day period and would transfer 3657 Ml of water from Havant Thicket reservoir.

Table 17 - Option B.5 Bulk transfer imports utilisation (* minimum flow)

	PW Havant Thicket Potable Transfer			PW World's End Transfer		
Drought Return Period (years)	**Maximum Daily Supply (Ml/d)**	**Annual Days Operation (above sweetening flow)**	**Annual Volume Transferred (Ml)**	**Maximum Daily Supply (Ml/d)**	**Annual Days Operation (above sweetening flow)**	**Annual Volume Transferred (Ml)**
1	1.6*	0	583	0.4*	0	146
2	1.6*	0	583	0.4*	0	146
5	1.6*	0	584	4.5	31	273
10	1.6*	0	584	4.5	84	490
20	11	11	623	4.5	169	839
50	21	43	1166	4.5	289	1331
100	21	67	1569	4.5	322	1466
200	21	102	2201	4.5	353	1593

An analysis has been undertaken to identify the frequency of use for bulk transfer imports, and the results are shown in Table 17. The Havant Thicket potable water transfer becomes operational (above daily sweetening flow) during a drought with an approximate return period of 14 years and is operational for 102 days per year during a 1-in-200-year drought. The Portsmouth Water World's End transfer becomes operational (above daily sweetening flow) during a drought with an approximate return period of 4 years and is operational for 353 days per year during a 1-in-200-year drought.

4.3.3. Differences in Utilisation Data Between Options B.4 and B.5

Havant Thicket /WRP to Otterbourne WSW Transfer

The sweetening flow differs between options, being 8 Ml/d in option B.4 and 15 Ml/d in Option B.5. This difference in supply to Otterbourne WSW affects abstractions taken from the River Itchen meaning that restrictions in abstractions occur at different times for the two model runs, and the required capacity from the proposed new raw water transfer to Otterbourne WSW will differ.

Havant Thicket and World's End Potable Transfers

The difference in sweetening flows described above means that the requirements for the potable transfers will be delayed in Option B.5 compared to Option B.4 resulting in a lower volume of water transferred.

Transfer to Portsmouth Water [redacted] Zone

The discrepancy is caused by the [redacted] model's reaction when Havant Thicket drawdown reaches zero (i.e. no available water), and this occurs a small number (seven) of times in the 2000-year model sequence when rainfall has been very low for consecutive years. The rate and duration of drawdown differs between options B.4 and B.5 as the former option recharges Havant Thicket from the WRP, meaning that the different options present different levels of available water in Havant Thicket. As the export to [redacted] falls to zero when Havant Thicket is empty, different volumes of water available to be transferred occur at different times in the model runs for the two options.

Drought Return Periods

In any model run, each drought return period is likely to be a different year for different parameters. There is no "single year" in a model run that represents a drought return period (such as a 1-in-200-year drought) for all modelled parameters. The return period, for any single parameter, is determined by the ranking of that particular parameter and these might not align with the same return period for a different parameter. For example, the 1-in-200-year value for Maximum Daily Supply will be the 10th highest value for Maximum Daily Supply in the 2000-year model run, and this will relate to a particular year. The 1-in-200-year value for Annual Volume Transferred will be the 10th highest value for Annual Volume Transferred in the 2000-year model run, but the year to which this relates will not necessarily be the same as that for the Maximum Daily Supply. Consequently, the year that determines a drought return period for a particular parameter will not necessarily be the same for different model runs, and values that might be expected to align between model runs can often differ.

5. Progression from Gate 1 to Future Needs Assessment

5.1. Residual Deficit

The Gate 1 submission identified the supply-demand deficit as 61 Ml/d and did not utilise any benefit from the storage within Havant Thicket as the modelling had not progressed enough to suggest a reduced size. Following the Gate 1 submission the water resources modelling study was developed further and the understanding of the elements and assumptions included in the supply-demand balance deficit improved. The progression of the SDB deficit and new source capacity required for the *recalculated residual deficit* is described in Section 3.1.3, and the inclusion of wastewater treatment works discharges in river flow series data led to a change to the magnitude of the residual deficit to **51 Ml/d**. The Future Needs Assessment identified changes to the elements in supply-demand balance, namely the sustainability reductions and process losses as described in Section 4. The inclusion of these changes led to a *revised residual deficit*, which was calculated to be **83 Ml/d**. The values of these deficits exclude any allowance for process losses at Otterbourne WSW and are detailed in Figure 18.

Table 18 - Progression of Gate 2 Supply-Demand Balance Deficits (excluding process losses at Otterbourne WSW)

Stage	Residual Deficit (Ml/d)
Recalculated Gate 2	51
Revised FNA	83

5.2. Revised New Source Capacities

The Future Needs Assessment also identified a potential supply-demand deficit in Portsmouth Water's Farlington zone that could affect abstractions from Havant Thicket reservoir (described in Section 4.2.1). The water resources model was re-run to include both the changes to elements in the supply-demand balance and the deficit in Farlington. The results, showing the required capacity of the strategic new source, are summarised in Table 19, and include an allowance for process losses at Otterbourne WSW.

Table 19 - Summary of New Source Capacity (including losses at Otterbourne WSW)

Residual Deficit	Option A.1/A.2		Option B.2/B.5		Option B.4		Option D.2	
	Resolves Deficit?	Required Capacity (Ml/d)	Resolves Deficit?	Required Capacity (Ml/d)	Resolves Deficit?	Required Capacity (Ml/d)	Resolves Deficit?	Required Capacity (Ml/d)
Recalculated Gate 2 SDB deficit (51 Ml/d)	Yes	51	Yes	54	Yes	0	Yes	0
Revised FNA SDB deficit (83 Ml/d)	N/A	N/A	Yes	87	Yes	25	No	N/A

6. Conclusions

A review of the supply-demand deficit for the Gate 2 Future Needs Assessment resulted in a revised residual deficit of 83 Ml/d, and it is this value that informs the required capacity of the strategic new source.

For Option B.5 a WRP of capacity 87 Ml/d will resolve the FNA revised residual supply-demand deficit of 83 Ml/d. For Option B.4 a WRP of capacity 25 Ml/d will resolve the FNA revised residual supply-demand deficit of 83 Ml/d. Figure 20 illustrates that the required new source capacity for Option B.4 is significantly lower than for Option B.5.

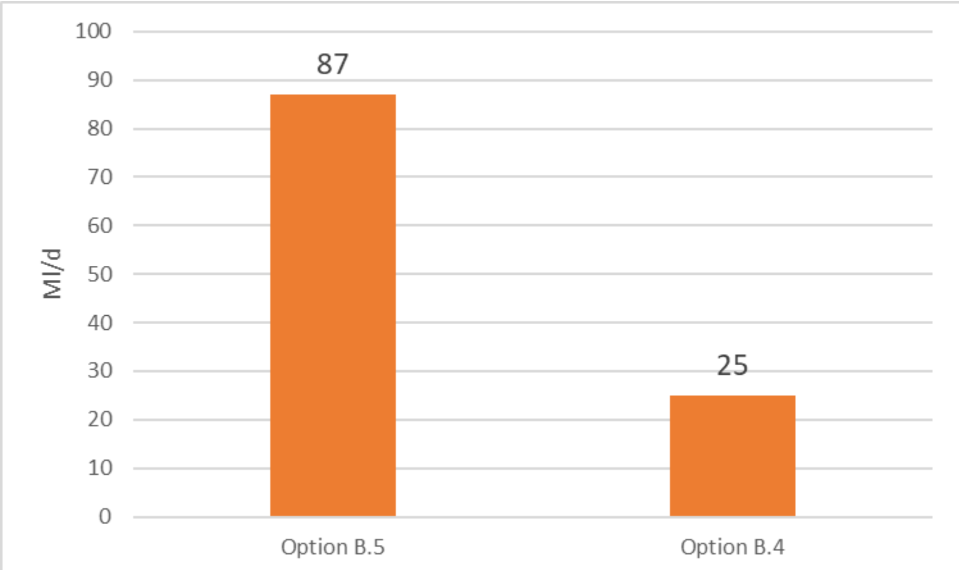

Figure 20 - New strategic supply source capacity required for the WRP for FNA 83 Ml/d revised residual deficit (includes allowance for process losses at Otterbourne WSW)

Annex 12, Outline Option Evolution Plans, reports on how the Future Needs Assessment has taken the results of the water resources modelling study and reviewed them against the emerging results from WRSE to consider the possible impact of a 1-in-500-year drought up to 2040.

6.1.1. Future Studies

The impact of potential abstractions to Portsmouth Water's [redacted] demand zone is an emerging need, and further studies are required to better understand the impact this will have storage levels in Havant Thicket reservoir in a 1 in 200-year drought. These studies will define the required capacity for the WRP in Option B.4. However the required transfer capacity from Havant Thicket reservoir to Otterbourne WSW will remain unchanged at 87 Ml/d.