Section 7

Appraisal of resource options

Table of contents

Figures

Tables

Section 7.

Appraisal of resource options

Section 7 describes:

- How we have identified our feasible list and constrained list of water resource options
- The associated system elements that are required to deliver the constrained list resource options into supply
- The further option development that has been conducted on the constrained list options to inform programme appraisal

A. Introduction

Purpose of section

7.1 Section 7 summarises the approach that has been followed for identifying water resource options and how screening has been applied to determine the constrained list of options that has been taken forward into programme appraisal. The section then summarises the information that has been gathered on the constrained list of options.

7.2 In conducting option screening we have balanced the need to have the widest choice of water resource options for assessment at programme appraisal against the need to have a manageable number of options.

Structure of this section

7.3 Following this introduction, Section 7 of the draft Water Resources Management Plan 2019 (draft WRMP19) summarises:

- the generic option type screening we have conducted (Section 7.B)
- the feasibility assessments we carried out to define the feasible list of specific resource options (Section 7.C)
- the cross option studies we conducted to identify raw water system, treatment and network reinforcement requirements needed to deliver potable water to customers (Section 7.D)
- the fine screening exercise that combined the outputs of the feasibility reports and the cross option studies to provide a constrained list of elements to be carried forward for further development (Section 7.E)
- the further development conducted for elements on the constrained list to inform programme appraisal (Section 7.F)

- Drought Permit options considered (Section 7.G)
- references to the sources of further information available for the elements on the constrained list (Section 7.H)

Phased approach to water resource option development

7.4 Following the principles of the Water Resource Planning Guideline (WRPG) (04/2017) section 6, a phased approach to developing water resource options for the draft WRMP19 has been undertaken so that effort on reducing uncertainties is focused on the issues that could influence option screening decisions. An overview of the four-phase approach to reviewing and assessing resource options in the preparation of the draft WRMP19 is shown in Figure 7-1. The four phases comprise: option review and screening; detailed investigations; programme appraisal; and scheme selection design and planning. These are described in more detail below.

7.5 **Phase 1 – Option review and screening:** The objective of Phase 1 was to review the options carried forward from WRMP14 and to enable better targeting of Phase 2 option assessments by focusing on uncertainties and risks that were fundamentally material to option selection. The outputs from Phase 1 were fine screening reports for large[1] and small[2] water resource options.

7.6 **Phase 2 – Detailed investigations:** In Phase 2, targeted detailed investigations were undertaken to enable a clear explanation of how specific options have been identified and to reduce uncertainties concerning the identification of the best value options. The required investigations identified in Phase 1 were considered in a series of feasibility reports and cross-option studies listed in section 7.H.

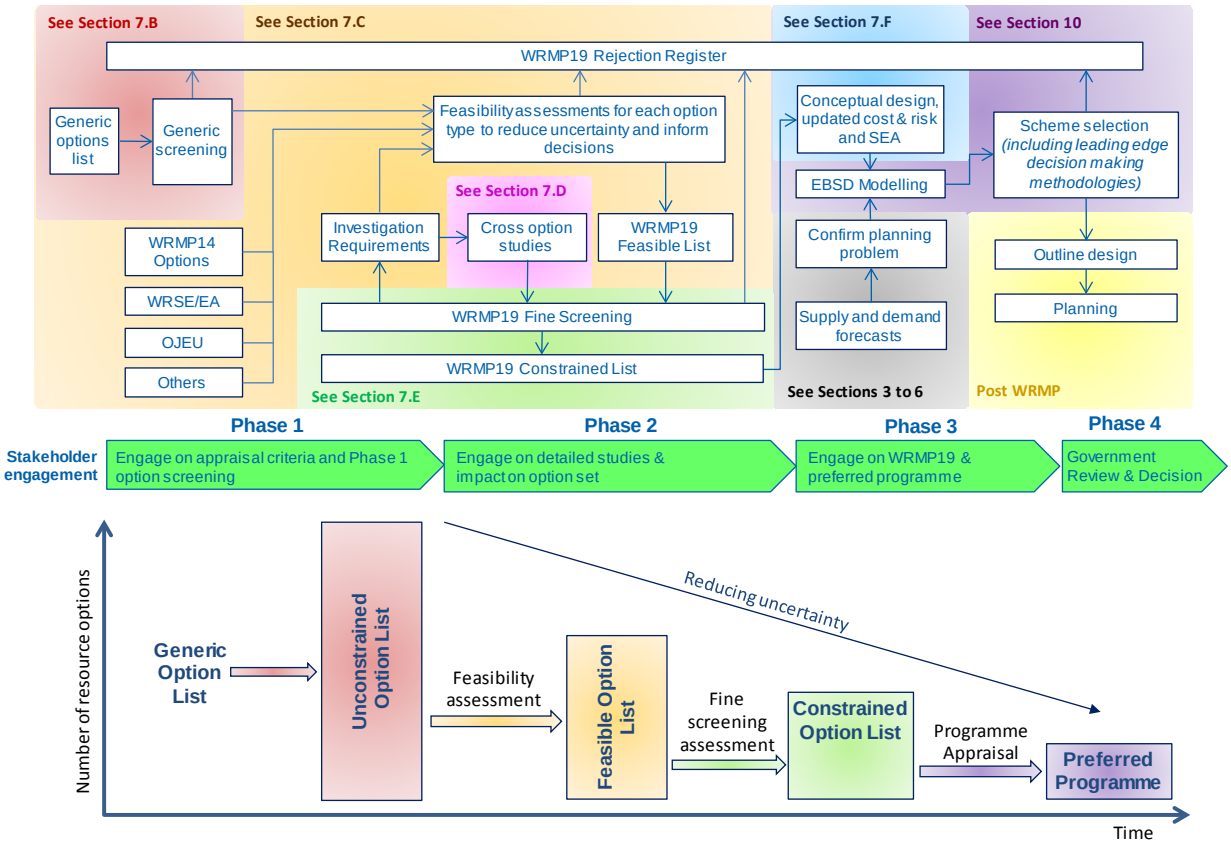
7.7 As these investigations were completed the fine screening process was re-applied to ensure that the new information was reflected in the assessment and in screening decisions. The resulting output of this updated fine screening exercise, reported in the fine screening report[3], is the constrained list of options that have then been carried forward for conceptual design and programme appraisal in Phase 3.

7.8 **Phase 3 – Programme appraisal:** In Phase 3, conceptual designs were prepared for options on the constrained list, costs have been updated for all options, bottom-up risk assessments have been undertaken for options larger than 50 Ml/d and strategic environmental assessments have been carried out. Options on the constrained list have then been subject to programme appraisal to determine the optimum best value programme of solutions to ensure that supply balances demand, taking account of future forecast water resource scenarios.

7.9 **Phase 4 – Scheme selection, outline design and planning:** Subject to confirmation of the preferred programme following consultation, Phase 4 will involve progressing the selected water resource options through to outline design for submission as applications for planning permission or a development consent order.

[1] Phase 1 Large Option Screening Report, Mott MacDonald, (May 2015)
[2] Phase 1 Small Option Screening Report, Mott MacDonald, (November 2015)
[3] Fine Screening Report, Mott Macdonald, (January 2018)

Figure 7-1: A phased approach to reviewing and assessing water resource options



Stakeholder engagement

7.10 Throughout the water resource option development process we have worked closely with stakeholders. We formed a Technical Stakeholder Group comprising representatives of interested stakeholders[4] and have held regular meetings with the group briefing them on the work that we have been doing and to seek their feedback and input to the process so that we can take it into account in developing our Constrained List of options. Technical Stakeholder Group meetings were held on the following dates, to discuss resource option development:

- September 2014 – review of WRMP14 options, any other options that should be considered and approach to option screening
- January 2015 – review of draft Phase 1 option screening report for large options
- March 2015 – review of updated Phase 1 option screening report for large options
- July 2015 – review of draft Phase 1a option screening report for small options
- November 2015 – overview and update on Phase 2 investigations into resource options
- May 2016 – Update on Phase 2 investigation findings

[4] Refer to Appendix S: Stakeholder engagement

- October 2016 – review of draft feasibility report and cross option study findings, together with updated fine screening report
- February 2017 – initial response to comments from stakeholders on feasibility and fine screening reports
- April 2017 – presentation of updated fine screening report
- June 2017 – presentation on environmental assessment of constrained list

7.11 Documents shared with stakeholders, meeting minutes and presentations are all available on our website[5]. A log of stakeholder comments has also been kept, together with a record of how the comments have been considered and what the response was (including what, if any, change has been required).

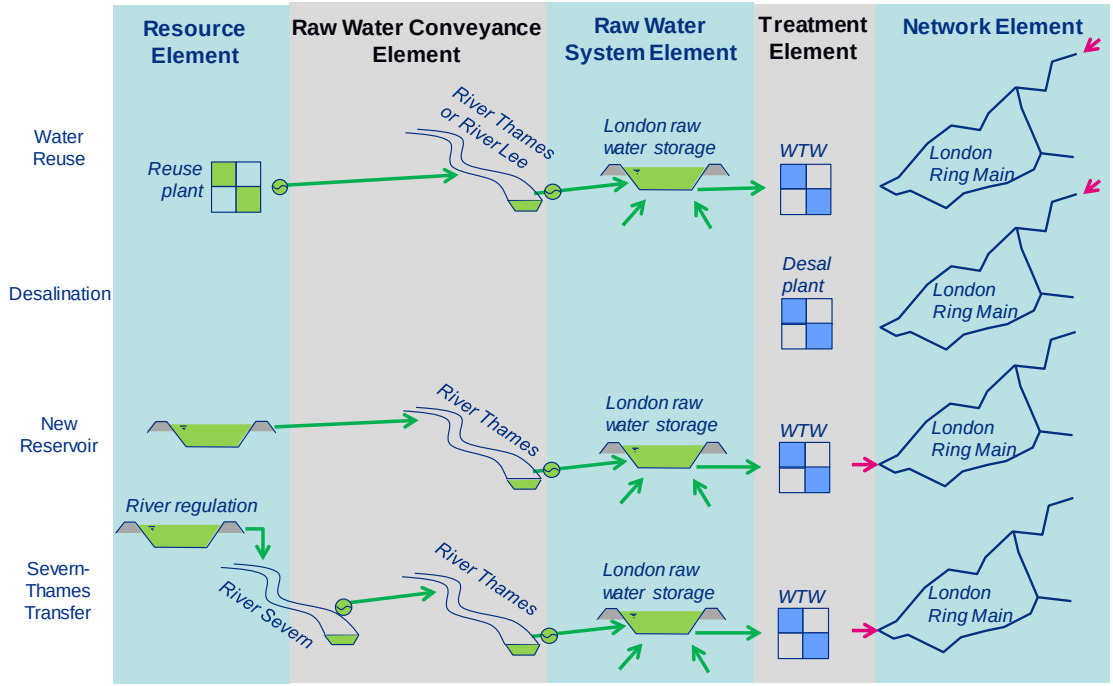
Taking a system approach

7.12 For new water resources to be put into supply reinforcements are often required to other parts of the water supply system downstream of the resource, including to the raw water conveyance system, water treatment works and water distribution infrastructure. In many cases these water supply system reinforcements are common to a number of different water resource options. The supply system elements may also be implemented at a different time to water resource elements, for example if a zone is resource constrained and has sufficient treatment/network capacity in the short term but will require reinforcements in the medium-long term as demand increases. For these reasons separate supply system elements have been developed for new water resources, raw water conveyance, raw water system reinforcements, treatment reinforcements and treated water network reinforcements. The reinforcement elements have been combined with the resource and conveyance elements, where required, into options for the purpose of fine screening and programme appraisal.

7.13 Cross option studies have been carried out to identify the supply system reinforcement elements required and to establish the system operating philosophy. Figure 7-2 illustrates examples of how the different supply system elements combine to make up an overall water resources option.

[5] https://corporate.thameswater.co.uk/about-us/our-strategies-and-plans/water-resources/document-library

Figure 7-2: Separation of water resource options into supply system elements



B. Generic screening

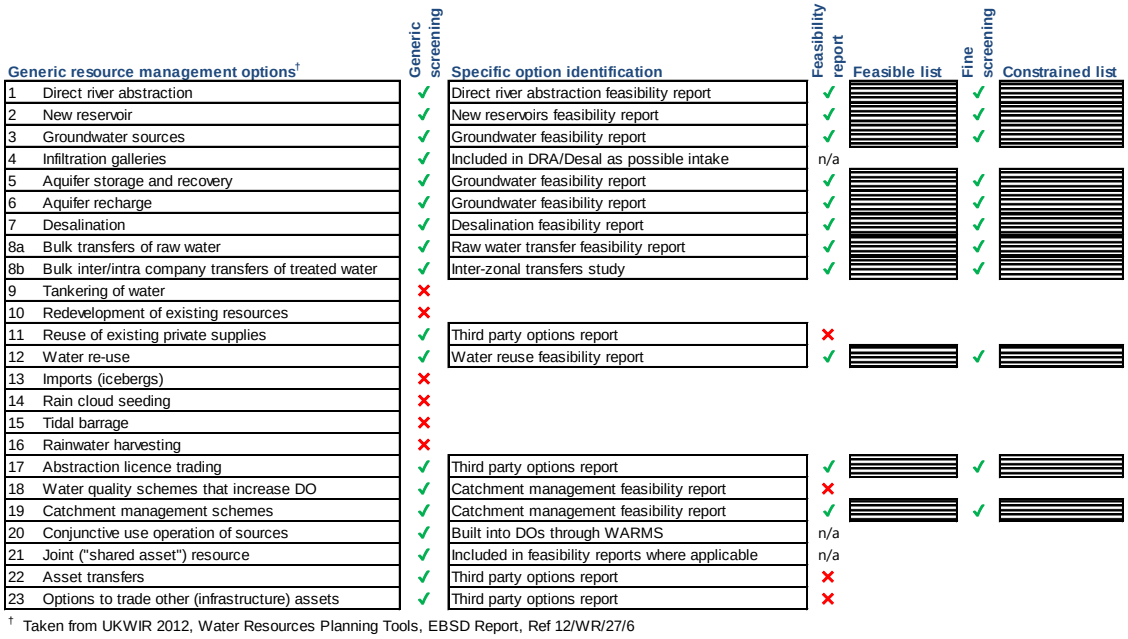
7.14 The starting point for water resource option development is the generic list of resource option types (e.g. reservoirs, water transfers) referenced in the UKWIR Water Resources Planning Tools report[6]. The list has been reviewed to identify option types that have potential for providing feasible specific water resource options for the Thames Water supply area. A summary of the results of the generic screening exercise that we carried out is shown in Figure 7-3.

7.15 Water resource option types that have been rejected are marked with a cross in Figure 7-3. A summary of reasons for rejection can be found in Table 7-1, with further detail provided in the Rejection Register (see Appendix Q)

7.16 Resource option types that were assessed as having potential to provide specific options for the draft WRMP19 are marked with a tick in Figure 7-3. For these option types the figure also references the report that goes on to identify feasible specific options for our supply area.

[6] UKWIR (2012), Water Resources Planning Tools 2012, Economics of Balancing Supply and Demand Report (Ref 12/WR/27/6), pp 10-12.

Figure 7-3: Summary of generic water resource option type review



	Generic resource management options†	Generic screening	Specific option identification	Feasibility report	Feasible list	Fine screening	Constrained list
1	Direct river abstraction	✓	Direct river abstraction feasibility report	✓			
2	New reservoir	✓	New reservoirs feasibility report	✓			
3	Groundwater sources	✓	Groundwater feasibility report	✓			
4	Infiltration galleries	✓	Included in DRA/Desal as possible intake	n/a			
5	Aquifer storage and recovery	✓	Groundwater feasibility report	✓			
6	Aquifer recharge	✓	Groundwater feasibility report	✓			
7	Desalination	✓	Desalination feasibility report	✓			
8a	Bulk transfers of raw water	✓	Raw water transfer feasibility report	✓			
8b	Bulk inter/intra company transfers of treated water	✓	Inter-zonal transfers study	✓			
9	Tankering of water	✗					
10	Redevelopment of existing resources	✗					
11	Reuse of existing private supplies	✓	Third party options report	✗			
12	Water re-use	✓	Water reuse feasibility report	✓			
13	Imports (icebergs)	✗					
14	Rain cloud seeding	✗					
15	Tidal barrage	✗					
16	Rainwater harvesting	✗					
17	Abstraction licence trading	✓	Third party options report	✓			
18	Water quality schemes that increase DO	✓	Catchment management feasibility report	✗			
19	Catchment management schemes	✓	Catchment management feasibility report	✓			
20	Conjunctive use operation of sources	✓	Built into DOs through WARMS	n/a			
21	Joint ("shared asset") resource	✓	Included in feasibility reports where applicable	n/a			
22	Asset transfers	✓	Third party options report	✗			
23	Options to trade other (infrastructure) assets	✓	Third party options report	✗			

† Taken from UKWIR 2012, Water Resources Planning Tools, EBSD Report, Ref 12/WR/27/6

Source: Taken from UKWIR 2012, Water Resources Planning Tools, EBSD Report, Ref 12/WR/27/6

7.17 We also have a number of drought permit options. These options require a drought permit or drought order to be issued by the Environment Agency or the Secretary of State and are subject to a significant level of uncertainty. Therefore they are not considered to provide any deployable output (DO) and are only available in the event of a drought arising from an exceptional shortage of rainfall. These options are covered in more detail in section 7.G.

Table 7-1: Summary of generic option rejection reasons

Scheme	Key elements	Screening decision	Comments
9 Tankering of water			
Tankering by sea	Tankering requires the development of new infrastructure, including pipelines and deep water facilities for loading / unloading. The logistical, environmental and planning constraints at the Thames Estuary are considerable as the estuary is relatively shallow and access would be restricted.	✗	A proposal by Albion Water for tankering from sources in Norway and the Netherlands has been considered. We concluded that while technically feasible at full utilisation (one tanker per day) it would be excessively costly; and at low utilisation (one tanker per week) the option remains uncompetitive with other options of a similar size. Tankering has therefore not been developed as a water resources option, but we are considering it as a potential emergency drought plan option to avoid level 4 restrictions.
13 Imports (icebergs)			
Icebergs	This option would require the development of a system for towing of icebergs over long distances e.g. from the Norwegian Sea to the Thames Estuary.	✗	Rejected on the basis that the techniques involved are not sufficiently advanced for commercial use and because of the high level of uncertainty around scheme yield. Also, as the Thames Estuary is designated under the Environment Agency Habitats Directive, an Appropriate Assessment is likely to be required.

Scheme	Key elements	Screening decision	Comments
			As part of this, the company would be required to demonstrate that there are no feasible alternative options; which is not the case.
14 Rain cloud seeding			
Rain cloud seeding	This option would require the development of a system for wide commercial implementation.	✗	Rejected on the basis that the techniques involved are not sufficiently advanced for commercial use and because of the high level of uncertainty that the scheme would provide significant yield.
15 Tidal barrage			
The Thames Barrier	The option for the use of the Thames Barrier to impound fresh water.	✗	Rejected as this option would limit the navigation of the river Thames to both private and commercial traffic resulting in disproportionate social and economic costs. It would also limit the passage of aquatic life which would cause significant ecological damage. The option could also result in raising the groundwater levels in the surrounding areas which could increase the incidence of flooding and cause damage to services and historic buildings in London.
16 Rainwater harvesting			
Rainwater harvesting	Direct collection and storage of rainwater.	✗	Rejected on the basis of limited drought resilience.
10 Redevelopment of existing resources			
Redevelopment of existing resources (e.g. Staines Reservoir)	Changes to current system that could yield benefits to the supply /demand balance.	✗	Redevelopment of reservoir storage is not possible unless sufficient surplus resources are available to compensate for the temporary loss of storage and the consequent risks to security of supply that would therefore result whilst the reservoir is being redeveloped. The provision of the surplus resources would be likely to be required for several years to allow the redevelopment of existing sources.

C. Water resource feasibility assessment

Approach to feasibility assessment

7.18 For the water resource option types that have passed the generic screening, feasibility assessments have been conducted. A four stage approach has been adopted for the feasibility assessment:

- **Stage 1:** a systematic search was conducted to identify potential new resources of each type, these collectively form the Unconstrained List of resource elements (see Appendix P) that were then screened against absolute constraints (pass/fail)
- **Stage 2:** the performance of each potential new resource was evaluated qualitatively against a number of criteria that enabled differentiation between options of that type
- **Stage 3:** the performance of the potential new resources was assessed in further detail (e.g. including costing)
- **Stage 4 – validation:** verification and review of the final list of specific resource elements was undertaken to determine the Feasible List

7.19 Further detail relating to the criteria used at each stage of the feasibility assessment can be found within each of the feasibility reports referred to in section 7.H.

7.20 New resource elements have been carried forward from the feasibility assessment into the Feasible List for further fine screening where they meet the following criteria:

- the resource is not compromised by any absolute or key constraints
- if there is mutual exclusivity between elements, only the best performing has been carried forward, provided that this assessment can reasonably be made based upon the information available at the feasibility assessment stage
- if the total estimated DO of resources for a given option type in a water resource zone (WRZ) exceeds the indicative deficit for the WRZ over the period of the planning horizon then only the best performing new resources have been carried forward to the Feasible List, provided that this assessment can reasonably be made based upon the information available at the feasibility assessment stage

Identifying third party options

7.21 We have sought to identify potential third party water resource options through three main approaches:

1) Request for proposals for water resources in the Official Journal of the European Union (OJEU)
2) Bilateral discussions with other water companies
3) Active engagement with regional water resource planning groups including the Water Resources in the South East Group (WRSE) and the Water Resources East Group (WRE)

Request for proposals for water resources

7.22 In preparation for WRMP14, on 1 June 2012 we published an OJEU notice to invite third party organisations to register interest in providing a bulk supply of raw or treated water. We regularly update the OJEU notice (17 February 2015, 25 January 2016 and 18 February 2017). A summary of the responses related to new resource options is set out in Table 7-2 together with an update on their draft WRMP19 status.

Table 7-2: Status of OJEU water resource options

Company	Nature of supply option	Volume (Ml/d)	Draft WRMP19 status
Tankering by sea			
Albion Water	Raw water tankering by sea from Norway	30 - 440	Assessment at WRMP14 found tankering by sea to be excessively costly to supply our geographic area. Albion engaged further with us during preparation of the draft WRMP19 throughout the stakeholder engagement process. However the assessment of the option
Iceland Ventures Limited	Raw water from Iceland via shipping tankers, bladders or pipeline	>400	
Scottish Water Horizons	Raw water tankering by sea from Loch Glass catchment, Scotland	5	

Company	Nature of supply option	Volume (Ml/d)	Draft WRMP19 status
			remains that it is excessively costly as a water resource option. Tankering has therefore not been developed as a water resources option, but we are considering it as a potential emergency drought plan option to avoid level 4 restrictions
Raw water inter-company transfers			
United Utilities	Redeployment of Lake Vyrnwy for Severn-Thames Transfer	=<180	Proposals further developed for the draft WRMP19 and included in the Raw Water Transfers Feasibility Report[7].
Severn Trent	Combination of redeployment of resources, resource development and water reuse to support Severn-Thames Transfer	128 - 198	
Joint United Utilities/Severn Trent Option	Alternative method for making water from Lake Vyrnwy release available to Thames Water through joint approach from United Utilities and Severn Trent	12-30	Included in Programme Appraisal[8]
Desalination			
Subsea Desalination	Redeployment of an existing mobile desalination plant to Beckton	20.5	Technical and commercial risks too high compared with a permanent solution tailored to our specific needs.
Licence trading/transfer			
RWE Npower	Temporary agreement in relation to Didcot power station abstraction licence.	17 Ml/d	Agreement reached over temporary transfer (10 years) of 17 Ml/d.

Source: Adapted from WRMP14, Table 7-10

Bilateral discussions with other water companies

7.23 We have engaged on a bilateral basis with other water companies to identify and develop potential new resource options in the form of:

- inter-company raw water transfers – these are assessed in the raw water transfers feasibility report
- inter-company treated water transfers – these are assessed in the inter-zonal transfer feasibility report

7.24 Companies that are willing to offer water to supply us include: Wessex Water, South East Water, Severn Trent Water, Welsh Water, Canal and River Trust, RWE NPower and United Utilities.

7.25 We have also engaged with other companies concerning their future deficits and how we may be able to provide water to addresses these.

[7] Raw Water Transfer Feasibility Report, Mott MacDonald, January 2018
[8] This option will be included in all resource option tables for the revised draft WRMP19

Regional groups (WRSE)

Purpose

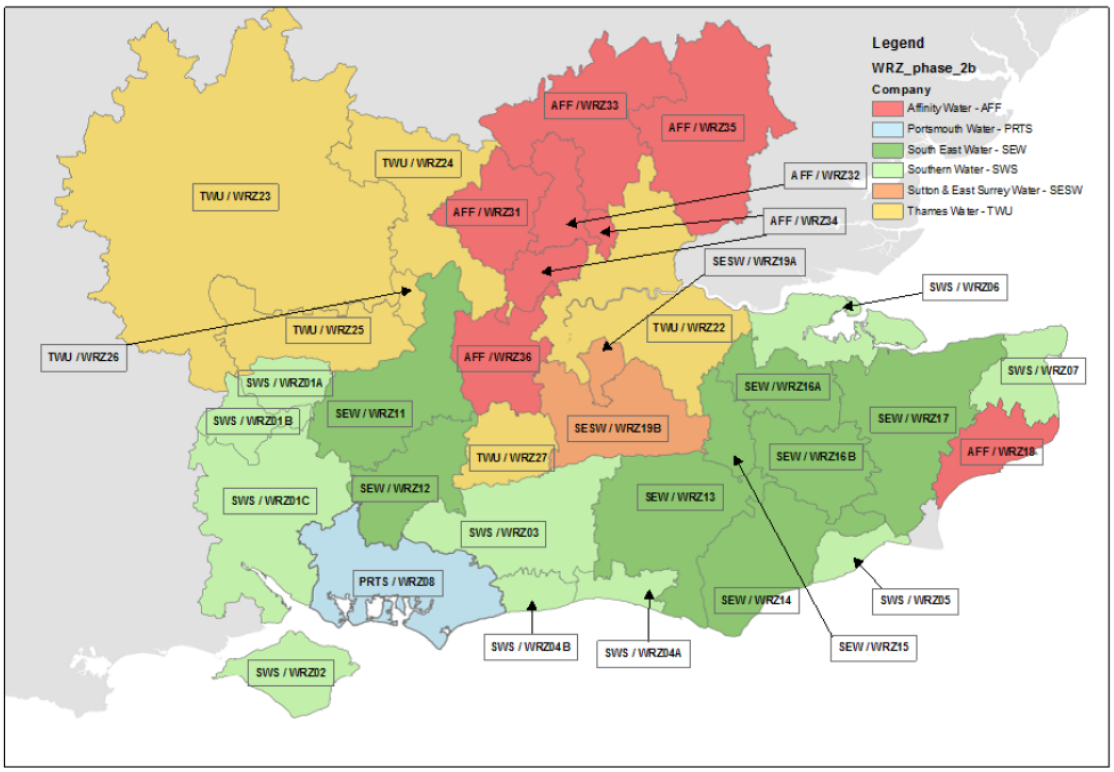
7.26 The overall aim of the WRSE group is:

> *"to identify and investigate a range of regionally based scenarios which when collated will form a range of potential regional strategies; and*
>
> *to work together to understand the investments required for those strategies."* [9]

7.27 We have been working with five other water companies (Portsmouth Water, South East Water, Southern Water, Affinity Water and Sutton & East Surrey Water), the Environment Agency, Ofwat, Natural England, CCWater and consultant partners to identify potential opportunities for sharing of resources in South East England[10]. WRSE companies' supply areas are shown in Figure 7-4.

7.28 The outcomes of this engagement have been to inform the participating water companies of potential resource sharing options for consideration in their own WRMPs and to provide a regional framework for the requirement for strategic resource development for the south east of England. The group addresses all aspects of water resources planning and attempts to identify areas of common ground, which can then be adopted by the water companies for planning should they chose to do so.

Figure 7-4: Water companies participating in WRSE and their respective WRZs



[9] Water Resources in the South East of England Memorandum of Understanding January 2016
[10] WRSE Collaborative Agreement April 2016

Background

7.29 The WRSE work is centred on the strategic application of a water resource planning options selection model, with the objective function of balancing supply and demand across the region at least cost. The model has been constructed to meet the requirements and principles of the WRPG. It contains water resources planning options for all participating companies, including:

- various types of new resources
- existing supply enhancements
- demand management options (leakage reduction, household metering, household and non-household water efficiency)
- raw and treated water transfers between resource zones and water companies

7.30 A 60 year planning horizon to 2080 has been chosen and several scenarios examined to explore the uncertainty inherent in forecasting future water resource development requirements. These include:

- A variety of different drought severities representing historical 20th century droughts, 1 in 200 year severe drought events and 1 in 500 year extreme drought events
- Reductions in water availability linked to the effects of climate change
- Application of the Water Industry National Environment Programme (WINEP) sustainability reductions
- Application of supply side drought permit options and drought order water use restriction savings
- Reductions in raw water availability linked to water quality issues

7.31 A total of eight scenarios[11] were run through the WRSE model using different combinations of the above factors to enable the model to select a broad range of options in order to test the resilience of potential investment portfolios against a wide range of future uncertainties. This facilitated identification of options that could be considered 'no regrets' best value options, as opposed to strictly least cost options, which are consistently selected under a wide range of different futures. Four of the investment scenarios were selected for more detailed resilience testing using an advanced decision making approach, Info-Gap, to quantify robustness given minimum performance requirements. Info-Gap Decision Theory (IGDT)[12] characterises the uncertainty of future system stresses by establishing a series of progressive incremental deviations between the best future estimate of a parameter (such as an expression of supply or demand) and its change in value due to uncertainty.

7.32 The WRSE work is jointly funded by the water companies and the Environment Agency. CH2M was commissioned to apply the modelling consultancy package. Other parallel work packages undertaken by other consultants for the WRSE Group are:

- Independent project management (Atkins)
- Construction and application of a water resources system simulation model of the south east area (Atkins and the University of Manchester)

[11] 12 scenarios were examined in the Phase 2 modelling work
[12] WRMP19 Methods - Decision Making Process: Guidance UK Water Industry Research 2016 Report Ref. No. 16/WR/02/10

- Cumulative and in combination environmental impact assessment of the water resource options selected within the WRSE water companies' draft WRMP19 plans (Ricardo)

Strategic transfer options to other companies

7.33 The strategic water resource options for Thames Water that are explored within the WRSE analysis include:

- Bulk transfer of raw water by pipeline from Oxfordshire to Southern Water's network in Hampshire. A number of different volumes were available for transfer of up to 100 Ml/d
- Bulk transfer of 100 Ml/d of raw water from Oxfordshire using the River Thames as the conveyance mechanism to Affinity Water's existing abstraction points on the Lower Thames
- Bulk transfer of up to 60 Ml/d of raw water from Oxfordshire using the River Thames as a conveyance mechanism to South East Water using a new abstraction location on the River Thames at Reading
- Bulk transfer by pipeline from our treated water network in south east London to Southern Water's network in Kent. A number of different volumes were available for transfer, of up to 50 Ml/d
- Bulk transfer by pipeline from our treated water network in south London to Sutton and East Surrey Water. A number of different volumes were available for transfer, of up to 30 Ml/d
- Bulk transfer of treated water by pipeline from London and Guildford to Affinity Water. These options capture the existing treated water bulk supply agreements between Thames Water and Affinity Water where the total amount of available water is not yet taken

WRSE modelling

7.34 All companies provided their baseline supply and demand data and draft option costs for all water supply/demand options for modelling purposes in September 2017. Details of all our options can be found in Section 7: Appraisal of resource options, Section 8: Appraisal of demand options and in Appendix P: Options list tables.

7.35 The project was divided into three phases:

- **Phase 1:** April 2014 to March 2015 – scoping, preparation, formalisation of modelling work
- **Phase 2:** April 2015 to August 2017 – main period of technical assessment and development using WRMP14 data. Application of Info-Gap stress testing of selected investment portfolios
- **Phase 3:** September 2017 to January 2018 – final strategic modelling runs using data that companies used for the draft WRMP19 plans

7.36 The intention of the Phase 3 modelling was to allow water companies to assess the consistency of the WRSE results with their own draft WRMPs, to understand the causes of

any significant differences and to support companies in the submission of their draft plans. The draft WRMP19 has been shown to be consistent with the plans of our neighbouring WRSE companies and where transfers have been agreed between us these are included in the results discussed in Section 10: Programme appraisal.

Feasible list

7.37 The output from the Phase 2 Feasibility Reports was the Feasible List of water resource options. The specific options on the Feasible List are summarised in Table 7-3 below.

Table 7-3: Feasible list of resource options

Option type	Name	Yield (Ml/d)
London WRZ		**DYAA**
Water Reuse	Beckton Reuse - 380 Ml/d	336
	Beckton Reuse - 300 Ml/d	268
	Beckton Reuse - 200 Ml/d	183
	Beckton Reuse - 150 Ml/d	138
	Beckton Reuse - 100 Ml/d	95
	Beckton Reuse - 50 Ml/d	49
	Mogden Reuse - 200 Ml/d	180
	Mogden Reuse - 150 Ml/d	137
	Mogden Reuse - 100 Ml/d	94
	Mogden Reuse - 50 Ml/d	49
	Deephams Reuse – 46.5 Ml/d	45
	Crossness Reuse - 190 Ml/d	174
	Crossness Reuse - 150 Ml/d	138
	Crossness Reuse - 100 Ml/d	95
	Crossness Reuse - 50 Ml/d	49
	Mogden South Sewer Reuse - 50 Ml/d	49
Desalination	Crossness Desalination (Unblended) - 65 Ml/d	60
	Crossness Desalination (Blended) - 100 Ml/d	95
	Crossness Desalination (Blended) - 200 Ml/d	189
	Crossness Desalination (Blended) - 300 Ml/d	284
	Beckton Desalination - 150 Ml/d	142
Raw Water Transfer	Severn Thames Transfer, Deerhurst - Culham 300 Ml/d, Vyrnwy + Mythe 195 Ml/d	160*
	Severn Thames Transfer, Deerhurst - Culham 400 Ml/d, Vyrnwy + Mythe 195 Ml/d	200*
	Severn Thames Transfer, Deerhurst - Culham 500 Ml/d, Vyrnwy + Mythe 195 Ml/d	213*
	Severn Thames Transfer, Deerhurst - Culham 300 Ml/d, Vyrnwy + Mythe 163 Ml/d	144*
	Severn Thames Transfer, Deerhurst - Culham 400 Ml/d, Vyrnwy + Mythe 163 Ml/d	179*
	Severn Thames Transfer, Deerhurst - Culham 500 Ml/d, Vyrnwy + Mythe 163 Ml/d	191*
	Severn Thames Transfer, Deerhurst - Culham 300 Ml/d, Vyrnwy + Mythe 75 Ml/d	98*
	Severn Thames Transfer, Deerhurst - Culham 400 Ml/d, Vyrnwy + Mythe 75 Ml/d	120*
	Severn Thames Transfer, Deerhurst - Culham 500 Ml/d, Vyrnwy + Mythe 75 Ml/d	131*

Option type	Name	Yield (Ml/d)
	Oxford Canal	15
Reservoir#	Abingdon Reservoir 150m^3	287
	Abingdon Reservoir 125m^3	247
	Abingdon Reservoir 100m^3	204
	Abingdon Reservoir 75m^3	153
	Abingdon Reservoir 50m^3	103
	Abingdon Reservoir 30m^3	59
	Abingdon Reservoir Phased 80+42Mm^3 Phase 1	165
	Abingdon Reservoir Phased 80+42Mm^3 Phase 2	75
	Abingdon Reservoir Phased 30+100Mm^3 Phase 1	59
	Abingdon Reservoir Phased 30+100Mm^3 Phase 2	196
	Chinnor Reservoir 50Mm^3	103
	Chinnor Reservoir 30Mm^3	59
	Marsh Gibbon Reservoir 75 Mm^3	153
	Marsh Gibbon Reservoir 50 Mm^3	103
	Marsh Gibbon Reservoir 30 Mm^3	59
Direct River Abstraction	River Lee Direct River Abstraction - 150 Ml/d	35
	Teddington Direct River Abstraction 300 Ml/d	268
	Didcot Power Station – unused part of licence (NPower)	17
Aquifer Recharge	Kidbrooke Aquifer Recharge/Aquifer Storage and Recovery (SLARS1)[13]	7
	Merton Aquifer Recharge (SLARS3)	5
	Streatham Aquifer Recharge (SLARS2)	4
Aquifer Storage and Recovery	South East London (Addington) Aquifer Storage and Recovery	3
	Thames Valley Central Aquifer Storage and Recovery	3
Groundwater	Addington	1
	London Confined Chalk (north)	2
	Southfleet/Greenhithe (new water treatment works (WTW))	8
	Merton Recommissioning	2
	North London Licence Trading	1
Swindon & Oxfordshire (SWOX) WRZ		**ADPW**
Raw Water Transfer	Severn Thames Transfer, Deerhurst – Culham: see London WRZs for sizes	20*
	Oxford Canal	15
New Reservoir	Abingdon Reservoir: see London WRZs for sizes	20
	Chinnor Reservoir: see London WRZs for sizes	20
	Marsh Gibbon Reservoir: see London WRZs for sizes	20
Groundwater	Moulsford 1	3.5
Removal of Constraints to DO	Ashton Keynes borehole pumps - Removal of Constraints to DO	1.6

[13] SLARS – south London Artificial Recharge Scheme

Option type	Name	Yield (Ml/d)
Internal Inter-Zonal Transfer	Henley to SWOX - 2.4 Ml/d	2.4
	Kennet Valley to SWOX - 6.7 Ml/d	6.7
	Kennet Valley to SWOX - 2.3 Ml/d	2.3
Inter-Company Transfers	Wessex Water to SWOX	2.9
Slough, Wycombe & Aylesbury (SWA) WRZ		**ADPW**
Raw Water Transfer	Severn Thames Transfer, Deerhurst – Culham: see London WRZs for sizes	20*
	Oxford Canal	15
New Reservoir	Abingdon Reservoir: see London WRZs for sizes	20
	Chinnor Reservoir: see London WRZs for sizes	20
	Marsh Gibbon Reservoir: see London WRZs for sizes	20
Direct River Abstraction	Didcot Power Station – unused part of licence (NPower)	17
Groundwater	Datchet	6
Removal of Constraints to DO	Datchet Main Replacement Removal of Constraints to DO	1.1
	Eton Removal of Constraints to DO	1.6
Internal Inter-Zonal Transfer	Henley to SWA - 2.4 Ml/d	2.4
Guildford WRZ		**ADPW**
Groundwater	Dapdune Licence Disaggregation	2.2
Removal of Constraints to DO	Dapdune Removal of constraints to DO	1
	Ladymead WTW Removal of Constraints to DO	4.6
Inter-Company Transfers	Southeast Water to Guildford	10
Henley WRZ		
No feasible options identified		
Kennet Valley WRZ		**ADPW**
Groundwater	Mortimer Disused Source (Recommission)	4.5
Removal of Constraints to DO	East Woodhay borehole pumps Removal of Constraints to DO	2.1

Table Notes:

** Stochastic yield based upon stochastic analysis and taking account of estimated impacts of climate change and other abstractors. Further information can be found in the Raw Water Transfers Feasibility Report and Fine Screening Report*

[#] Reservoir yields used have been based upon WARMS2 modelling, not stochastic analysis. Initial stochastic analysis shows a minor reduction of approximately 2% when stochastic analysis is used. Stochastic yields will be used for the revised draft WRMP19.

Yields for London are for Dry Year Annual Average (DYAA) condition, whereas for the Thames Valley they are for Average Day Peak Week (ADPW) condition.

7.38 For those options that have not been carried forward to the feasible list an explanation of the reasons for rejection is included in Appendix Q: Scheme rejection register.

Options requiring further investigation to confirm feasibility

7.39 There remain several water resource elements where there is currently insufficient information to either confirm that the proposal is feasible, or reject it as infeasible. For these water resources, further investigations are continuing with a view to confirming their status for the revised draft WRMP19. Resources requiring further investigation include:

- 75 Ml/d canal transfer through the Birmingham and Fazeley Canal, Coventry Canal and Oxford Canal supported by Minworth sewage treatment works (STW) effluent. This option would be mutually exclusive with the transfer of Minworth effluent through the Deerhurst pipeline
- Support from Severn Trent Water to the Severn-Thames Transfer through the Deerhurst Pipeline from the following sources:
    - Draycote Reservoir expansion (24 Ml/d)
    - Transfer of Minworth effluent (115 Ml/d) to the River Avon (a tributary of the River Severn)
    - Transfer of Hayden STW effluent (20 Ml/d)
    - Transfer of Netheridge STW effluent (35 Ml/d)
- Support from Welsh Water (up to 60 Ml/d) through licence transfer in the River Wye to the Severn-Thames Transfer through the Deerhurst Pipeline

7.40 We have excluded the Severn Trent water transfer schemes at this stage because of Environment Agency feedback and our own initial analysis which indicates there are likely to be unacceptable detrimental environmental impacts associated with these options. Severn Trent Water is working with us to provide sufficient information to address the concerns raised by the Environment Agency.

D. System reinforcements

7.41 Cross-option studies have been conducted to identify the water treatment, raw water system and treated water transmission reinforcements required to deliver the new resources into distribution. In many cases the same system reinforcements are required for a number of different water resources and the timing of the need for the system reinforcements may also not coincide with the need for water resources. The system reinforcements have therefore been developed as separate system elements that can be combined with water resource elements when developing an overall programme. It should be noted that the exact configuration of system reinforcements required at a programme level will be refined and explained at the programme appraisal stage in Section 10. Demand management options that are selected will also have a significant impact on the requirement for additional system reinforcements.

Water treatment cross option study

7.42 We are continuing our review of the resilience of water treatment capability in the London WRZ. Demand management options that are selected will also have a significant impact on the requirement for additional water treatment. However, following preliminary findings, it has been concluded that new water resource options for London will require additional treatment capacity, except in the case of desalination which produces potable water. A cross-option study has been undertaken to investigate feasible options for additional treatment capacity. Two options have been identified in London, with sites at:

- **Kempton WTW** for additional resources from the west (e.g. Upper Thames Reservoir, Severn-Thames Transfer, Teddington Direct River Abstraction), including a new connection into the Thames Water Ring Main (TWRM)
- **Coppermills WTW** for additional resources from the east (e.g. Beckton and Deephams reuse) – this would entail redevelopment of the existing works as there is no further space on the existing site. Alternative sites to Coppermills in east London are also being investigated.

7.43 For the SWOX WRZ two sites have been identified for additional treatment:

- **Abingdon WTW** for resources from the Abingdon Reservoir
- **Radcot WTW** for resources from the Severn-Thames Transfer

7.44 For the SWA WRZ two options have also been identified for additional treatment of resources from either the Abingdon reservoir or the Severn-Thames Transfer

- **Abingdon WTW** for treated water transfer into the north of the SWA area
- **A new river abstraction from the River Thames** and treatment works in the vicinity of Medmenham supplying the south of SWA.

Network reinforcement cross option study

7.45 A cross-option study has been undertaken to identify supply network reinforcement requirements for London. The report identified six interventions that could be required, including two extensions to the TWRM, with the necessary reinforcements dependent on whether the additional water resource is treated in east or west London. The network reinforcement requirements identified are:

1) Replace pump infrastructure at New River Head
2) Replace pump infrastructure at Barrow Hill
3) TWRM extension - Hampton to Battersea
4) TWRM level controlled by new header tank and pumping station at Coppermills WTW
5) TWRM extension - Coppermills to Honor Oak
6) Resolve issues with supply to Surbiton during TWRM outage

7.46 The matrix in Table 7-4 shows which of these reinforcements would be required for different combinations of new treatment capacity, depending upon whether the additional water resource is available for treatment to the east or the west of the existing TWRM. It can be

seen that initially no reinforcement may be required. The precise timing of the requirement for individual network reinforcements is optimised as part of programme appraisal but will also depend on the demand management options selected as part of the programme appraisal process.

Table 7-4: Network reinforcement requirements for additional water resources treated in east or west London

		East (Ml/d)								
		0	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**
West (Ml/d)	**0**	-	-	5	4,5	4,5	4,5	4,5	1,4,5	1,4,5
	100	1	1	3,4,5	3,4,5	3,4,5	3,4,5	4,5	1,4,5	
	200	1,3	1,3	3,4	3,4,5	3,4,5	3,4,5	3,4,5		
	300	1,3	1,3	1,3,4	3,4,5	3,4,5	3,4,5			
	400	1,3	1,3	1,3,5	3,4,5	3,4,5				
	500	1,3,5,6	1,3,5,6	1,3,5	1,3,5					
	600	1,2,3,5,6	1,3,5,6	1,3,5,6						
	700	1,2,3,5,6	1,2,3,5,6							
	800	1,2,3,5,6								

7.47 Additional network reinforcement elements have been identified that are specific for individual options. These include:

- Tunnel from Beckton to Coppermills WTW for blending of water from Beckton and Crossness desalination options
- Tunnel from Crossness desalination plant site to Beckton to extend the Beckton-Coppermills tunnel to Crossness so that it can transfer resource from the proposed desalination plant at Crossness
- Pipeline from proposed Abingdon WTW to Long Crendon to supply SWA

7.48 Further work is being undertaken to identify local supply network reinforcements required to accommodate growth however these interventions are outside the scope of the WRMP and so are not included as specific elements.

Raw water system cross option study

7.49 A cross-option study has been undertaken to identify supply reinforcements required to the raw water system (between the point of abstraction and the WTW inlet) for the different water resource options. This is of particular relevance for options that augment resources in the River Thames or the River Lee (including new reservoir options, raw water transfers, effluent reuse and some direct river abstraction options). The study used currently available models of the raw water system for the River Thames and River Lee abstractions.

7.50 The study identified ten interventions that may be required, the most significant including an extension to the Thames Lee Tunnel , a second Spine Tunnel and additional conveyance from Queen Mary Reservoir to Kempton WTW. The necessity for the reinforcements will be dependent on the water resource options selected and whether they enter the raw water system in east or west London. The identified raw water system reinforcements, divided between east and west London, are:

East London

1) King George V Reservoir intake capacity increase
2) Chingford South intake capacity increase
3) Thames Lee Tunnel extension from Lockwood pumping station to King George V Reservoir intake
4) Thames Lee Tunnel upgrade to remove existing constraints to maximise transfer capacity (not shown in Table 7-5)
5) Additional conveyance from King George V Reservoir to break tank
6) Second Spine Tunnel from break tank to Reservoir 5 upstream of Coppermills WTW

West London

7) Datchet intake capacity increase with transfer to Queen Mother and Wraysbury Reservoirs
8) Littleton intake capacity increase with transfer to Queen Mary Reservoir
9) Surbiton intake capacity increase with transfer to Walton inlet channel, required for the Teddington Direct River Abstraction (DRA) option only (not shown in Table 7-5)
10) Additional conveyance from Queen Mary Reservoir to Kempton WTW

7.51 The matrix in Table 7-5 shows which of these reinforcements are required depending upon the additional water resource added to the east and west London raw water systems. It can be seen that initially no reinforcement may be required. The precise timing of the requirement for individual reinforcements is optimised as part of programme appraisal.

Table 7-5: Raw water system reinforcement requirements for additional water resources in east or west London

		Additional raw water resource in the east (Ml/d)								
		0	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**
Additional raw water resource in the west (Ml/d)	**0**	-	3	1,3,5	1-3,5,6	1-3, 5, 6	1-3, 5, 6	1-3, 5, 6	1-3, 5, 6	1-3, 5, 6
	100	-	3	1,3,5	1-3,5,6	1-3, 5, 6	1-3, 5, 6	1-3, 5, 6	1-3, 5, 6	
	200		3	1,3,5	1-3,5,6	1-3, 5,6	1-3, 5, 6	1-3, 5, 6		
	300		3	1,3,5	1-3,5,6	1-3, 5, 6	1-3, 5, 6			
	400	7	3,7	1,3,5,7	1-3,5-7	1-3, 5-7				
	500	7/8,10	3,7/8,10	1,3,5,7/8,10	1-3,5-7/8,10					
	600	7/8,10	3, 7/8,10	1,3,5,7/8,10						
	700	7/8,10	3, 7/8,10							
	800	7/8,10								

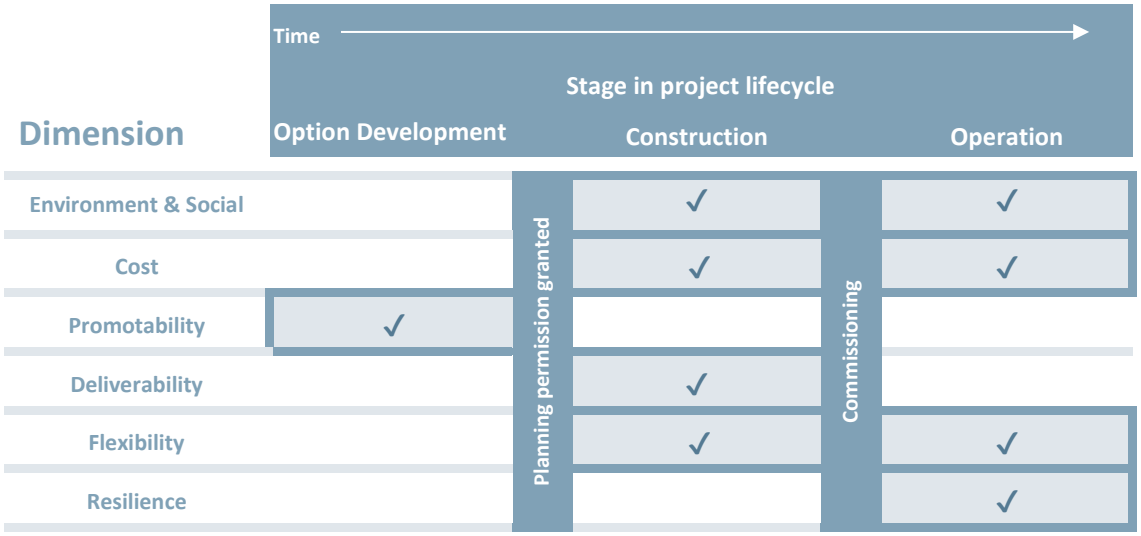
E. Fine screening of water resource options

Approach to fine screening

7.52 The water resource elements that passed the validation stage of the feasibility assessments form the Feasible List. These elements have then been subjected to a further fine screening stage to produce the Constrained List of elements for further development before Phase 3 programme appraisal. The fine screening process brought together all water resource types and compared them using a consistent set of criteria. Where options have been rejected an explanation is provided in the fine screening report[14] and in the Rejection Register (Appendix Q: Scheme rejection register).

7.53 The fine screening process compared water resource options within each WRZ. It combined quantitative analysis of costs with qualitative analysis using six relevant factors or 'dimensions'. These qualitative factors relate to the different stages in the project lifecycle as shown in Figure 7-5. These dimensions are defined in the fine screening report.

Figure 7-5: Mapping of six fine screening dimensions to project lifecycle



7.54 All resource options on the Feasible List have been assessed against these dimensions to identify the potential benefits/opportunities and the dis-benefits/risks of each option. The assessment against each dimension is categorised and visualised in summary matrices (included in the appendices to the fine screening report) using the categories shown in Table 7-6. For any one dimension more than one symbol was in some cases needed to capture the nature of the risks and benefits. For example, under the environmental and social dimension some options included material dis-benefits during the construction stage, but material benefits during the operational phase.

[14] Fine Screening Report, Mot MacDonald, January 2018

Table 7-6: Dimension category definitions

Symbol	Meaning	Definition
◉	Substantial benefit/opportunity	The option has substantial benefits/opportunities either individually or cumulatively.
◎	Material benefit/opportunity	The option has some material benefits/opportunities.
○	Neutral	The option does not have significant residual effects.
◑(r)	Material dis-benefit/risk	The option has some material residual dis-benefits/risks, either individually or cumulatively
●(r)	Substantial dis-benefit/risk	The option has substantial residual dis-benefits/risks, either individually or cumulatively

Note: A superscript '(r)' next to the symbol would highlight that a dis-benefit/risk could potentially be reduced to 'neutral' by additional development of mitigation measures during detailed design.

Results of fine screening

7.55 To arrive at the Constrained List of options from the Feasible List, fine screening decisions have been made by evaluating water resource options across all six qualitative dimensions. Rather than imposing rigid rules to make screening decisions, the focus has been on ensuring that there is a clear and robust reasoning for each screening decision which has then been recorded in Appendix Q: Scheme rejection register. The adoption of this approach has, nevertheless, shown that the reasons for rejecting options have tended to fall into three categories:

- Options were rejected if they presented substantial irreducible dis-benefits/risks unless these could be offset by a substantial benefit/opportunity
- Options would be rejected if they were clearly less favourable than other mutually exclusive options
- Options would be rejected if they were the least favourable of all options where there were more options than could reasonably be required over the planning horizon under future scenarios.

7.56 A summary of the fine screening results is presented in Table 7-7 showing those options that have passed from the Feasible List to the Constrained List and those that have been rejected. The reasons for screening decisions are recorded in Appendix Q: Scheme rejection register.

Table 7-7: Fine screening summary for specific options

Option	Size band (Ml/d)							
	0	25	75	125	175	225	275	325
London WRZ								
Reuse - Beckton								
Reuse - Mogden								
Reuse - Deephams								
Reuse - Crossness								
Reuse - Mogden South Sewer								

Option	Size band (Ml/d) 0	25	75	125	175	225	275	325
RWT - STT Deerhurst								
RWT - Oxford Canal								
New Reservoir - Abingdon								
New Reservoir - Chinnor								
New Reservoir - Marsh Gibbon								
DRA - Teddington								
DRA - Lower Lee								
Desalination - Beckton								
Desalination - Crossness (unblended)								
Desalination - Crossness (blended)								
AR/ASR - Kidbrooke (SLARS1)								
AR Merton (SLARS3)								
AR Streatham (SLARS2)								
ASR South East London (Addington)								
ASR Thames Valley/Thames Central								
GW - Addington								
GW - London confined Chalk (north)								
GW - Southfleet/Greenhithe (new WTW)								
GW - Merton recommissioning								
North London Licence Trading								
Swindon and Oxfordshire (SWOX) WRZ								
RWT - STT Deerhurst								
RWT - Oxford Canal								
New Reservoir - Abingdon								
New Reservoir - Chinnor								
New Reservoir - Marsh Gibbon								
GW - Moulsford								
Ashton Keynes borehole pumps								
IZT - Kennet Valley to SWOX								
IZT - Henley to SWOX								
ICT - Wessex Water to SWOX								
Slough, Wycombe & Aylesbury (SWA) WRZ								
RWT - STT Deerhurst								
RWT - Oxford Canal								
New Reservoir - Abingdon								
New Reservoir - Chinnor								
New Reservoir - Marsh Gibbon								
GW - Datchet								
Datchet main replacement								
Eton removal of constraints to DO								
IZT - Henley to SWA								
Henley WRZ								
No feasible options identified								
Guildford WRZ								
Dapdune licence disaggregation								
Dapdune removal of constraints to DO								

Option	Size band (Ml/d)							
	0	25	75	125	175	225	275	325
Ladymead WTW								
ICT - South East Water to Guildford								
Kennet Valley (KV) WRZ								
GW - Mortimer recommissioning								
East Woodhay borehole pumps								

Key

- Screened out at fine screening
- Passes fine screening onto Constrained List
- Screening status to be confirmed

Constrained List

7.57 For programme appraisal, resource and system elements have been combined to provide the best value 80 year programme to address future water supply requirements. A summary of the elements included on the Constrained List is provided in Table 7-8 and Table 7-9.

Figure 7-6: Map of Constrained List options

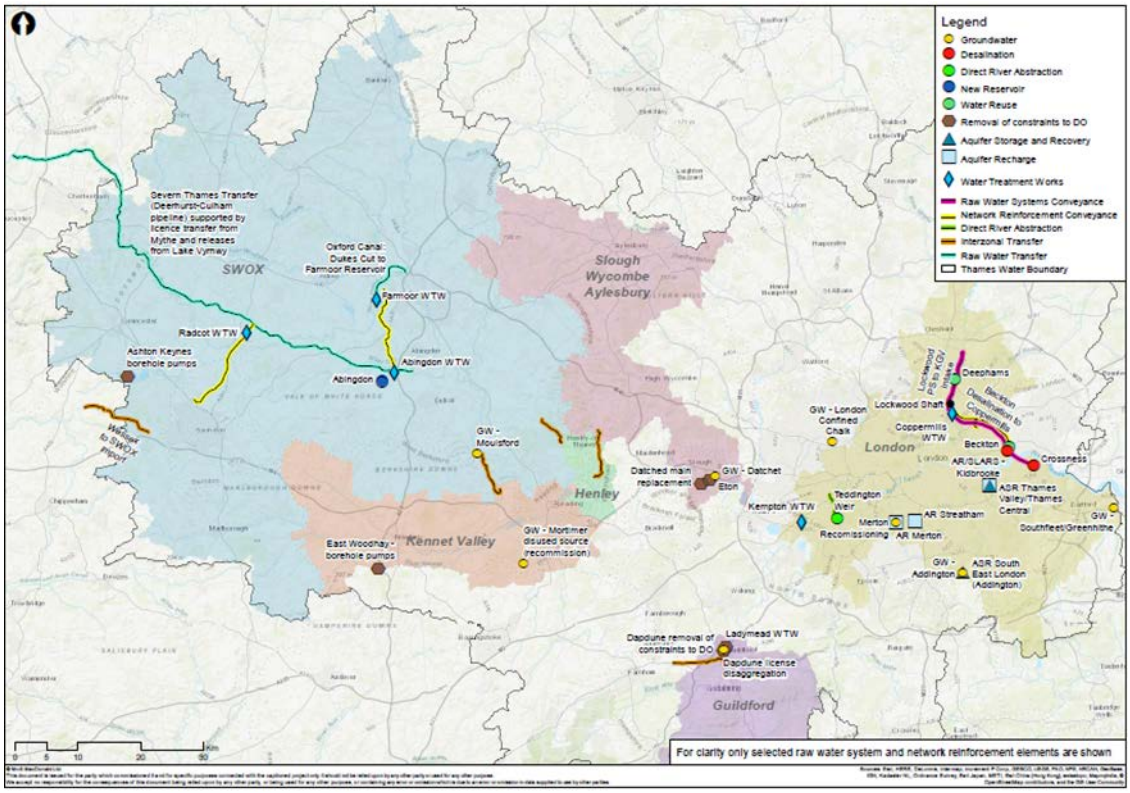


Table 7-8: Constrained List for London WRZs

Option Type	Resource Element		Conveyance Element		Raw Water System	Treatment Element		Network Element
	Location	Nominal Capacity Ml/d	Location	Nominal Capacity Ml/d		Location	Nominal Capacity Ml/d	
Water reuse	Deephams	46.5	Deephams to KGV	60		East London	100	See network reinforcement matrix - Section 7-D
			Deephams to TLT extension		See raw water system matrix - Section 7-D			
	Beckton	3nr 100 or 2nr 150	Beckton to Lockwood shaft	800		East London	3nr 100 or 2nr 150	
Raw Water Transfer	Vyrnwy	60/148/180	Deerhurst to Culham	300/400/500	See raw water system matrix - Section 7-D	Kempton	3nr 100	See network reinforcement matrix - Section 7-D
	Mythe	15						
	Oxford Canal	15						
Desalination	Beckton (blended)	150	N/A		N/A	N/A		See matrix Section 7-D, plus **Beckton to Coppermills**
	Crossness	3nr 100			Beckton-Crossness			As above plus **Crossness to Beckton**
New Reservoir	Abingdon 75Mm3	153	N/A		See raw water system matrix -Section 7-D	Kempton	300	See network reinforcement matrix - Section 7-D
	Abingdon 100Mm3	204					150	
	Abingdon 125Mm3	247					100	
	Abingdon 150Mm3	287						
	Abingdon 30+ 100Mm3	59+196						
	Abingdon 80+ 42Mm3	165+75						
Direct River Abstraction	Teddington Weir (Mogden effluent transfer)	300	Mogden to Teddington Tunnel and Teddington to Thames-Lee Tunnel	300	See raw water system matrix - Section 7-D	Kempton / East London	100 200	See network reinforcement matrix - Section 7-D
	Didcot	17	N/A		N/A	N/A		N/A
Aquifer Recharge	AR/SLARS - Kidbrooke (SLARS1)	7	N/A		N/A	N/A		N/A
	AR Merton (SLARS3)	5						
	AR Streatham (SLARS2)	4						
Aquifer Storage and Recovery	ASR South East London (Addington)	3	N/A		N/A	N/A		N/A
	ASR Thames Valley/Thames Central	3						
Groundwater	GW - Addington	1	N/A		N/A	N/A		N/A
	GW - London Confined Chalk (north)	2						
	GW - Southfleet/Greenhithe (new WTW)	8						
	Merton recommissioning	2						

Table 7-9: Constrained List for Thames Valley WRZs

	Option Type	Resource Element Location	Resource Element Nominal Capacity Ml/d	Conveyance Element Location	Conveyance Element Nominal Capacity Ml/d	Raw Water System	Treatment Element Location	Treatment Element Nominal Capacity Ml/d	Network Element Location	Network Element Nominal Capacity Ml/d
Swindon & Oxfordshire (SWOX)	Raw Water Transfer	Vyrnwy	24/48/72	Deerhurst to Culham	300 400 500	N/A	Radcot WTW	24 each phase	Transfers to service reservoir included in WTW elements	
		Oxford Canal	15	Dukes Cut to Farmoor	15		Farmoor WTW	24 each phase		
	New Reservoir	Abingdon 75Mm3	24/48/72	N/A		N/A	Abingdon SWOX WTW	24 each phase	Transfers to service reservoir included in WTW elements	
		Abingdon 100Mm3	24/48/72							
		Abingdon 125Mm3	24/48/72							
		Abingdon 150Mm3	24/48/72							
		Abingdon 30+ 100Mm3	24/48/72							
		Abingdon 80+ 42Mm3	24/48/72							
	Groundwater	GW - Moulsford 1	3.5 (ADPW)	N/A		N/A	N/A		N/A	
	Removal of constraints to DO	Ashton Keynes borehole pumps	1.6 (ADPW)	N/A		N/A				
	Inter-zonal transfers	GW - Mortimer disused source		Kennet Valley to SWOX	6.7	N/A				
					2.3					
				Henley to SWOX	2.4					
	Inter-company transfer			Wessex Water to SWOX (Flaxlands)	2.9	N/A	N/A		N/A	
Slough, Wycombe & Aylesbury (SWA)	Raw Water Transfer	Vyrnwy	24/48/72	Deerhurst to Culham	300 400 500	N/A New intake	Abingdon SWA WTW Medmenham WTW	24 each phase 24 each phase	Abingdon to north SWA Transfers to service reservoir included in WTW elements	72
		Oxford Canal	15			New intake	Medmenham WTW	24 each phase		
	New Reservoir	Abingdon 75Mm3	24/48/72	N/A		N/A	Abingdon SWA WTW	24 each phase	Abingdon to north SWA	72
		Abingdon 100Mm3	24/48/72							
		Abingdon 125Mm3	24/48/72							
		Abingdon 150Mm3	24/48/72			New intake	Medmenham WTW	24 each phase	Transfers to service reservoir included in WTW elements	
		Abingdon 30+ 100Mm3	24/48/72							
		Abingdon 80+ 42Mm3	24/48/72							
	Direct River Abstraction	Didcot	17	N/A		New intake	Medmenham WTW	24 each phase	Transfers to service reservoir included in WTW elements	
	Groundwater	GW - Datchet		N/A		N/A	N/A		N/A	
	Removal of constraints to DO	Datchet main replacement	8.7 (ADPW)	N/A		N/A	N/A		N/A	
		Eton removal of constraints to DO								
	Inter-zonal transfers			Henley to SWA	2.4	N/A	N/A		N/A	
Guildford	Groundwater	Dapdune licence disaggregation		N/A		N/A	N/A		N/A	
	Removal of constraints to DO	Dapdune removal of constraints to DO	7.8 (ADPW)	N/A		N/A	N/A		N/A	
		Ladymead WTW								
	Inter-co. transfers			SouthEast Water to Guildford	10	N/A	N/A		N/A	
Kennet Valley	Groundwater	GW - Mortimer disused source (recommission)	4.5 (ADPW)	N/A		N/A	N/A		N/A	
	Removal of constraints to DO	East Woodhay borehole pumps	2.1 (ADPW)	N/A		N/A	N/A		N/A	

F. Further option development for the Constrained List

Conceptual design

7.58 For water resource elements on the Constrained List Conceptual Design Reports (CDRs) have been prepared. The CDRs provide information on the location of the works, engineering and land requirements, dependencies with other elements, construction impacts, environmental and social mitigations, DO, programme assumptions and risks.

7.59 The information from the CDRs is used as the basis for updating cost estimates, developing a risk register, and for conducting the Strategic Environmental Assessment of options (SEA).

Cost and risk

7.60 For all elements on the constrained list a review of feasibility stage costs has been conducted. Costs have been updated to reflect conceptual designs, where these have changed from the feasibility stage. Unit rates have also been updated for material cost items where confidence in the feasibility stage estimates was low.

7.61 For all large resource elements on the Constrained List (i.e. resources with a capacity of more than 50 Ml/d) a risk register has been developed and estimates of likelihood and consequence of risks occurring have been assigned. Monte Carlo analysis has been used to combine these estimates to provide a probability distribution for risk.

7.62 An allowance for optimism bias has also been applied to all elements, and this has been scaled back to reflect the level of confidence around solution delivery at conceptual design stage. For elements where a risk allowance has been applied from the risk register, the scaling back of optimism bias has been revisited following completion of the risk register so as to avoid double counting of risk between optimism bias and the bottom-up allowance of risk identified through the risk register.

Strategic environmental assessment

7.63 For all elements on the constrained list a SEA has been conducted. Further information on the Strategic Environmental Assessment appraisal can be found in Section 9: Environmental appraisal.

Further investigations into constrained list options

7.64 The options on the Feasible List and Constrained List are assessed as being feasible based upon existing knowledge. At this stage of project development it is inevitable that uncertainties will exist and a number of investigations are ongoing to further reduce uncertainty. These include:

- Investigation into losses that would occur in the River Severn associated with regulation releases from Lake Vyrnwy and other potential sources of support for a

Severn-Thames Transfer. Associated with these investigations are discussions through the River Severn Working Group on potential future abstraction arrangements. The Environment Agency considers that the existing 10% allowance for losses is too low and it could be significantly higher. To protect the Severn Estuary Special Area for Conservation (SAC) the Environment Agency will therefore enforce the existing 'hands off flows' regime at Deerhurst instead of accepting a new put and take licensing arrangement

- Further investigations to address stakeholder comments about potential impacts of the Teddington DRA option on the environment and navigation in the River Thames and Thames Tideway
- Feasibility assessments of vertical alignments for proposed London tunnels required for raw water conveyance and network reinforcement

G. Drought permits

7.65 We have identified a number of drought permit options that would be used to augment existing water supplies in the event of a severe drought. Drought permits are options that enable water companies to abstract more water than permitted by their abstraction licences. These options are only available in drought situations and require the water company to demonstrate that there has been an exceptional shortage of rainfall. They are initially issued for a six month period but may be extended for a further six months if the drought persists. These drought permit options are set out in more detail in our Drought Plan and its appendices[15].

7.66 The volumes associated with each drought permit are uncertain because the yields will be subject to the impact of the severe drought that would trigger their implementation. The Drought Plan provides an indication of the yield that would be expected from each option. An estimate of this yield has been produced and used for modelling of scenarios by WRSE. The yields for each WRZ under the worst droughts from the historic record and the worst droughts from a 1:200 stochastic record are below in Table 7-10. The historic record is the period for which data is available and is used to calculate the deployable output for our water resources. The 1 in 200 year estimate has been derived from stochastic analysis to provide a longer period than the historic record which can then be used to examine the impact of more severe droughts than those that occur in the historic record.

[15] Thames Water draft Drought Plan, 2017

Table 7-10: Yields for each WRZ under the worst droughts from the historic record and the worst droughts from a 1:200 stochastic record

WRZ	Historic record	1:200
London	240 Ml/d	126 Ml/d
SWOX	73 Ml/d	42 Ml/d
Kennet Valley	43 Ml/d	9 Ml/d
SWA	14 Ml/d	11 Ml/d
Guildford	12 Ml/d	9 Ml/d
Henley	6 Ml/d	6 Ml/d

7.67 The drought permit options generally exist where we have water sources that are restricted or have been closed because of their potential to exacerbate low flows in rivers. Therefore the options, in most cases, would have some adverse environmental impact is exercised, although in most cases it would be temporary and reversible in that the ecology would recover after drought conditions ceased. In each case the environmental impact has been assessed and Environmental Assessment Reports produced and these have been used in the production of a Habitats Regulations Assessment and a SEA for the Drought Plan.

7.68 These drought permit options provide an important resource to ensure continuity of supply in the event of severe drought. The longer a drought permit option is used the greater the environmental impact is likely to be. It is also important to consider that the yield of these options would decrease through time as the drought severity intensifies and this is shown above in Table 7-10 for a 1:200. In addition there is a risk that drought permits may not be renewed for a further period of six months if the Environment Agency / Secretary of State consider the actual or potential environmental impact would be too great.

7.69 We have assessed the impact of more severe droughts for our Drought Plan using stochastically generated data to provide a much longer time series which gives a greater range of droughts for assessment. Figure 7-7 and Figure 7-8 show the impact of droughts of severity of 1:300 and demonstrate the importance of drought permits in preserving reservoir storage. In the first example we would need to implement drought permits from 1st February until the end of September. In the second example we would need drought permits from 1st March until the end of October. In each case drought permits would have been needed for longer than six months and so a reapplication would be necessary. The reapplication would be subject to significant uncertainty in yield, because of the impact of a more severe drought on water resource availability, and environmental impact and would be likely to be strongly opposed by regulators and stakeholders concerned with impact on the environment.

Figure 7-7: Impact of the Generated 'Severe' Drought Event 1 (modelled 1 in 300 Return Period) on Aggregated London Reservoir Storage – example 1[16]

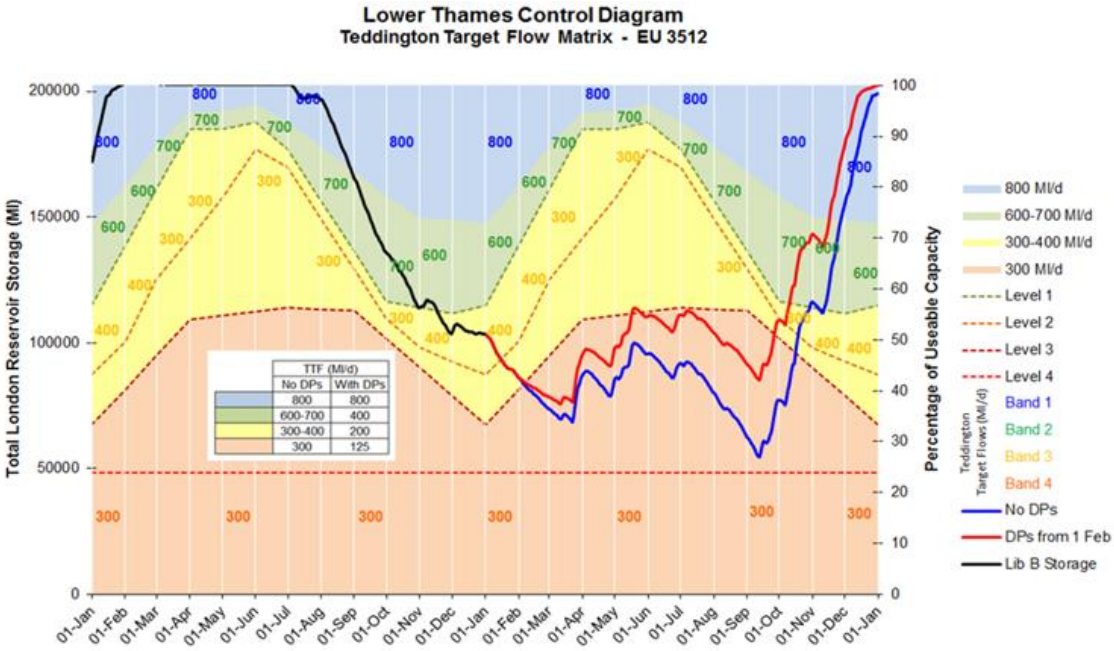
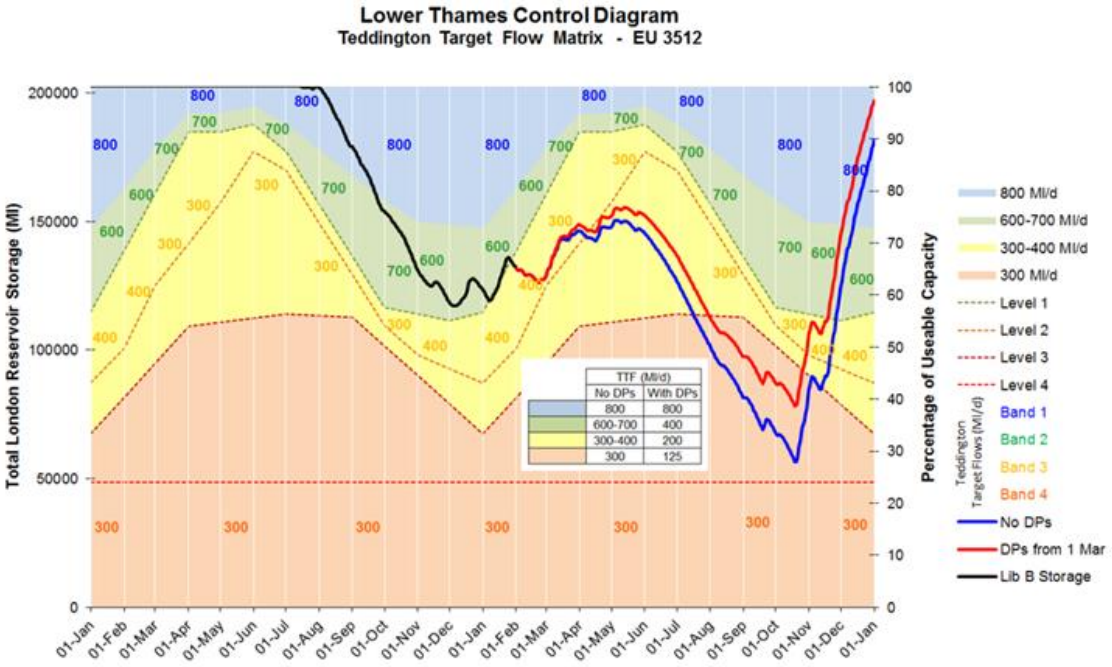


Figure 7-8: Impact of the Generated 'Severe' Drought Event 2 (modelled 1 in 300 Return Period) on Aggregated London Reservoir Storage – example 2



[16] Thames Water draft Drought Plan, 2017

7.70 We do not consider the prolonged use of drought permits to be a sustainable use of water resources for a resilient 1:200 water supply system. Therefore these options are not taken forward to appraisal. However they do provide a short term unsustainable option which would need to be implemented in the event that a severe drought occurs. We believe that, in the long term, alternative options should be developed to provide resilience to more severe droughts such as those with a level of severity of 1:200.

H. Sources of further information

7.71 The following information is available on the constrained list options*.

- Fine screening report, Mott MacDonald, January 2018
- Feasibility reports
    - Raw water transfer feasibility report, Mott MacDonald, January 2018
    - Groundwater feasibility report, Mott MacDonald, January 2018
    - New reservoirs feasibility report, Mott MacDonald, January 2018
    - Water reuse feasibility report, Mott MacDonald, January 2018
    - Desalination feasibility report, Mott MacDonald, January 2018
    - Direct river abstraction feasibility report, Mott MacDonald, January 2018
    - Catchment management feasibility report, Mott MacDonald, January 2018
    - Inter-zonal transfer feasibility report, Mott MacDonald, January 2018
- Risk and deliverability methodology, Mott MacDonald, January 2018
- Cost and carbon and Whole Life Cost methodology reports, Mott MacDonald, January 2018
- Network reinforcement cross option study, Mott MacDonald, January 2018
- Raw water system cross option study, Mott MacDonald, January 2018
- Water treatment cross option study, Mott MacDonald, January 2018
- Third party options report, Mott MacDonald, January 2018
- Discharge design standards cross option study, Mott MacDonald, January 2018
- Operating philosophy, Mott MacDonald, January 2018
- Conceptual Design Reports – these are available in CWC by appointment
- Constrained list Scheme Dossiers, Appendix R
- Table of constrained list Elements referencing the relevant element summaries and CDRs

*Please contact consultations@thameswater.co.uk for access to any of these documents