GARD response to

Thames Water's Consultation on

Draft

Water Resource Management Plan 2024

21st March 2023

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GARD response to consultation on Thames Water's draft WRMP24

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Summary

This report contains our detailed comments on Thames Water's draft WRMP24. Appendix A includes our responses to the questions posed in Thames Water's consultation document.

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1. Overall conclusion of GARD's response

The overall conclusion of this consultation response is that Thames Water have grossly overestimated the need for new sources and there is probably no need for any major new water supply like Abingdon reservoir. However, we propose that a modest portfolio of adaptable schemes should go ahead, including the first phase of a 300 Ml/d Severn to Thames transfer, as an insurance against population growth or climate change being much worse than current reasonable expectations.

2. The need for more water

Thames Water's future supply deficits

From our reassessment of the drivers of future water supply deficits, we have concluded that Thames Water have over-estimated the deficits in 2075 by: 44

- 430 Ml/d in the London water resource zone
- 33 Ml/d in the SWOX water resource zone
- 90 Ml/d in the other Thames valley water resource zones

The largest source of over-estimated deficits is abstraction reductions for environmental improvements. In GARD's opinion, allowances for sustainability reductions in the Plan are unrealistically large and not economically or environmentally justifiable, especially when the costs and impacts of replacement sources are taken into account. 17

If the abstraction reductions are focused on the ecologically sensitive chalk streams, as proposed by the CaBA chalk stream group, the loss of deployable output would be about 270 Ml/d less than Thames Water's allowance. GARD proposes that the remaining and much needed reductions should be brought forward to the early 2030s, without needing to wait for Abingdon Reservoir. 35

In view of the dominance of environmental improvements in deficit forecasts, no decisions should be taken on the need and choice of new resource schemes until the proper and transparent prioritisation of abstraction reductions has been completed. 30

The 2020 Office of National Statistics (ONS) population projection for England indicates that the Thames Water's population figures are too high by 1.2 million by 2050 and 1.8 million by 2100. We think it would be reasonable, ie reasonably cautious, to make a central planning assumption for population growth as for the ONS 2020 forecast for England, with an added 30% increase in the growth rate as a safety factor. This reduces the 2075 deficits by about 190 Ml/d. 26

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The records of the past 100 years show no evidence of a reduction in London deployable due to climate change and suggest that wetter winters and higher groundwater levels at the start of summer are increasing the deployable output of London's supplies. The historic evidence suggests the 'Low' climate change impact scenario is much more likely than the 'High' scenario. We can see no justification for the 'High' scenario being the central planning assumption for the climate change allowance in the preferred plan. We propose that it would be reasonably cautious to assume the 'Medium' scenario as the central planning assumption. This reduces the London deficit in 2075 by about 70 Ml/d. 36

Future PCC and leakage reductions

Thames Water falls far short of achieving the Government's PCC target of 110 l/person/day by 2050, especially in the London zone. This contrasts with United Utilities' plan to meet the PCC target in their Strategic Zone, which covers a comparably large and heavily urbanised region, including Manchester and Liverpool. If the 110 l/person/day target is met in London by 2050, the need for new sources in 2050 is reduced by 134 Ml/d. Outside London in Thames Water's Thames valley zones, achievement of the PCC target by 2050 would save a further 26 Ml/d compared with Thames Water's plan. 47

Most of Thames Water's proposed leakage reductions are in London, where the planned reduction is 60% and well ahead of the Government's 50% reduction target. However, Thames Water's proposed leakage reductions in the zones outside London are all well short of the 50% target, including just 14% in SWOX zone. Outside London, the planned leakages in 2050 are still in the range 90 to 135 l/property/day and far higher than the typical 40 l/property/day planned elsewhere in the South East. GARD proposes that leakage in zones outside London should be reduced to 40 litres/property/day by 2050 to be in line with the leakages planned by other SE water companies. This would give a total saving of 74 Ml/d in the zones outside London compared to Thames Water's plan. 50

The need for the Thames to Southern transfer

In GARD's opinion the Thames to Southern transfer is not needed. The primary drivers for the scheme are the perceived need to reduce groundwater abstractions in the upper Itchen and Test valleys and the removal of lower Test and Itchen drought orders from Southern Water's drought plan. The CaBA report on abstraction reductions as a % of catchment recharge concluded that no abstraction reductions were needed in the upper Itchen and Test valleys. The drought orders would only rarely give substantial reductions in abstractions and it is hard to see how the occasional benefits could justify the huge c.£2 billion cost of the scheme. ***GARD proposes that the Thames to Southern transfer should be abandoned at Gate 2 due to its minimal benefit and disproportionate cost.*** 56

The need for the Thames to Affinity transfer 52

In our response to Affinity Water's WRMP, we showed that all their needs to 2075 could

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be met by a 50 Ml/d Thames to Affinity transfer combined with the Grand Union Canal transfer and metering to achieve the Government's 110 l/p/day PCC target. GARD proposes that the 50 Ml/d transfer should be brought forward to the early 2030s, connecting Affinity Water to Thames Water's London supply system. This would allow all the planned upper Colne/Lea chalk stream reductions to be in place by the early 2030s.

The Chalk Streams First report on re-naturalising chalk stream flows showed deployable output recovery should be around 60% of the abstraction reductions and not the 17% assumed in Thames Water and Affinity Water's plans. This substantially reduces the Thames to Affinity transfer's net demand on London's supply system. GARD recognises that there is uncertainty in the amount of deployable output recovery and suggests that an insurance against recovery being less than expected should be provided by introduction of drought support schemes in the upper Colne and Lea chalk streams similar to the existing West Berkshire Groundwater Scheme.

Thames Water's need for new supply sources

GARD's analysis, with no allowance for chalk stream flow recovery, shows that neither Abingdon reservoir nor the Severn to Thames transfer is required to meet the needs of London and Affinity Water, even bringing forward the 1:500 year resilience to 2035. Without Abingdon reservoir or the Severn to Thames transfer, there would be a surplus of about 150 Ml/d in London's supplies continuously from 2040, if leakage and PCC reduction are on a trajectory to meet the Government targets by 2050. This shows the danger of creating a costly and environmentally damaging white elephant, if a decision to build Abingdon reservoir is made in the current cycle of business planning. 62

However, GARD recognises that there is uncertainty over the amount and timing of the leakage and PCC reductions. Therefore, it could be prudent to provide extra supply capacity *as early as possible to* give a cushion against accelerating climate change and bring forward the date for 1 in 500 year drought resilience. On that basis, we propose the following schemes should go ahead, even if not strictly needed under our realistic assessment of reduced future needs:

By early 2030s: the Teddington DRA scheme (67 Ml/d), the first phase of the GUC transfer (50 Ml/d) and the 50 Ml/d Thames to Affinity transfer to allow early chalk stream relief 65

By 2035/36: the 1st phase of the 300 Ml/d (pipeline capacity) Severn-Thames transfer and the 2nd phase of GUC transfer, if not included in the first phase GUC transfer

Thus about 300-400 Ml/d of 'over-provision' would be deployed early to 'hedge' against climate change or population growth being substantially higher than the forecasts.

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3. ***The proposed Abingdon reservoir (if needed at all)***

Size of reservoir

Thames Water's plan says that the choice between the 150 Mm^3 and 100 Mm^3 Abingdon reservoir is a key topic for this consultation. The plan puts forward two spurious reasons for choosing the larger version. Firstly, the 150 Mm^3 reservoir *"has lower regrets if the future is worse than predicted"* – it seems highly improbable that the future will be even worse than Thames Water's overly-pessimistic predictions. Secondly, the 150 Mm^3 reservoir *"Provides additional headroom for changes in environmental policy requiring further abstraction reductions or improved levels of service"* – it seems inconceivable that the abstraction reductions will need to be more than the High scenario that Thames Water has assumed or that a future level of service will be more severe than a 1:500 drought. If an ill-judged decision was made to build a reservoir at Abingdon, we can see no valid reason for it to be the 150 Mm^3 version, apart from benefits to Thames Water's shareholders. 67

Most of the information on water resources modelling requested by GARD in mid-December 2022 has still not been received. Therefore, we have been unable to address various concerns relating to the deployable output of Abingdon reservoir, particular those related to its resilience to long duration droughts and, consequently, its deployable output. We expect the information to be available soon and will use it in an Addendum to this response, and in our submission to the RAPID Gate 2 process. 69

The proposed Abingdon reservoir still only allows 6% of emergency storage, as compared to typically 20% for other major UK reservoirs. The last 6% of water will probably be of very poor water quality and is likely to be unusable. Increasing the emergency storage to a more prudent 20% would reduce the yield of the reservoir by about 15% or 30 Ml/d. 71

Environmental assessment of the reservoir

In GARD's opinion the Natural Capital Assessment of the reservoir is based on unrealistic aspirations of the site post-construction. It fails to take proper account of the large scale habitat destruction and the time needed for postulated improvement. The assessment is not transparent and it is riddled with unexplained inconsistencies. We conclude the Natural Capital Assessment is not fit-for-purpose. 72

Similarly, the Biodiversity Net Gain assessment lacks clarity and suffers from aspirational and unfounded assertions of habitat creation with many inconsistencies and errors. Thames Water should be asked to revisit this work and make it consistent with the RAPID Gate 2 documentation in accuracy and transparency. 78

Carbon impact of the reservoir

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Abingdon Reservoir is the strategic resource option with the largest carbon footprint in

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the construction phase and realistically it can only be built in a single phase. The carbon footprint is dominated by the construction of the embankment works, which would involve a huge fleet of earth moving equipment and transport to site of large quantities of materials, especially as rip-rap. The carbon reports make weak claims for reduction in construction carbon through technological developments and carbon sequestration:

- over-optimistic and aspirational claims for reduced carbon in construction materials such as steel (for pipelines) and concrete, without any *timetabled technology-development roadmap* for any of these materials; 83
- unrealistic claims for availability of low emission plant for earthworks, quarrying and riprap transport and placement, which dominate the embodied carbon for a reservoir; 83
- carbon sequestration 'opportunities' of limited scale and uncertain impact which are no more than could be achieved by local initiatives (funded by new DEFRA rules and Local Authorities) at vastly less cost. 84

The 'analysis' is woefully lacking in substance and hopelessly optimistic. There are no details of existing technologies, industry-accepted roadmaps, or indeed of anything that could not be found from a Google search. Instead, anecdotal discussions are cited, with manufacturers suggesting, for example, that hydrogen powered *large excavators are being developed and are potentially available.* Such 'analyses' are used to derive an astounding (for its *chutzpah*) conclusion that a '*mid-case*' scenario could result in a 60% reduction in embodied carbon in the 2025-2040 timeframe.

There are also crucial carbon footprints omitted including the Abingdon water treatment works, the loss of about 40 MW of existing solar farm within the site and failure to allow for greenhouse gas emissions arising from decaying vegetation and the inevitable algal blooms arising from nutrient rich water filling the reservoir. 85

GARD calls for the GHG emissions for the Abingdon reservoir to be included with the carbon budget, as well as a statement regarding the treatment of water pumped into the reservoir and the policy for extraction from the Thames at times of sewage spills. 86

Reservoir safety

We believe that Thames Water has failed in its duty of due diligence in safety matters. The issues we raise should have already been investigated, especially as the reservoir has been on the table, essentially in the current format, for at least 15 years. That studies have not been done (or at least remain secret) is a real scandal and cannot be allowed to go unchallenged. These issues include: 87

- engineering design of the embankment and associated structures to deal with slope stability, internal seepage, wave protection, settlement and pore pressure

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monitoring – all matters of crucial importance in design of large earth dams, but given minimal coverage in the skimpy conceptual design report.

- The threat of dam breach and associated catastrophic flood of downstream communities – there is no reference to any consideration of this. 90
- The effect of emergency drawdown on potential flooding of downstream communities and need for evacuation. 94
- The threat of terrorism to the embankment and associated structures – there appears to have been no consideration of this and the limitations it might pose on the use of the reservoir for the recreation uses, which are supposedly a major benefit. 96
- The limitations that wave protection and upstream erosion prevention will place on the potential for recreation use and habitat creation.

These are all matters that appear to have been left to later investigation in Gate 3 (if at all), thereby removing them from the public eye and the next stage of decision making. GARD views this as unacceptable, and has carried out its own assessment of consequences of dam breach, which highlights the dangers and point to the need for risks to 'peripheral' and 'downstream' communities to be evaluated at the present stage in the RAPID process, before progress to Gate 3. 98

Impacts on customer bills and benefits to Thames Water shareholders

The high capital cost of Abingdon reservoir would give a large increase in Thames Water's Regulatory Asset Value with a guaranteed big increase in shareholder returns throughout the 250-year long asset life term. It would also drive a substantial increase in customer bills. The WRMP documentation and Gate 2 reports give no indication of these effects and there is no recognition of the perverse effect of the regulatory regime in creating this situation.

GARD believe that there is a fundamental and extremely perverse incentive in the Water Industry regulatory regime that encourages investment in "big concrete" projects as the solution to any and all problems. GARD believe this flawed incentive structure explains why Thames Water keep proposing an unneeded reservoir.

The alternatives to the reservoir include fixing leaks, installing smart meters, the Severn to Thames Transfer, reuse and desalination. All these alternatives involve lower capital expenditure and shorter life assets. Consequently, all these alternatives look less attractive from the perspective of Thames Water shareholders.

GARD calculate that customers would pay £4.8 billion in today's money for the reservoir, this is £3.0 billion more than the cost of the reservoir and £3.0 billion more than 99 customers would pay if the same money was spent on operating expenditure fixing leaks and reducing demand instead of the reservoir.

These aspects of costs to consumers and benefits to shareholders should be made explicit in any evaluation of dWRMP and Regional Plans. The only way this can be done is if they are transparently laid out by WRSE and the companies in these plans. The matter should be *used in a metric* as input to the establishment of a Best Value Plan, perhaps through the '*Inter-generational Equity*' metric.

4. The Severn to Thames transfer

The timing of the Severn to Thames transfer

We do not agree with Thames Water's proposal to delay the STT to beyond 2050 in their preferred plan. In Thames Water's own words, the scheme provides a modular, adaptable source of water, whereby water from support sources can be introduced as and when necessary. We propose that the STT transfer aqueduct should be built as quickly as possible, initially with only a modest amount of support sources, but with the capability of adding new sources if needed. 101

The WRMP should recognise that there is a strategic need to transfer water from the relatively wetter and less populated north and west of the country to the dry and heavily populated South East. This need has been a primary conclusion of every national strategic water resource study of the past 50 years. By delaying the Severn to Thames Transfer to 2050, Thames Water is removing the possibility of any major transfer into the South East for another 30 years.

Aqueduct capacity

We think that the proposed initial STT aqueduct capacity of 500 Ml/d is too high. We think it inconceivable that this amount of transfer would ever be needed, especially if abstraction reductions for improved river flows are properly prioritised, with account taken of the costs and environmental impacts of replacement sources. 102

We suggest that a 300 Ml/d aqueduct capacity, or at most 400 Ml/d, would be sufficient for a reasonable insurance against climate change and population growth being much worse than expected. A 300 Ml/d aqueduct could also be provided by the Cotswold canal transfer, with its potential for a lot of secondary benefits through the canal restoration, although we recognise the higher risk of this option in both construction and operation. 102

Phasing of the scheme and deployable output

We propose that the first phase of the scheme should comprise the 300 Ml/d aqueduct, support from Netheridge and both phases of the 115 Ml/d support from treated Minworth WWTW effluent. This would give a deployable output of 195 Ml/d using

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Thames Water's figures.

We have noted a number of inconsistencies in Thames Water's assessment of deployable output from the scheme, but, as for Abingdon reservoir, we will provide more comment on this through an Addendum to this response, once the requested Pywr model 102
information is available.

5. Comparison of Abingdon reservoir and STT

Comparative costs

Neither Thames Water's WRMP nor WRSE's regional plan has provided the clear cost comparison that is needed to support the choice of Abingdon reservoir instead of the STT as the first major new source in the development programme. 106

GARD welcomes the cost information that has been made available in the WRMP tables and Gate 2 reports. However, making cost information available is not the same as presenting it transparently to justify choices between options. Failure to present clear cost comparisons is just as bad as failing to provide cost data at all.

In the absence of any Thames Water cost comparisons, GARD has compared the 100 Mm^3 Abingdon reservoir with the 300 Ml/d Severn to Thames transfer, supported by Netheridge and both phases of Minworth support. Both schemes give about 190 Ml/d of deployable output and we assumed both would be operational from 2040 to give a like-for-like comparison, as shown below:

	Abingdon reservoir 100 Mm3	**300 Ml/d STT with Minworth and Netheridge**
Initial Capex as Gate 2 reports	£1,878 m	£1,171 m
Opex in Gate 2 report	£4.3 m/year	£43.7 m/year
GARD modelled opex	£4.3 m/year	£18.3 m/year
NPV with Gate 2 opex	**£1,301 m**	**£1,544 m**
NPV with GARD opex	**£1,301 m**	**£1,165 m**

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This shows the STT option to be about 10% less costly than Abingdon reservoir overall, if costed with realistic operational use. Even this is not a fair comparison, because the 300 Ml/d STT aqueduct can potentially deliver another 100 Ml/d of deployable output, whereas Abingdon reservoir deployable output is fixed at 185 Ml/d. This shows the 110
misleading nature of Thames Water's statement that removal of Abingdon reservoir from the programme would add over £500 million to the NPV costs (WRMP paragraph 11.62).

Carbon comparisons

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The construction of the 100 Mm^3 Abingdon reservoir and the 300 Ml/d STT supported by

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Netheridge and Minworth, as proposed by GARD, both have capital carbon of about 400,000 tCO_2eq. About 60% of the STT's capital carbon comes from the construction of the pipeline and the rest from the support sources. If the Cotswold can is used for the aqueduct, the capital carbon for the STT would be a lot less.

As cited above, the lack of availability of the detailed resources modelling, has not only disabled our ability to make definitive evaluations of drought resilient deployable output, and cost comparisons between strategic options, but has also made it very difficult to compare operational carbon budgets for the 'equivalent' Abingdon Reservoir and STT options. Thus we have not compared detailed operational carbon, but note that, if the GARD realistic usage of the STT Phase 1 scheme is assumed, the operational carbon budget drops to around 38% of that estimated in the RAPID Gate 2 documentation. 118

There are further drops (to around 34%, if a consistent assumption of electricity grid decarbonisation is use across the STT subsystems, and around 28% if initiatives currently under examination with the STT project team and the Environment Agency come to fruition. 121

One overriding conclusion about assessment of the STT is that it is currently too fragmented in its assessment, between separate teams (at least 3 teams, and 4 sets of documentation), for a proper optimisation of the system to be performed. For a water transfer system, representative of a type which has been promoted by the National Infrastructure Commission, this is no longer acceptable, and GARD calls on the Regulators to bring about a rationalisation. 121

6. Adaptable schemes for early implementation

The Thames to Affinity transfer

GARD proposes that 50 Ml/d of the Thames to Affinity transfer should be brought forward to the early 2030s, connecting Affinity Water to Thames Water's London supply system. Combined with the GUC transfer, this would allow upper Colne and Lea chalk stream re-naturalisations to be in place by the early 2030s. This would be much better than waiting until 2040 (or even later) for Abingdon reservoir to be built and filled. 125

GARD does not accept the above argument that Abingdon reservoir is a pre-requisite for the Thames to Affinity transfer because without it Thames Water with have a reduced volume of strategic storage. The 50 Ml/d demand from Affinity Water on the London supply system would be no different to any other London demand and can be enabled by the planned Teddington DRA scheme in conjunction with existing reservoirs.

GARD's analysis of the London supply/demand balance shows that the Thames to Affinity transfer can go ahead from the early 2030s, even accepting Thames Water's unrealistically low estimates of deployable output recovery from enhanced chalk stream flows.

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WBGWS-type scheme for the Chilterns chalk streams

GARD recognises that the uncertainty in the amount of flow recovery from the planned chalk stream abstraction reductions that can be converted into additional deployable output from London's reservoirs. However, this uncertainty can be managed, and with a possible net increase in deployable output from downstream reservoirs, if the chalk aquifer is used for drought support schemes similar to the existing West Berkshire Groundwater Scheme, which contributes nearly 100 Ml/d to existing London DO. 126

GARD proposes that the WBGWS concept should now be investigated as a matter of urgency for potential replication in the Chilterns chalk streams, with the aim of implementing one or more pilot schemes in AMP8 and full implementation in AMP9.

The Grand Union canal scheme 130

Although the GUC transfer is primarily an Affinity Water scheme, Thames Water will benefit from "new water" coming into the lower Thames and Lea via enhanced chalkstream flows and STW effluent. The larger versions of the GUC transfer also have the potential for Affinity Water to transfer surplus water to Thames Water.

Although our analysis shows that a 50 Ml/d GUC transfer would be more than enough for Affinity Water's needs and re-naturalising chalk stream flows, there would be additional security of supplies for both Affinity and Thames Water, if the GUC carrying capacity can be increased to 100 Ml/d at relatively little additional capital cost, via the 'Phase 2' of the scheme for completion by 2035.

Early completion of both phases of the GUC transfer would also allow more and earlier reduction of some of Thames Water's abstractions in the lower Lea valley, which probably have a low priority, but would be feasible if the second phase of the GUC generates extra headroom for Affinity Water. The earlier reduction of Thames Water's abstractions in the lower Lea would also allow the Deephams re-use scheme to be brought forward, if needed, perhaps to facilitate abstraction reductions in the River Darent.

The Teddington DRA scheme and Deephams reuse

GARD welcomes the planned Teddington DRA scheme delivering 67 Ml/d of deployable output for London. Although shows that this would not be needed after about 2040 if the Government's leakage and PCC targets are met, the early construction of this scheme would ensure water availability from London's supplies to be transferred to Affinity Water, 131 allowing early re-naturalisation of Colne and Lea chalk stream flows. Spare headroom after 2040 could be used to bring forward some of Thames Water's lower priority abstraction reductions in the lower Lea, which would open the door for earlier implementation of the Deepham's reuse scheme

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GARD recommends that the 67 Ml/d capacity Teddington DRA scheme now proposed should be planned as the first stage of a potentially larger scheme and there should be more investigation of the limits that the EA has put on the size of the scheme due to concerns over water temperatures.

Thames estuary desalination options

Thames Water’s plan appears not to have seriously considered new desalination schemes and they were not part of the Gate 1 or 2 investigations nor do they appear to have been seriously considered as part of Thames Water’s plan. 132

In GARD’s opinion a modest sized desalination scheme should be properly investigated for rapid implementation to relieve the over-abstraction in the Darent.

1. Introduction

1.1 GARD's role

Group Against Reservoir Development (GARD) is a community-based organisation representing local residents and businesses, mainly in the South Oxfordshire villages of Steventon, Drayton, East and West Hanney and Marcham, who would be affected by Thames Water's plans to build a major new reservoir near Abingdon.

GARD campaigns against this inappropriate reservoir solution and in favour of sustainable water resource options such as effluent reuse and raw water transfer from Severn to Thames. We also strongly support demand-side measures to reduce leakage of water and efficient use strategies, including metering. GARD's membership includes many technically-qualified people, and we are advised by Water Industry professionals. GARD's website is at http://www.abingdonreservoir.org.uk/.

1.2 The scope of this response

This response focuses on Thames Water's need for a major new water source like Abingdon reservoir and, if a major scheme is needed, whether it should be the Severn to Thames transfer or Abingdon reservoir.

We have completed and submitted brief responses to Thames Water's consultation via the consultation web-site. These brief responses are cross-referenced to this document. Copies of our web-site responses are included in Appendix A.

Our work on this response has been impeded by the late and mainly incomplete response to our information request for stochastic data and Pywr model output. Most of the requested data have still not been received by 20th March 2023. There is more detail of this in Section 4.2.1 of this report. We will make an Addendum to this response when we have received the requested data and had time to review them and use them in our own modelling. The Addendum can be expected to cover the deployable outputs and operating costs of the Abingdon reservoir and Severn to Thames transfer options.

Our review of option costs has also been hampered by the out of date costs in the WRMP tables, especially the tab '5a to 5c Cost profiles'. The out of date data in the WRMP table was confirmed by an email from Admin WRSE on 3rd February[1] which said *"These costs [ie WRMP and Gate 2 costs] are different, as the timelines for the WRMPs and RAPID Gated process are not in alignment. Gate 2 submissions came after WRSE needed data to be able to run the investment model. Therefore, the draft regional plan and dWRMPs largely include Gate 1 information, rather than Gate 2".* We have found that the relatively limited data shown in Gate 2 cost reports is often substantially different to the cost data in tab '5a to 5c Cost profiles', making this crucial source of cost information unreliable and largely unusable.

[1] Email from Admin WRSE to John Lawson on 3rd February 2023

2. Thames Water's need for new resources

2.1 Thames Water's supply demand balances

2.1.1 The London water resource zone

The dry year annual average (DYAA) baseline supply demand balance for London is shown in Figure 1 (copied from WRMP tables, London zone worksheet):

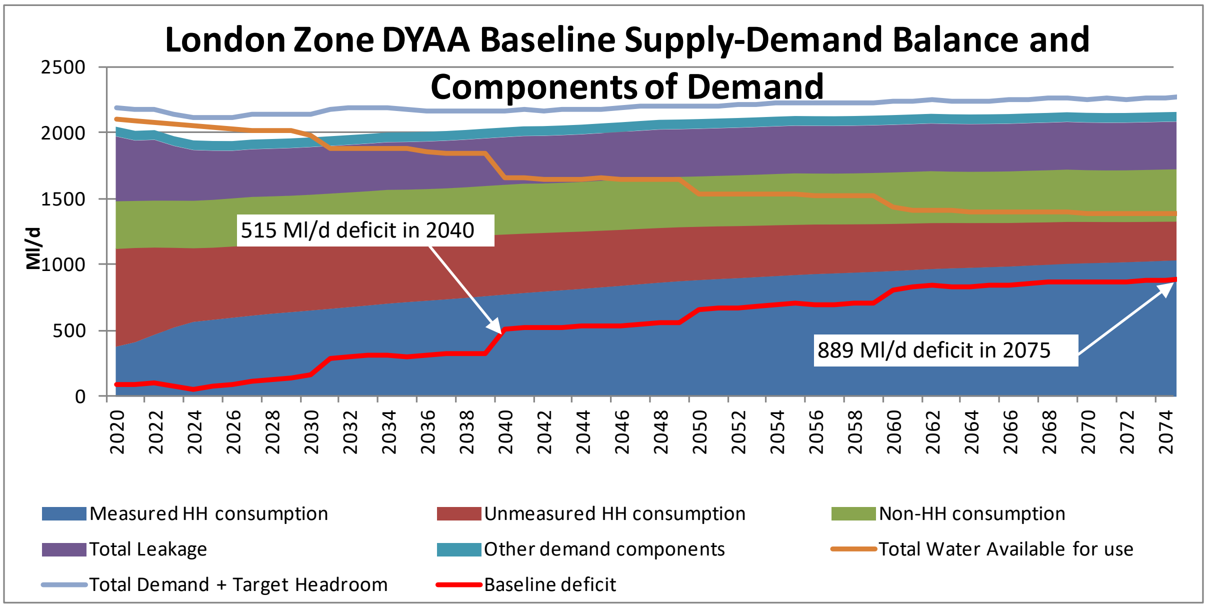


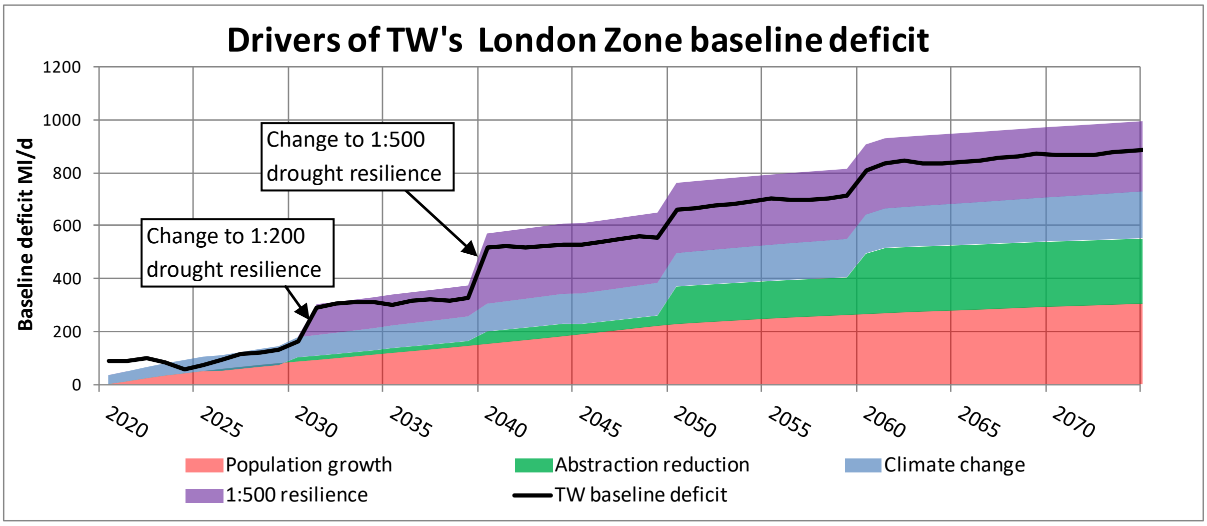
Figure 1 - London DYAA baseline supply demand balance

The "baseline" supply demand balance includes measures in the current, 2019-24, business plan for leakage reduction, demand reduction and new sources; it does not include any such measures beyond 2024. The declining 'Water Available for use' allows for planned future abstraction reductions and loss in deployable output due to climate change throughout the planning period. The deficit does not include the proposed supply to Affinity Water.

The baseline supply demand balance shows a deficit between supply and demand rising from 98 Ml/d in 2022 to 889 Ml/d by 1975. The deficits are over-stated by about 100 Ml/d because, following Water Resource Planning Guidelines, they do not allow for the demand reductions due to Temporary Use Bans and Non-essential Use Bans which are part of current Levels of Service[2]. The TUBs and NEUBs are included as measures in the Final Plan.

The main drivers of the deficit are shown in Figure 2 below. Up to 2040, the main drivers are TW's estimates of population growth and loss of deployable output due to climate change. The deficits due to change in resilience standard are a DO loss of 117 Ml/d from adopting a 1:200 year standard in 2031 and 266 Ml/d loss from a 1:500 year standard in 2040[3].

[2] TW response to GARD information request EIR-22-23-390, page 3, 26 January 2023
[3] TW Main WRMP document, Table 4-2



Note: drivers don't include savings from baseline leakage and PCC reductions

All in Ml/d	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
Population growth	0	49	86	119	153	189	228	249	266	280	296	306
Abstraction reduction	0	0	16	18	47	39	142	142	230	247	247	247
Climate change	34	55	76	86	105	115	126	136	147	157	170	178
Resilience to 1:500	0	0	0	117	266	266	266	266	266	266	266	266
Total deficit drivers	**34**	**104**	**177**	**339**	**571**	**610**	**762**	**794**	**908**	**951**	**980**	**998**

Figure 2 - Main drivers of London zone baseline deficits 2020 to 2075

The main drivers of the London deficit total 571 Ml/d by 2040 and 981 Ml/d by 2075. These figures are somewhat more than the deficits shown on Figure 1 which total 515 Ml/d by 2040 and 889 Ml/d by 2075. The reason for the difference is that the baseline deficits allow for leakage and PCC reductions which are being implemented in the current AMP7 business plan.

GARD's comments on the population, environmental and climate change drivers of deficits are in Sections 2.2 to 2.4.

2.1.2 Deficits in the SWOX water resource zone

The baseline supply demand balance for SWOX zone is shown in Figure 3:

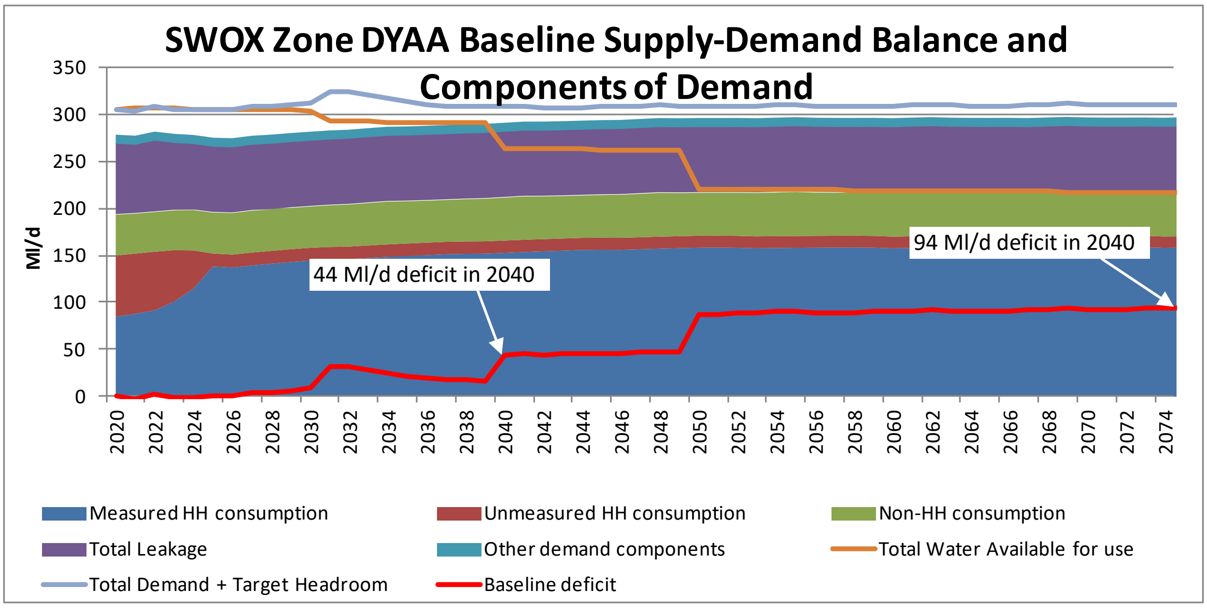
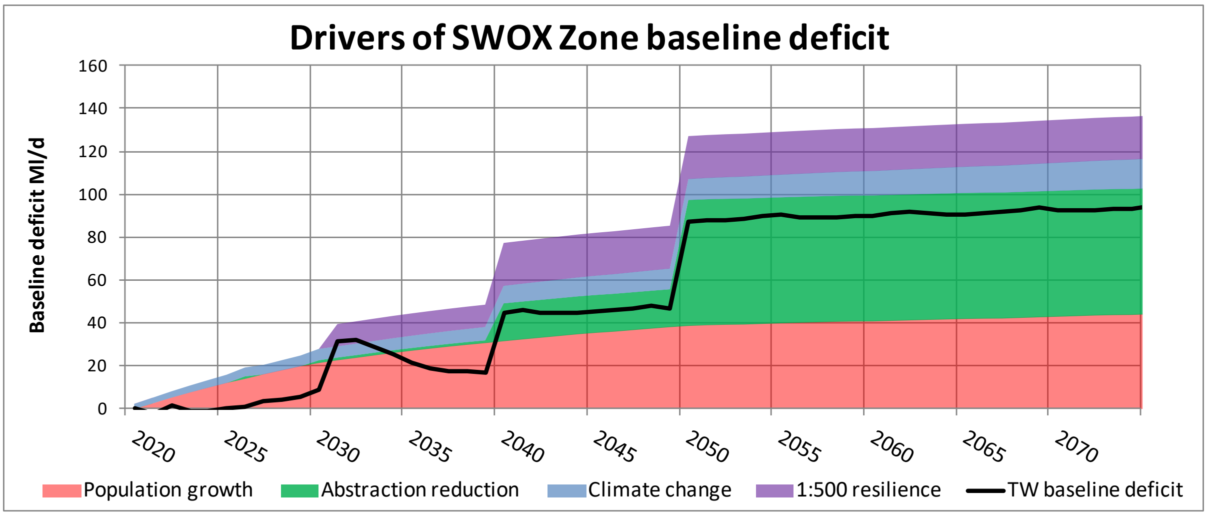


Figure 3 - SWOX zone DYAA baseline supply demand balance

The drivers of the SWOX deficit are shown on Figure 4[4]:



All in Ml/d	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
Population growth	0	12	21	27	32	35	39	40	41	42	43	44
Abstraction reduction	0	0	1	1	18	18	59	59	59	59	59	59
Climate change	2	4	5	6	8	9	10	11	12	12	13	14
Resilience to 1:500	0	0	0	10	20	20	20	20	20	20	20	20
Total deficit drivers	**2**	**16**	**28**	**45**	**77**	**82**	**127**	**129**	**131**	**133**	**135**	**137**

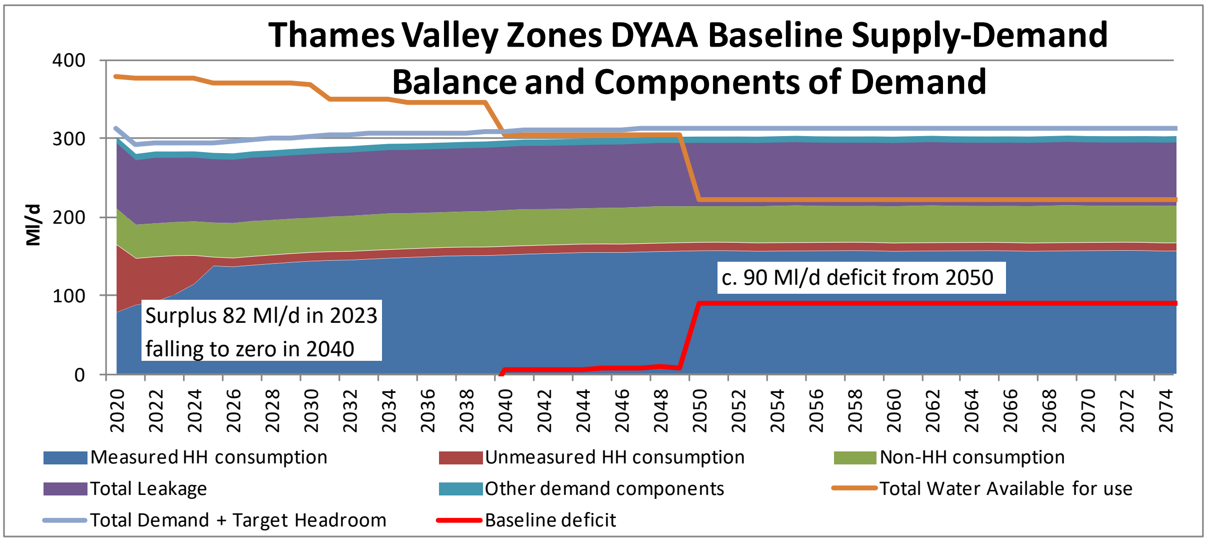
Figure 4 - Main drivers of SWOX zone baseline deficits 2020 to 2075

The relatively small 45 Ml/d deficit up to 2040 is mainly driven by Thames Water's population growth forecast. After 2040 and, especially after 2050, there are large losses in deployable output due to abstraction reductions for environmental improvements.

[4] Data on drivers are from the TWSSWX worksheet in the WRMP tables

2.1.3 Deficits in the Thames Valley water resource zones

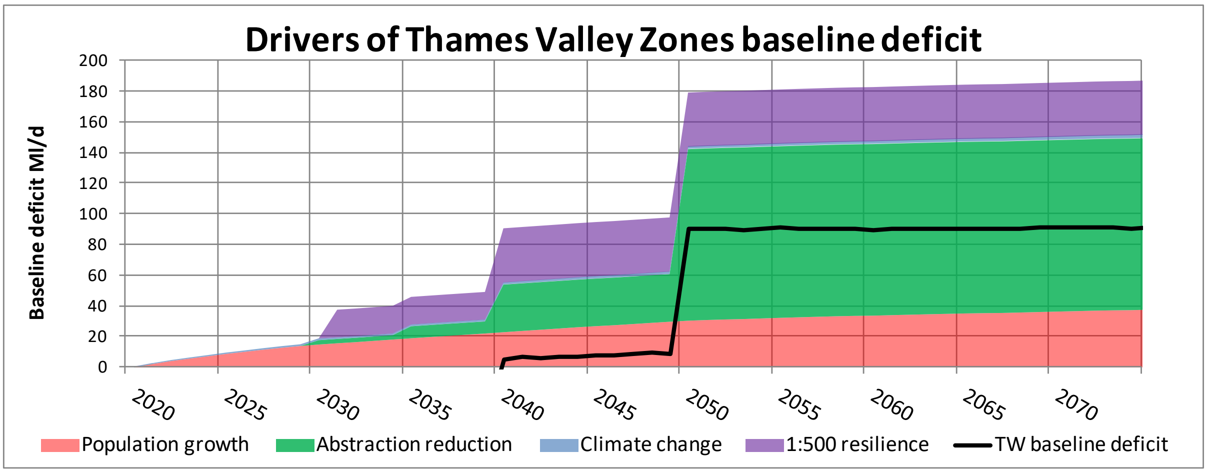
The combined supply demand balance for the Thames Valley, comprising the Kennet Valley, Henley, Guildford and SWA (Slough-Wycombe-Aylesbury) zones, is shown in Figure 5:



Note: Plot derived by summing the TWSHNY, TWSKNV, TWSGLF and TWSSWA worksheets in the WRMP tables

Figure 5 - Thames Valley zones DYAA baseline supply demand balance

The drivers of deficits in the Thames Valley zones e shown in Figure 6[5]:



Note: drivers don't include savings from baseline leakage and PCC reductions

All in Ml/d	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
Population growth	0	9	15	19	23	27	30	32	34	35	37	38
Abstraction reduction	0	0	3	8	31	31	112	112	112	112	112	112
Climate change	1	1	1	1	1	2	2	2	2	2	2	2
Resilience to 1:500	0	0	0	18	35	35	35	35	35	35	35	35
Total deficit drivers	**1**	**10**	**19**	**46**	**91**	**95**	**179**	**181**	**183**	**184**	**186**	**187**

Figure 6 - Main drivers of Thames Valley zones baseline deficits 2020 to 2075

[5] Data on drivers are summed from the TWSHNY, TWSKNV, TWSGLF and TWSSWA worksheets in the WRMP tables. Climate change losses are from TW WRMP main report tables 4.5, 4.7, 4.9 and 4.11

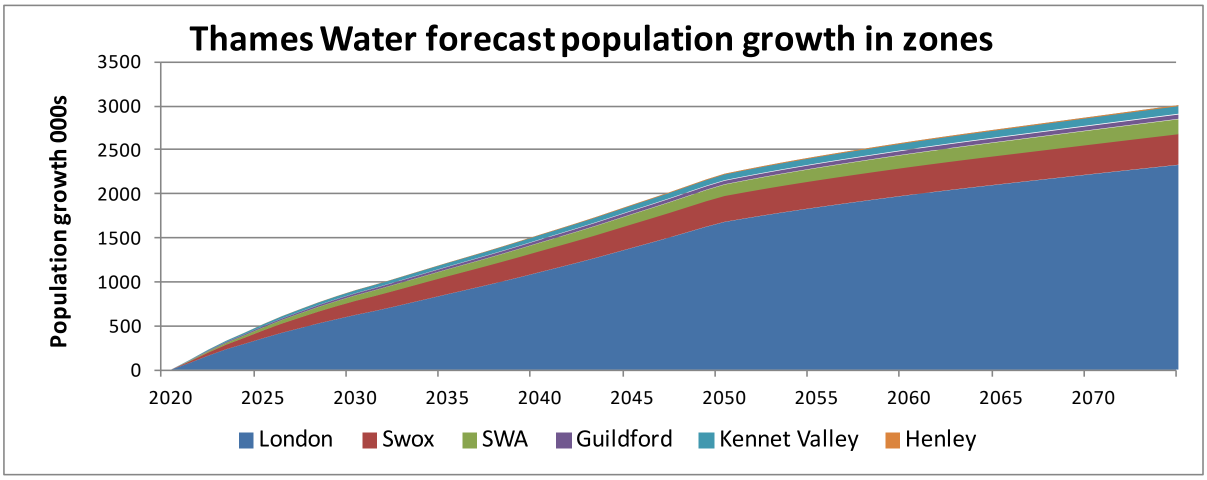
The losses of deployable output due to the changes for 1:200 and 1:500 year resilience are assumed to occur in 2031 and 2040 as for the London zone. After 2040, the main driver of deficits is the losses of DO due to abstraction reductions for environmental improvements. The deficits due to loss of DO due to climate change are far smaller than for the SWOX zone, as shown in Figure 4.

GARD's comments on the population, environmental and climate change drivers of deficits are in Sections 2.2 to 2.4.

2.2 Population growth

For this section, paragraph numbers refer to Section 3 of Thames Water's main WRMP report – Demand.[6]

The population growth assumed in Thames Water's preferred plan is shown in Figure 7:



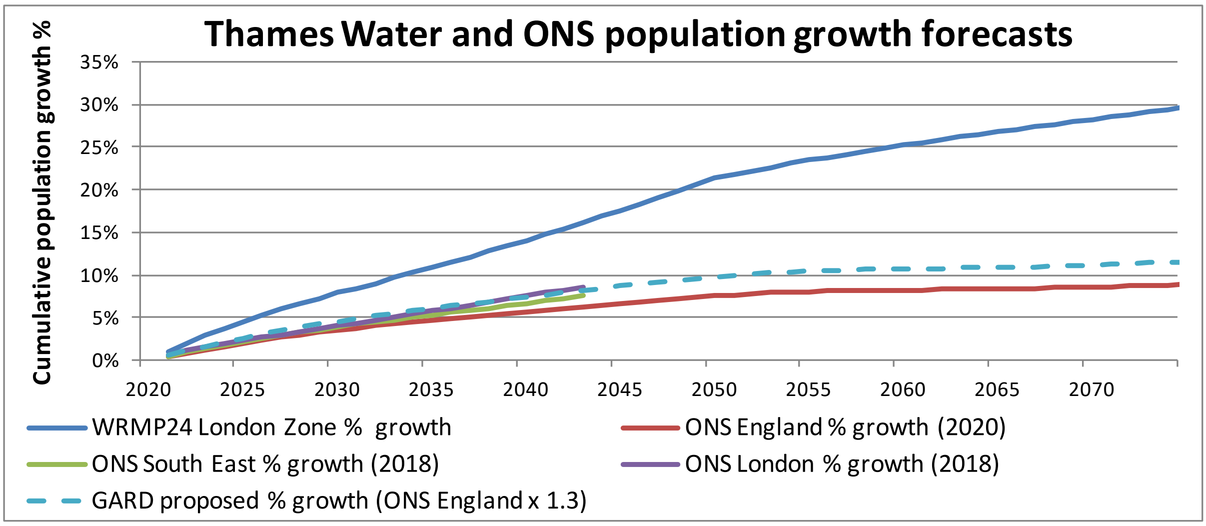


Figure 7 - Population growth assumed in TW's preferred plan

This shows population growth rates that are far in excess of ONS forecasts. Paragraph 3.78

[6] dWRMP24 Section3 - Demand, November 2022

notes that Section 6.3 of the WRPG states:

> *"Your planned property and population forecasts, and resulting supply, must not constrain planned growth. For companies supplying customers in England you should base your forecast population and property figures on local plans published by the local council or unitary authority."*

This guideline is the root cause of much of the over-estimation of population in this and previous WRMPs. While noting that the guidance is clear that growth must not be constrained, the use of the word 'should' rather than 'must' in relation to using local plan data implies that this element is not mandatory. It should be perfectly possible to develop a model that will not constrain growth, takes account of local plans and that also takes account of, and includes, other factors. In previous discussions between GARD and Senior Ofwat staff, this approach has been outlined and not rejected.

In short, the water companies are free to propose alternate methodologies, provided they are backed up by data. Discussion with TW personnel at recent public meetings indicate that the problem with using local plan data is well known and well understood, yet is always accompanied with a statement that '*we have no choice*'. It seems odd that water companies are happy to challenge or ignore targets for pcc, leakage, sewage disposal etc, yet don't challenge and propose alternatives to a demand methodology that forces short to medium term decision making that will over-provide by up to 60%. Even worse, most local plan data are still based on ONS 2014 projections - data that has been revised downwards on each ONS update in 2016, 2018 and 2020 and are thus no longer credible.

For example, GARD and others have long argued, with evidence, that historically less than 50% of planned development is achieved. It makes more sense at the strategic level, therefore, to use a central (ONS) projection, when planning for the overall future supply requirement. As ONS note, their figures are produced for exactly this sort of purpose and are widely used in other sectors for public planning (including water in Wales). The local plans could then be used at the operational level to determine hot spots and potential pinch points, thus efficiently targeting any increases in supply that the strategic level planning has provided.

Given the propensity for Thames Water to repeatedly use high, or even worst case, estimates in its calculations (population, pcc, leakage etc), we would argue that headroom is already built in throughout the modelling. However, in the case of population, a useful discussion could be held between TW, the regulators and key stakeholders to agree any headroom element that should be applied to this part of the model. Somewhere between 10% and 20% would seem reasonable and should calm any concerns over using modified local plan data.

A change of approach such as this would allow consultancy effort to be directed to do more of its work to provide a 'most likely' outcome - a much more useful figure and around which a sensible debate could be held. There is no such discussion that can be held over the local plan data, as it is already hard against the stops of the highest worst case. When the worst case is the basis for the plan, it's hard to see how that can result in an adaptive plan as it simply directs that everything is built as quickly as possible, regardless of the real-world situation.

A central projection would allow a truly adaptive plan to be created with plans in place to produce incremental increases or decreases in supply over time, as the situation develops. The result: a more realistic (and believable) adaptive plan that didn't rely on starting to build the largest infrastructure programme (Abingdon Reservoir) immediately, thus removing any adaptability for the first 10 years of the planning period.

At para 3.104, 3 long term growth scenarios for the period 2050-2100 are presented based on low, principal and high ONS 2018 figures. We would make the following suggested changes/observations:

- The figures should be updated using ONS 2020 England data as soon as practicable. Given that UK interim 2020 based figures were published on 12 Jan 2022 and England interim 2020 on 27 Jan 2023, it is hard to see why this plan is still using data that is 5 years out of date. Use of 2020 data would highlight even more clearly, how unrealistic the local plan data is.

- Applying ONS long-term growth rates to 2050-local-plan-derived data simply continues to compound the errors introduced by using the unrealistic figures up to 2050. As an example, if using the local plan data has produced a figure that is 1 million too high in 2050, then applying a 3% (as an indicative figure only) growth rate would produce an extra non-existent 30,000 people in the first year with this error being compounded each year for the next 50 years.

- Population forecasts over the next century are being consistently downgraded in most advanced countries such as the UK. The last 3 updates to ONS have each significantly reduced expected growth. With this in mind, and with the uncertainties over how low growth will fall to, it seems pointless producing 3 long term scenarios – particularly as there doesn't seem to be any attention paid in the adaptive plan to alternative outcomes. Instead, just one principal projection, updated with each ONS update would be adequate for use beyond 2050.

- Most population experts agree that the UK population will start to fall at some point around the middle of the century. This has already happened in Italy, and Germany is thought to have peaked this year and will slowly decline from now on. The FT reported[7] that UK natural population will start to decline by 2025 and after that, any increase will be solely due to migration. The latest ONS 2020 interim principal projection indicates that, for the UK, deaths will exceed births by 2025 with a slowly increasing population due to migration until it is effectively steady from 2050, with minimal change. By 2060, growth is around 0.1%/year. None of this seems to be adequately reflected in the TW long term plan. Ignoring this means that a reservoir completed by 2040 will be a white elephant within 20 years.

Using the TW WRMP baseline planning assumption of a 2020 starting population of 10,112,000 and applying ONS 2020 England growth levels, produces the population figures shown in Table 1 below (note that 2090 figures are not included). Previously, TW have argued that the South East region has higher growth rates than the rest of England, but the latest ONS projections shows this is no longer the case. The figures in the table use average England growth rates, but when sub-regional figures are released, they would be expected to be slightly lower than shown.

all in millions	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2100**
ONS 2020 Growth (Baseline 10.1)	10.6	10.9	11.1	11.3	11.4	11.6	11.8
TW Forecast (Baseline 10.1)	11.0	11.7	12.3	12.7	13	13.3	13.7
ONS 2020 Cumulative Increase from 2020	0.5	0.8	1.0	1.2	1.3	1.5	1.8
TW Plan Cumulative Increase from 2020	0.9	1.6	2.2	2.6	2.9	3.2	3.6
Difference between TW and ONS 2020	**0.4**	**0.8**	**1.2**	**1.4**	**1.6**	**1.7**	**1.8**

Table 1 - Population growth from 2020: Thames Water vs ONS 2020 figures

The effect of using over-inflated local plan figures is clearly illustrated. At each 10 year point up to 2050, the assumed growth is more than twice the ONS projection at the same point. From 2050, the ONS projection is for around an extra 100,000 people per decade, whereas the TW projection is around 300,000, due mainly to the compounding effect of starting with an inflated 2050 local plan figure as described earlier and then using outdated 2018 figures. This shows that, although the WRMP states that ONS growth levels are used after 2050, the figures generated for each decade are between 2 and 3 times the latest ONS projection. This means that the statement at para 3.111 that '*we revert to ONS based forecasts*' is simply incorrect. Similarly, the statement at para 3.112 that the ONS forecasts predict a population growth of 22% by 2100 is incorrect. The ONS 2020 England figures project a growth between 2020 and 2100 of only 17%.

Further comments on Section 3 of the WRMP include:

- The plan derived growth in the last 20 years of the century makes little sense, as the ONS projection is for flat or negative growth rates from 2080.

[7] FT, UK natural population set to start to decline by 2025, Jan 12 2022

- The statement at para 3.111 that the local authority plan-based and ONS18 forecasts provide a good representation of upper and lower forecasts is completely incorrect. The subsequent discussion appears to use ONS 18 principal projection figures and so the figures presented represent the upper and median scenarios only. For example, para 3.112 quotes local plan and ONS figures as if they were the upper and lower forecasts referred to above. While an unspecified 'min scenario' line is shown on the graphs at Figure 3-7, they are not mentioned or discussed in the analysis.
- This is further illustrated at para 3.114 and the accompanying Figure 3-8 where just plan-based and ONS principal projection (now just called ONS Projection) are clearly presented as if they were the upper and lower boundaries of forecasts. If it is valid to consider high scenarios and incorporate them into an adaptive plan, why is it not equally valid to treat low scenarios in the same way (or at least present an argument for not doing so). The adaptive plan eventually presented, being based on the local planning figures, takes no account of even a most likely out-turn, yet alone a low projection. This makes all of the discussion on population in Section 3 rather pointless.

Inspection of para 3.115 and associated Tables 3-12 and 3-13 strongly supports the argument that the plan-based figures should be considered unusable, with the SWOX, SWA, Kennet Valley and Guildford figures clearly vastly inflated with unrealistic growth rates. The SWOX figure in particular looks to be an outlier. Using the ONS 2020 growth rates, the SWOX growth figure is more likely to be around 17% up to 2100 rather than the 40% used in the plan. Using a starting figure of 1,069,000 in 2020 would result in growth to only 1,159,900 by 2050 and 1,250,700 by 2100, a reduction of 209,000 and 243,000 respectively on the WRMP plan. These figures correlate strongly with the slight reduction between ONS 2018 and 2020 updates, and the figures presented at Table 3-13. If TW disagree with this, they should present evidence as to why this area will outgrow the rest of England by more than 100% over the rest of the century.

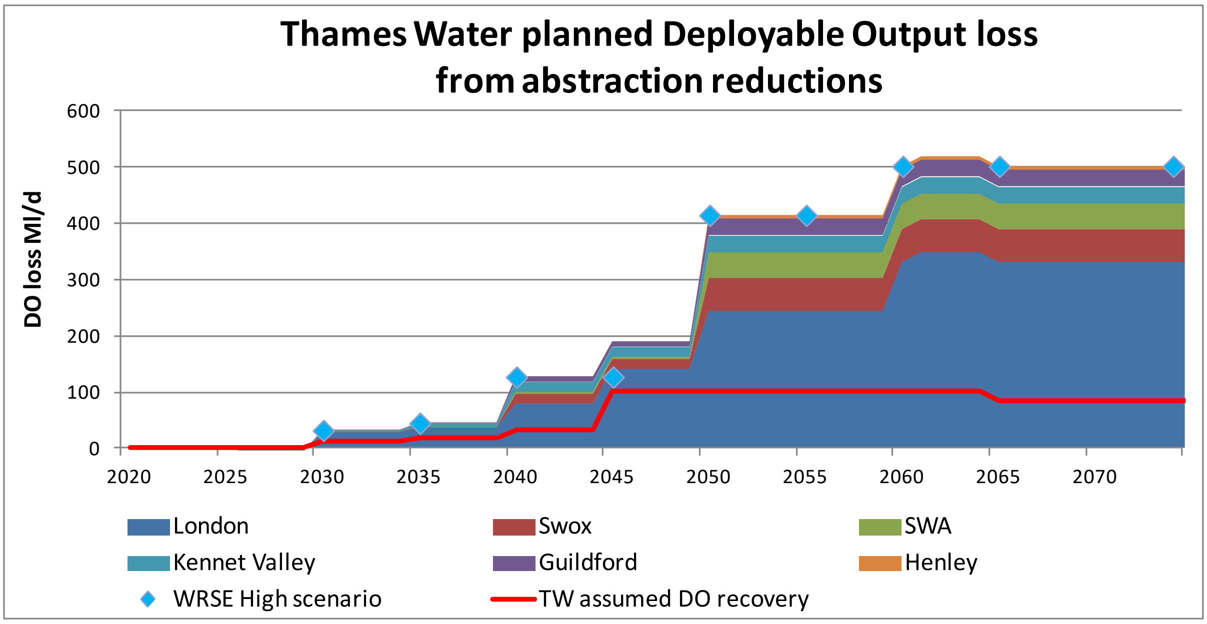
The debate on OxCam is largely pointless. Regardless of the rhetoric, the outcome will be a balance between political ambition and real-world practicality and affordability. Given the recent decision to delay elements of HS2 by 2 years due to cost, it is unlikely that anything significant will happen in terms of OxCam in the next decade. Supply planning with regard to OxCam should therefore be delayed until at least the next WRMP round.

The 2020 ONS England projection indicates that the TW WRMP population figures are too high by 1.2 million by 2050 and 1.8 million by 2100, as shown in our earlier Table 1. This shows that the TW figures are not fit for purpose. The entire section on population should be revisited. In the meantime, we think it would be reasonable to make a central planning assumption for population growth as for the ONS 2020 forecast for England, with an added 30% increase in the growth rate as a safety factor. This growth rate applied to the London population is shown in our earlier Figure 1.

2.3 Environmental reductions and benefits to downstream supplies

2.3.1 Overall loss of DO due to environmental improvements

Thames Water's planned loss in deployable output due to abstraction reductions for environmental improvements are shown in Figure 8:



Notes: 1. The TW assumed DO recovery from abstraction reductions is as provided by WRSE in file 'GARD-09 Additional Source Level Environmental Ambition Data.xlsx'
2. Plotted amounts for each zone are from TW WRMP tables, 7.2BL + 7.3BL, with DO recoveries added to give DO loss before recovery

Figure 8 - TW planned losses of DO due to abstraction reductions

Figure 8 shows that Thames Water's planned abstraction reductions almost exactly match WRSE's 'High' scenario. Thames Water describes the basis of the abstraction reduction scenarios as below[8]:

"the 'high' scenario was, therefore, based on the requirement to meet the EFI [Environmental Flow Indicator], while the 'low' and 'medium' scenarios were developed considering existing and previous WINEP investigations and known sensitive catchments together with some expert judgement."

In Section 5 of the main WRMP report Thames Water describes the reasoning behind the abstraction reductions in Medium and Low scenarios as follows[9]:

"The prioritisation of abstraction sources to be included in the Low and Medium scenarios provided for WRSE use has been defined on the following basis:

[8] TW WRMP main report paragraph 5.33
[9] TW WRMP main report paragraph 5.39

- *Prioritisation of chalk streams taking into account the high profile of some chalk streams established through historic stakeholder concern Insight gained from sustainability reductions implemented previously at groundwater abstraction sources following investigations*

- *Insight gained from abstraction impact investigations during pre-AMP7 WINEP investigations, including those where no licence reductions were made*

- *Abstractions that have been prioritised in AMP7 for WINEP and specific WFD No Deterioration investigations*

- *Focus on priorities identified through discussions with the Environment Agency"*

In GARD's opinion, this would be a reasonable basis for prioritising abstraction reductions and, as we show in Sections 2.3.2 to 2.3.4, the Medium and Low scenarios entail much smaller losses of deployable output than the High scenario.

However, Thames Water's preferred plan has adopted the High scenario abstraction reductions for the reasons given below[10]:

> *"Through pre-consultation discussion with our regulator, the Environment Agency, the advice that has been given to us is that we should, in the absence of findings from investigations, assume that licence reductions would need to be made where identified by EFI-based calculations in identifying the pathway for our preferred programme. This means that the "high" environmental destination scenario referred to above should be used. As such, we have followed the regulator's guidance, which in essence applies a precautionary principle in our planning of likely future licence reductions."*

In other words, Thames Water have chosen to adopt the High scenario, based on EFI compliance, rather than use their own expert judgement based on knowledge of their sources and findings of previous investigations. In our response to WRSE's regional plan, we commented at length on the inappropriateness of slavishly following the EFI "handle turning" methodology. We pointed out the dangers of excessive and unjustified abstraction reductions leading to huge costs of replacement sources, which bring their own environmental impacts[11]. Excessive expenditure on abstraction reductions will inevitably lead to less money being available for much needed improvements to sewerage and sewage treatment. The point was made succinctly in Oxfordshire County Council's response to WRSE's regional plan[12]:

> *"There should be a focus on ecologically important chalk streams and reducing abstractions to enable those environments to be rehabilitated. However, we understand*

[10] TW WRMP main report paragraph 11.13
[11] GARD response to WRSE's regional plan Sections 2.2.2 and 2.2.5 5 https://www.gard-oxon.org.uk/downloads/Final%20GARD%20Response%20to%20WRSE%2022%202%2023%20v4.pdf
[12] Oxfordshire County Council response to WRSE consultation, paragraph 15, 2nd bullet, page 5

that the ratio of the marginal cost and utility of the highest of the three environmental options is very poor, and believe bill-payers would expect this to be weighed against the benefit of an equivalent shift in resources to reducing raw sewage discharges in other rivers. We consider that this plan should push back on any narrow focus and maximalist expectations from regulators."

In view of the dominance of environmental improvements in the resource needs of every region, no decisions should be taken on the need and choice of new resource schemes until the proper and transparent prioritisation of abstraction reductions has been completed.

GARD's comments on the abstraction reductions in TW's water resource zones are given in the following sections.

2.3.2 Planned abstraction reductions in the London zone

Thames Water's deployable output losses for the London zone due to abstraction reductions under the three scenarios are shown in Table 2:

		WRSE High Scenario							WRSE	WRSE
Source	**Catchment**	**2029-30**	**2034-35**	**2039-40**	**2049-50**	**2059-60**	**2064-65**	**2074-75**	**Medium**	**Low**
Bexley	Darent and Cray		0.0	31.7	31.7	31.7	31.7	31.7	15.0	9.0
Crayford	Darent and Cray		0.0	0.0	13.6	13.6	13.6	13.6	0.0	0.0
Darenth	Darent and Cray		0.0	0.0	20.7	20.7	20.7	20.7	0.0	0.0
Dartford	Darent and Cray		0.0	0.0	3.6	3.6	3.6	3.6	0.0	0.0
Epsom Sources	London	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
Green St Green	Darent and Cray		0.0	0.0	4.5	4.5	4.5	4.5	0.0	0.0
Horton Kirby and Eynsford	Darent and Cray		3.4	6.8	6.8	6.8	6.8	6.8	3.4	3.4
Lower Lee	London		0.0	0.0	0.0	65.0	65.0	65.0	50.0	25.0
Lullingstone	Darent and Cray		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
New Gauge	Upper Lee		0.0	0.0	80.0	80.0	80.0	80.0	60.0	0.0
Northern New River Wells	London		0.0	0.0	0.0	40.0	40.0	40.0	18.0	18.0
Northern New River Wells (No Det) Licence Cap	London	18.0	18.0	18.0	18.0	0.0	0.0	0.0	0.0	0.0
Orpington	Darent and Cray		0.0	0.0	8.6	8.6	8.6	8.6	0.0	0.0
Sundridge	Darent and Cray		0.0	0.0	1.4	1.4	1.4	1.4	1.4	0.0
Waddon	London		0.0	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Wansunt	Darent and Cray		0.0	0.0	13.6	13.6	13.6	13.6	0.0	0.0
Westerham	Darent and Cray		0.0	0.0	0.9	0.9	0.9	0.9	1.0	0.0
Wilmington	Darent and Cray		0.0	0.0	19.0	19.0	19.0	19.0	0.0	0.0
	Sub-total	**28.2**	**36.1**	**78.7**	**244.5**	**331.5**	**331.5**	**331.5**	**170.9**	**77.6**
Return from TW SRs		-3.9	-3.88	-9.5	-57.8	-57.8	-57.8	-57.8	-22.6	-5.7
Returns from Colne		-5.2	-5.2	-12.1	-26.5	-26.5	-26.5	-26.5	-19.6	-11.1
Returns from Lee		-3.1	-8.9	-10.0	-17.7	-17.7	0.0	0.0	0.0	0.0
DO loss after recovery from returns		**16.0**	**18.1**	**47.1**	**142.5**	**229.5**	**247.2**	**247.2**	**128.7**	**60.8**

Table 2 - DO loses due to abstraction reductions in London zone

Table 2 shows that the deployable output losses for London zone are far higher for the High scenario than for the Medium or Low scenarios. It also shows that a lot of the deployable output losses for the London zone are due to abstraction reductions for the River Darent (and its Cray tributary), a chalkstream in Kent to the South East of London.

Without the Darent reductions,

London zone abstraction reductions are shown in Table 3:

	All in Ml/d	WRSE High Scenario							WRSE	WRSE
Source	**Catchment**	**2029-30**	**2034-35**	**2039-40**	**2049-50**	**2059-60**	**2064-65**	**2074-75**	**Medium**	**Low**
Epsom Sources	London	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
Lower Lee	London		0.0	0.0	0.0	65.0	65.0	65.0	50.0	25.0
New Gauge	Upper Lee		0.0	0.0	80.0	80.0	80.0	80.0	60.0	0.0
Northern New River Wells	London		0.0	0.0	0.0	40.0	40.0	40.0	18.0	18.0
Northern New River Wells (No Det) Licence Cap	London	18.0	18.0	18.0	18.0	0.0	0.0	0.0	0.0	0.0
Waddon	London		0.0	7.6	7.6	7.6	7.6	7.6	7.6	7.6
	Sub-total	**28.2**	**28.2**	**35.7**	**115.7**	**202.8**	**202.8**	**202.8**	**145.7**	**60.7**
Return from TW SRs		-3.9	-3.88	-9.5	-57.8	-57.8	-57.8	-57.8	-22.6	-5.7
Returns from Colne		-5.2	-5.2	-12.1	-26.5	-26.5	-26.5	-26.5	-19.6	-11.1
Returns from Lee		-3.1	-8.9	-10.0	-17.7	-17.7	0.0	0.0	0.0	0.0
DO loss after recovery from returns		**16.0**	**10.2**	**4.1**	**13.7**	**100.7**	**118.4**	**118.4**	**103.5**	**43.9**

Table 3 - London zone without Darent, DO losses due to abstraction reductions

Most of these reductions are from surface water abstractions from heavily modified parts of the River Lee and its man-made diversion channel, the New River. They are not abstraction reductions from an ecologically sensitive chalk stream. The New River abstraction could be switched to the lower Lea, which would put more flow into the middle Lea with no net loss of deployable output. The reductions from the Northern New River Wells are also of questionable ecological benefit, bearing in mind that the boreholes are near the lower limit of the "classic chalk stream" part of the River Lea. Furthermore, the lower river will benefit from about 90 Ml/d of urgently needed reductions in Affinity Water's groundwater abstractions in the Upper Lea and its chalk tributaries (Mimram, Beane, etc)[13], so further flow enhancements may not be needed.

In GARD's opinion, even WRSE's Low scenario reductions for the London sources shown in Table 3 could be difficult to justify in terms of benefits versus the cost and impact of replacement sources. However, we think that, at this stage it would be reasonable for TW's preferred plan to allow for the Low scenario reduction of 60.7 Ml/d gross loss of DO, which gives a net loss of 43.9 Ml/d after allowing for Thames Water's figures for DO recovery from enhanced river flows available for filling Thames Water's reservoirs.

Reduction in abstraction at Thames Water's sources in the lower River Lea could be justified if linked to development of the Deephams reuse scheme, if it is needed. This is further discussed in Section 7.4.

We have left the deployable output recovery figures in Table 3 as per Thames Water's figures. However, in our opinion, DO recovery will be a lot higher for the reasons set out in GARD's response to WRSE's consultation. We will say more about this in Section 3.4 of this response, when commenting n proposals for the Thames to Affinity transfer.

In contrast to the lower Lee, the Rivers Darent and Cray are potentially "classic" chalk streams

[13] GARD response to Affinity Water WRMP consultation, Table 2

with a much stronger case for abstraction reductions. TW and WRSE scenario reductions are shown in Table 4, using WRSE data which is identical to the data in WRMP Table 5-4:

	All in Ml/d	WRSE High Scenario					WRSE	WRSE
Source	Catchment	2029-30	2034-35	2039-40	2049-50	2074-75	Medium	Low
Wilmington	Lower Darent		0.0	0.0	19.0	19.0	0.0	0.0
Darenth	Lower Darent		0.0	0.0	20.7	20.7	0.0	0.0
Dartford	Lower Darent		0.0	0.0	3.6	3.6	0.0	0.0
Wilmington	Lower Darent		0.0	0.0	19.0	19.0	0.0	0.0
Crayford	Lower Cray		0.0	0.0	13.6	13.6	0.0	0.0
Bexley	Lower Cray		0.0	31.7	31.7	31.7	15.0	9.0
Green St Green	Mid Darent		0.0	0.0	4.5	4.5	0.0	0.0
Horton Kirby and Eynsford	Mid Darent		3.4	6.8	6.8	6.8	3.4	3.4
Lullingstone	Mid Darent		4.5	4.5	4.5	4.5	4.5	4.5
Sundridge	Upper Darent		0.0	0.0	1.4	1.4	1.4	0.0
Westerham	Upper Darent		0.0	0.0	0.9	0.9	1.0	0.0
Wansunt	Upper Cray		0.0	0.0	13.6	13.6	0.0	0.0
Orpington	Upper Cray		0.0	0.0	8.6	8.6	0.0	0.0
	Total DO loss	**0.0**	**7.9**	**43.0**	**128.8**	**128.8**	**25.2**	**16.9**

Table 4 - DO losses due to Darent/Cray abstraction reductions

This shows that most of the planned abstraction reductions in the High scenario are in the lower Rivers Darent and Cray which are heavily urbanised. Thames Water has justifiably given these reductions a low priority by mostly pushing them back to 2050.

The high priority for reductions should be the abstractions in the middle and upper Darent where the river is in the Kent Downs AONB and has the potential to be a "classic" chalk stream. The mid and upper Darent reductions shown in Table 4 only total 18 Ml/d and, in GARD's opinion, these should all be implemented by 2035. There could also be a case for some reductions in the upper Cray catchment, even though the river is heavily urbanised. Most the other Darent and Cray reductions seem unlikely to be justifiable through the urgently needed national prioritisation of abstraction reductions which GARD has advocated in its response to the consultation on WRSE's regional plan[14]:

In our opinion, it would be reasonable for Thames Water's preferred plan to allow for the Low scenario reductions for London only, ie 43.9 Ml/d as Table 3, plus the Mid scenario for Darent/Cray, ie 25.2 Ml/d as Table 3, making a total of 69.1 Ml/d for the London zone. This compares with the 247 Ml/d allowance in the preferred plan as shown in Table 2.

2.3.3 Planned abstraction reductions in the SWOX zone

Thames Water's planned deployable output loss due to abstraction reductions in the SWOX zone are shown in Table 5:

[14] GARD response to WRSE regional plan, page 22

	All in Ml/d	WRSE High Scenario					WRSE Medium	WRSE Low
Source	Catchment	2029-30	2034-35	2039-40	2049-50	2074-75		
Ashdown Park	Kennet and tributaries		0.0	0.0	1.0	1.0	0.0	0.0
Ashton Keynes	Gloucestershire and the Vale		0.0	0.0	1.7	1.7	1.7	0.0
Bibury	Gloucestershire and the Vale		0.0	0.7	0.7	0.7	3.0	3.0
Chinnor	Thames and South Chilterns		0.0	1.6	1.6	1.6	1.6	0.0
Chinnor Licence Cap	Thames and South Chilterns	1.27	1.3	0.0	0.0	0.0	0.0	1.3
Clatford	Kennet and tributaries		0.0	1.2	1.2	1.2	1.2	1.2
Farmoor	Cotswolds		0.0	0.0	35.0	35.0	15.0	0.0
Latton	Gloucestershire and the Vale		0.0	9.7	9.7	9.7	5.0	5.0
Marlborough	Kennet and tributaries		0.0	2.5	2.5	2.5	2.5	2.5
Seven Springs	Cotswolds		0.0	0.0	1.0	1.0	0.0	0.0
Syreford	Gloucestershire and the Vale		0.0	0.0	0.5	0.5	0.0	0.0
Upper & Lower Swell	Cotswolds		0.0	0.0	1.8	1.8	1.8	0.0
Watlington	Thames and South Chilterns		0.0	0.3	0.3	0.3	0.3	0.0
Woods Farm	Thames and South Chilterns		0.0	1.6	1.6	1.6	0.0	0.0
All	**Total DO loss**	**1.3**	**1.3**	**17.6**	**58.6**	**58.6**	**32.1**	**13.0**

Table 5 - DO losses due to abstraction reductions in SWOX zone

The main effect of planned abstraction reductions in SWOX zone is the loss of 35 Ml/d of deployable output from Farmoor from 2050. GARD's modelling shows that the 35 Ml/d deployable output loss corresponds to raising the Farmoor hands-off flow from 136 Ml/d to 188 Ml/d. However, raising the Farmoor hands-off flow leaves more water in the River Thames, which then becomes available for filling the London reservoirs. Our modelling shows that this would lead to recovery of 27 Ml/d of deployable output in the London zone. Therefore, the35 Ml/d loss of deployable output in SWOX zone is only a net loss of 8 Ml/d to Thames Water's supplies overall.

All the DO losses due the other groundwater abstraction reductions shown in Table 5 arise after 2040, presumably because of Thames Water's assumed need to wait for Abingdon reservoir to make replacement water available. However, as noted in Section 3.2, Thames Water's planned leakage reduction in SWOX zone is only 27%, far short of the Government's 50% target – if leakage is reduced to similar levels to other water companies in the South East, all the groundwater abstraction reductions could be brought forward, without the need for Abingdon reservoir.

Therefore, GARD proposes that the sensitive groundwater abstraction reductions in SWOX zone should be brought forward, starting in 2025 and complete by 2035.

2.3.4 Planned abstraction reductions in the Thames Valley zones

Thames Water's planned deployable output loss due to abstraction reductions in the Thames valley zones zone are shown in Table 6:

	All in Ml/d	WRSE High Scenario					WRSE Medium	WRSE Low
Source	Catchment	2029-30	2034-35	2039-40	2049-50	2074-75		
Albury	Wey (Tilling Brook)		0.0	3.6	3.6	3.6	0.0	0.0
Mousehill & Rodborough	Upper Wey		0.0	1.5	1.5	1.5	0.0	0.0
Netley Mill	Wey (Tillingbourne)	1.18	1.2	4.5	4.5	4.5	4.5	1.2
Netley Mill Licence Cap	Wey (Tillingbourne)		0.0	0.0	0.0	0.0	0.0	0.0
Shalford	Middle Wey		0.0	0.0	20.3	20.3	0.0	0.0
Sheeplands	Loddon and tributaries	0.00	0.0	0.0	6.2	6.2	0.0	0.0
Bishops Green	Enbourne		0.0	0.8	0.8	0.8	0.0	0.0
Bradfield	Pang	1.64	1.6	1.6	1.6	1.6	1.6	1.6
East Woodhay	Enbourne		0.0	3.9	3.9	3.9	0.0	0.0
Fognam Down	Lambourn		0.0	0.0	0.0	0.0	0.0	0.0
Pangbourne	Pang		5.0	5.0	5.0	5.0	5.0	5.0
Playhatch	Thames valley		0.0	6.5	6.5	6.5	0.0	0.0
Ufton Nervet	Kennet and tributaries		0.0	0.0	11.6	11.6	0.0	0.0
Bourne End	Thames valley		0.0	0.0	5.7	5.7	0.0	0.0
Datchet	Thames valley		0.0	0.0	13.1	13.1	0.0	0.0
Hampden Bottom	Misbourne		0.0	2.0	2.0	2.0	2.0	0.0
Medmenham	Thames valley		0.0	0.0	16.3	16.3	0.0	0.0
Pann Mill	Wye		0.0	0.0	7.5	7.5	7.5	7.5
Radnage	Wye		0.0	1.6	1.6	1.6	1.6	1.6
All	**Total DO loss**	**2.8**	**7.8**	**31.0**	**111.6**	**111.6**	**22.2**	**16.9**

Table 6 - DO losses due to abstraction reductions in Thames valley zones

GARD's comments on the abstraction reductions shown in Table 6 are:

1. The abstractions reductions shown as 'Thames valley' totalling 41 Ml/d, if they could be justified, are close to the River Thames and would lead to increased flows in the lower Thames and equivalent increases in deployable output for London zone. However, it is difficult to see how these reductions would lead to worthwhile ecological benefits, which is presumably why Thames Water have not included them in the Mid or Low scenarios.

2. The CaBA report on Abstraction as % Recharge showed that abstraction in the Pang catchment is only 1% of recharge[15] and no reductions are necessary, even if the Pang has been declared a Flagship catchment [16]. We also note that EA abstraction data shows that the Pangbourne licence expired in 2005 and there has been no abstraction since that date.

3. The CaBA report on Abstraction as % Recharge showed that abstraction in the Wye catchment is only 10% of recharge and reductions are barely necessary, if at all.

4. The Rivers Wey and Loddon were not covered by the CaBA report on Abstraction as % of Recharge. However, GARD is aware from local rivers trusts that there are concerns over abstraction in these catchments, although Thames Water's Loddon abstraction is close to the bottom of the river so probably has little impact. Therefore, the Upper Wey amounts shown in Table 6 are mostly justified (also probably the Enbourne and Misbourne reductions). In that case, the reductions

[15] Catchment as % Recharge, CaBA, December 2021, page 8 https://chalkstreams.org/2022/01/23/ar-abstraction-as-a-of-recharge-in-chalk-streams/

[16] Thames Water WRMP main report paragraph 5.19

should not be delayed until 2040 or 2050, presumably awaiting availability of water from Abingdon reservoir and the STT.

In GARD's opinion, it would be reasonable for Thames Water's preferred plan to allow for the High scenario reductions for the Rivers Wey, Misbourne and Enbourne, as shown in Table 6 and totalling 17 Ml/d (excluding the Shalford abstraction, which is unlikely to have a significant effect on the chalk streams upstream). These reductions should be made as quickly as possible and should not be dependent on Abingdon reservoir. They could be enabled initially by the baseline surplus in the Thames valley zones (see Figure 5) and subsequently by the additional water that would be available if Thames Water meet Government leakage targets and match the leakage levels achieved by other companies in the South East (see Section 3.3).

Therefore, GARD proposes that the sensitive groundwater abstraction reductions in the Rivers Wey, Misbourne and Enbourne should be completed by 2035.

2.3.5 Conclusions from GARD's review of environmental reductions

The conclusion from GARD's review of the losses of deployable output from the environmental reductions in Thames Waters preferred plan are shown in Table 7:

All in Ml/d	**Thames Water**	**GARD**	**Comments**
London zone			
London only	118	44	As TW Low scenario
Darent and Cray	<u>129</u>	<u>25</u>	Mainly upper/middle Darent, but brought forward
Total London zone	247	69	
Swox zone	59	59	Mostly Farmoor and recovered at London. GW reductions brought forward
Thames Valley zones	111	17	Only Wey, Enbourne and Misbourne, but sensitive sites brought forward
Total all zones	**417**	**145**	

Table 7 - Summary of GARD review of TW's DO losses from environmental improvements

In summary, in GARD's opinion Thames Water have overstated their loss of deployable output for environmental improvements by about 270 Ml/d. However, that figure is based on acceptance of Thames Water's estimates of deployable output recovery from the abstraction reductions. Although no detail is given of the basis for Thames Water's recovery figures, we think that the recovery from Colne and Lee chalk stream reductions may have been underestimated and we have seen no evidence that any allowance has been made for recovery from abstraction reductions in SWOX and the other Thames valley zones.

GARD proposes that the sensitive groundwater abstraction reductions in all Thames Water's zones, particularly those in the upper reaches of chalk streams, should be brought forward, starting in 2025 and completed by 2035.

2.4 Climate change

2.4.1 Climate change allowances in preferred plan

Thames Water's allowances in their preferred plan for loss of deployable output due to climate change are shown in Figure 9 [17]:

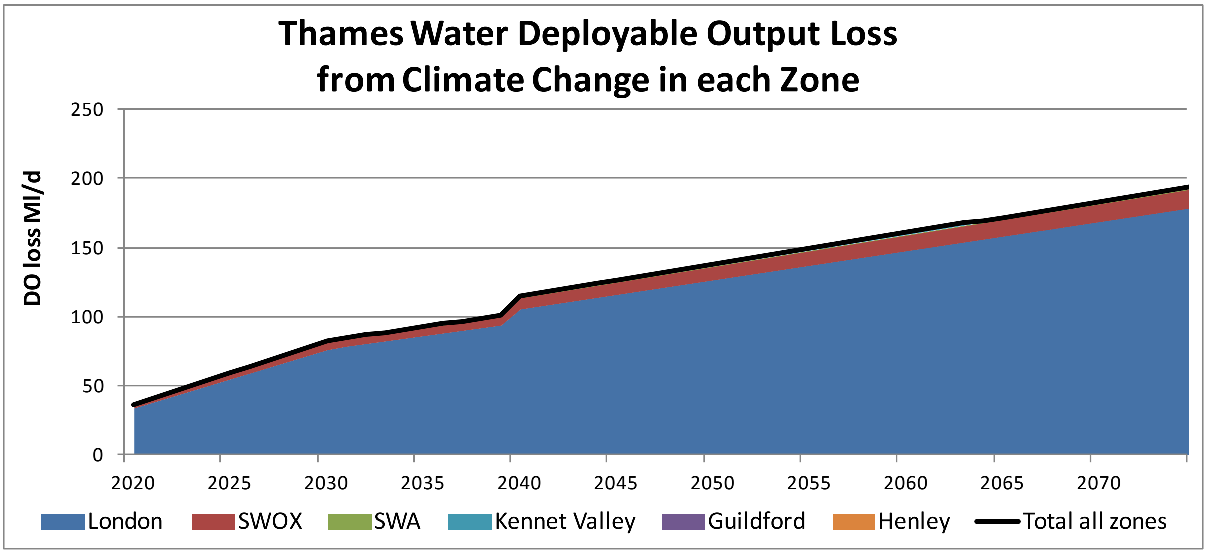


Figure 9 - Deployable output loss due to climate change in each zone

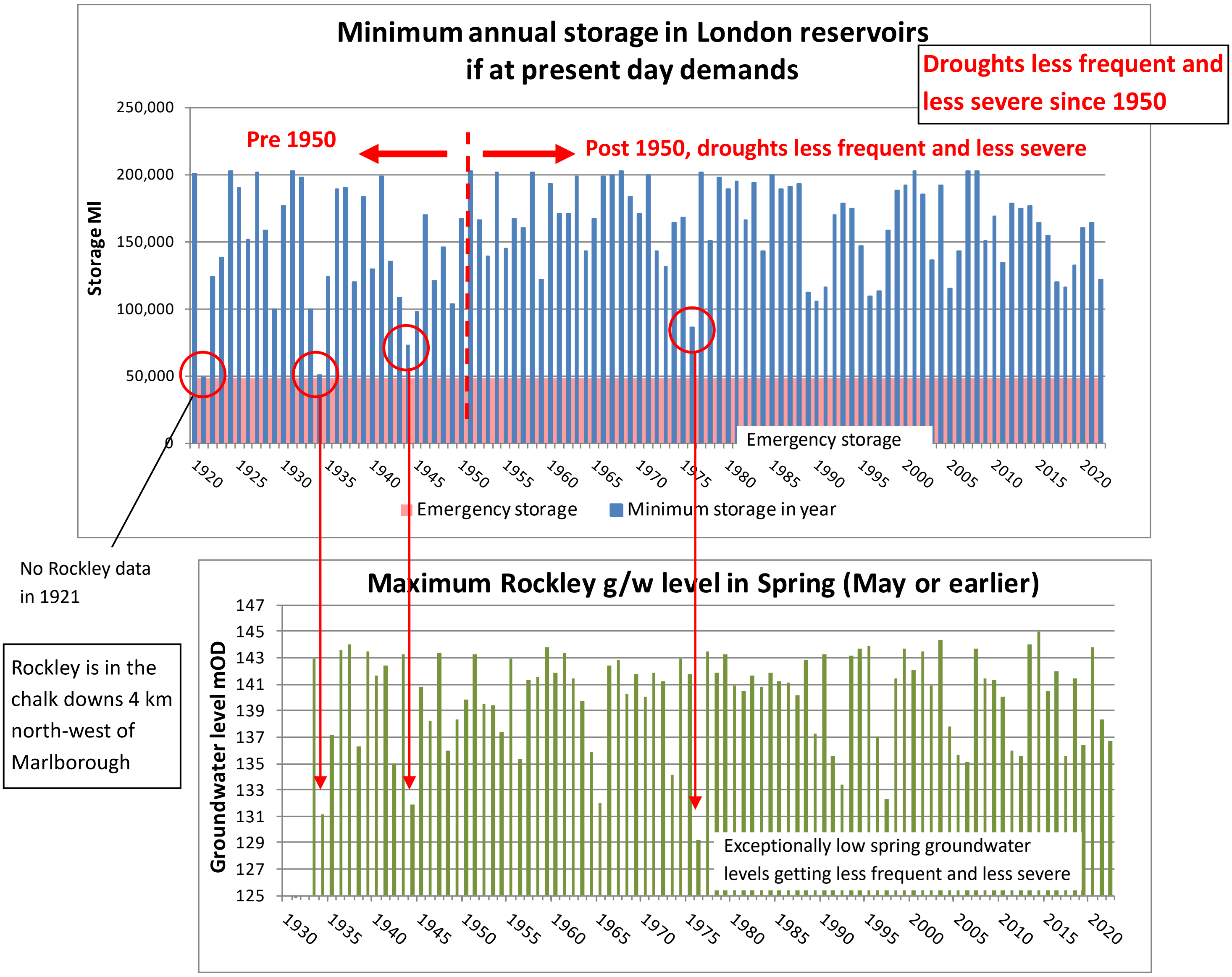
The preferred plan assumes the High scenario for climate change loss[18].

Figure 9 shows that that most of this loss is in Thames Water's London region, with smaller losses in SWOX zone. These are zones with surface water resources and reservoirs. Elsewhere, supplies are largely from groundwater from which deployable outputs are not expected to be significantly affected by climate change.

2.4.2 Evidence of historic climate change impacts on supplies

In GARD's opinion, London and SWOX climate change forecasts should recognise the evidence suggesting that climate change of the past 100 years has not adversely affected the deployable outputs of supplies in the South East to date. Indeed the evidence suggests that climate change to date (which GARD does not dispute) has increased the availability of water supplies for London. For example, we show below the minimum storages that would have occurred in London reservoirs since 1920, if operated at present day demand levels, together with a plot of the highest chalk groundwater level at Rockley in the spring of each year:

[17] Thames Water WRMP table, zonal supply demand balance worksheets
[18] Thames Water WRMP main report paragraphs 11.11 and 11.14



Note: Minimum London storages up to 2010 from WARMS2 modelling of 2305 Ml/d base case, using historic river flows from the actual climate since 1920. Post 2010 storages from CEH monthly hydrological summaries

Figure 10 - Minimum annual London storages and highest g/w levels in climate since 1920

The three most severe droughts of the past 100 years, in terms of impact on London's supplies, were in 1921, 1934 and 1944 – all were in the first 25 years of the past century. The most severe drought of the past 75 years, 1976, was appreciably less severe than the earlier droughts, in terms of impact on London's supplies. Droughts since 1976 have all had relatively little impact on London's supplies. Droughts of the type that would affect London's supplies, ie two summers and a winter, are getting less frequent and less severe.

The lower plot in Figure 10 shows the highest chalk groundwater level reached each year in spring at Rockley in the Marlborough downs. As can be seen comparing the upper and lower plots in Figure 10, the severe droughts affecting London's supplies are those where the chalk groundwater level is exceptionally low at the start of a summer drought. In those circumstances, the base flows in the lower Thames, which are needed to prevent rapid draw-down of the London reservoirs, become abnormally low. The critical period for London's reservoirs is two dry summers and an intervening dry winter. A combination of low groundwater levels in the spring, followed by a summer drought extending into the autumn is needed to create an exceptional drought for London's supplies.

A low chalk groundwater level in spring does not necessarily create a major drought for London's supplies – the preceding summer and the following summer and autumn need to be exceptionally dry as well. On the other hand, if the chalk groundwater level is not abnormally low in spring due to a dry winter, London's supplies are not tested, however severe the subsequent drought.

For example in 2018 –the Rockley groundwater level reached about 142 mOD in May, so the minimum storage in the London reservoirs up to the end of October was about 57%,[19] far above the emergency storage level, despite the severe summer drought which continued deep into the autumn. There was a similar picture in 2022, when minimum storage was 60% despite the severe drought.

The lower plot in Figure 10 shows that exceptionally low chalk groundwater levels in spring are becoming less frequent and less severe. This is consistent with the trend of increasing winter rainfall in England and Wales over the past 150 years shown in Figure 11[20]:

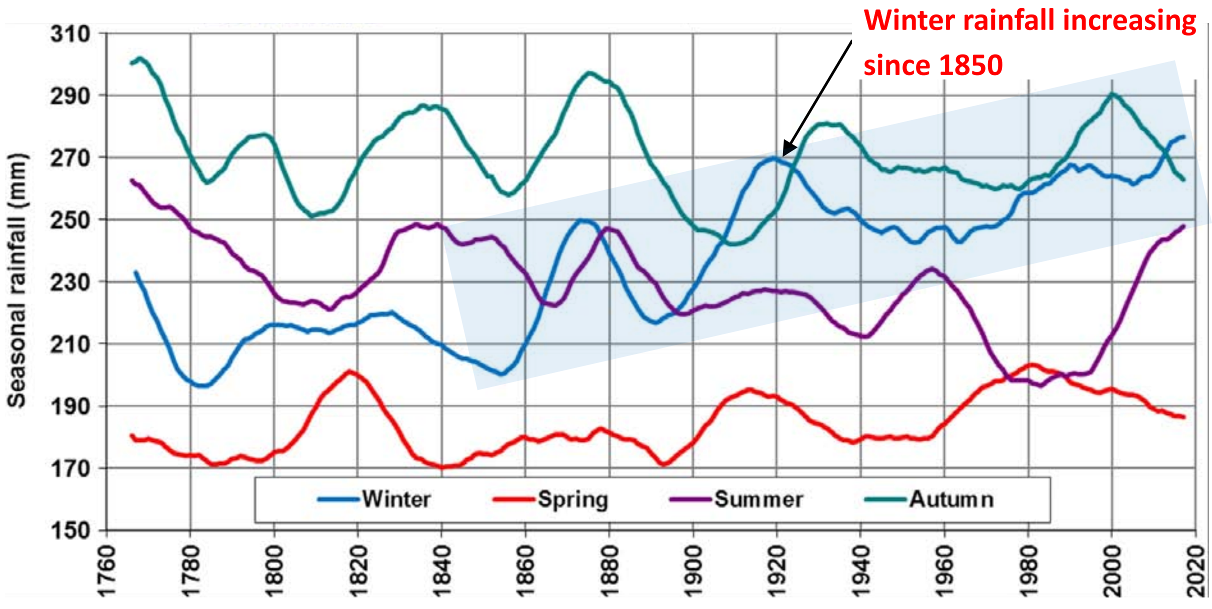


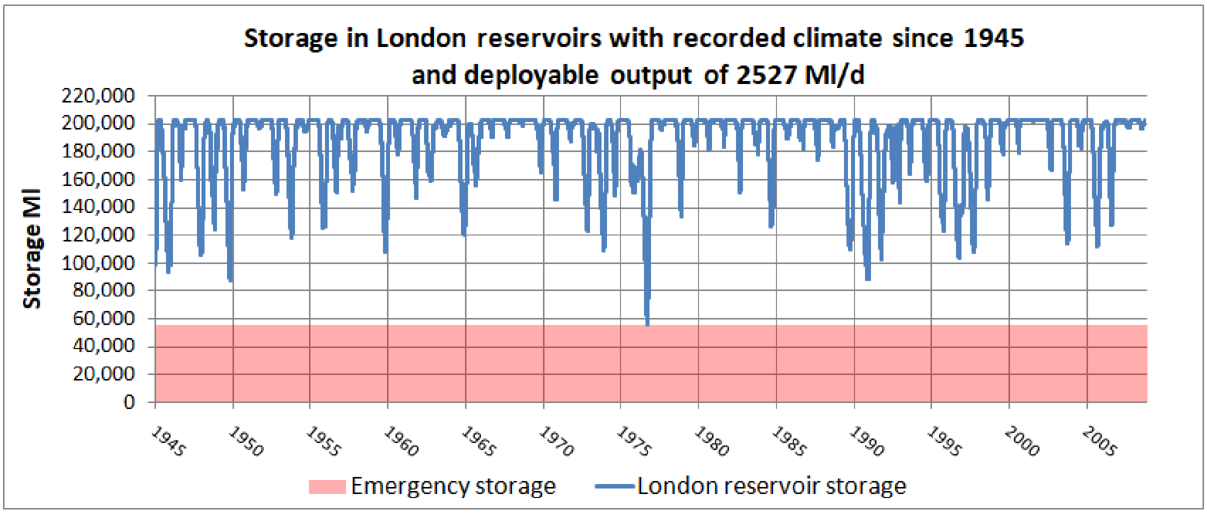
Figure 11 - Seasonal rainfall trends in England and Wales, since 1760

The increasing trend in winter rainfall improves the drought resilience of London's supplies, because the winter rain is stored in the chalk aquifer and released slowly through the summer. The falling trend in summer rainfall, as shown in Figure 11, has less of an impact on London's supplies, because most of the summer rain is absorbed by evapo-transpiration or

[19] Rockley groundwater levels and London storage from CEH monthly hydrological summary, October 2018
[20]State of the UK climate 2017, Volume: 38, Issue: S2, Pages: 1-35, First published: 30 July 2018, DOI: (10.1002/joc.5798. Royal Meteorological Society

slowly into the porous chalk strata that cover a large part of the Thames catchment. 11 shows no evidence of a trend of reducing autumn rainfall that might extend summer droughts and threaten London's supplies.

If the deployable output of London's existing supplies is determined only using the 70 years of river flow records since the 1940s, it rises to 2527 Ml/d, 222 Ml/d more than Thames Water's present-day base case of 2305 Ml/d. The modelled drawdown of London's reservoirs supplying 2527Ml/d since 1945 is shown in Figure 12:



Note: Storages from GARD modelling of existing supply system. Emergency storage increased by 6810 Ml, giving 30 days extra for 227 Ml/d DO increase, as per TW policy

Figure 12 - London storage with existing supplies, DO 2527 Ml/d and climate since 1945

With the climate since the 1940s, London's supplies could have sustained a deployable out 227 Ml/d more than Thames Water's currently assumed deployable output of 2305 Ml/d.

The three most severe droughts of the past 100 years, in terms of impact on London's supplies, were in 1921, 1934 and 1944 – all were in the first 25 years of the past century. The most severe drought of the past 75 years, 1976, was appreciably less severe than the earlier droughts, in terms of impact on London's supplies. Droughts since 1976 have all had relatively little impact on London's supplies. For example the drought of 2022, storage in London's reservoirs never fell below 60% full[21].

2.4.3 Selection of climate change scenario for the preferred plan

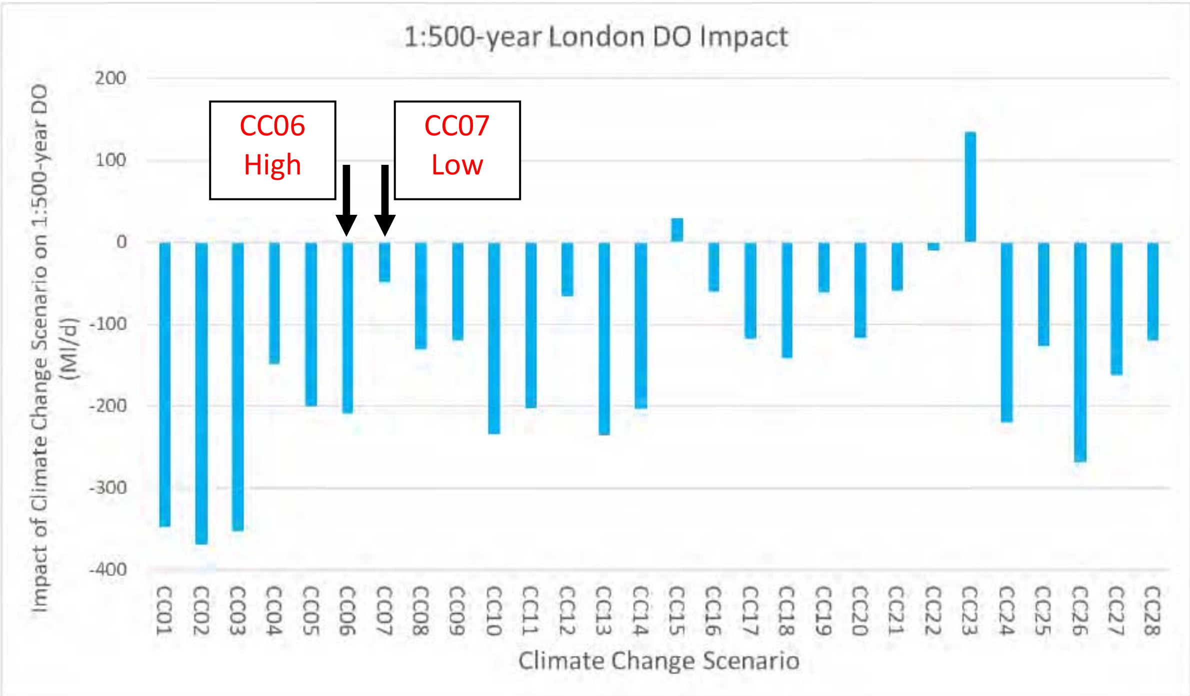
We think that Thames Water's climate change deployable output losses for London, including the allowance for 46 Ml/d loss of deployable output by 2023, have failed to recognise that severe reservoir depletion in summer droughts only occurs if chalk groundwater levels are exceptionally low in the previous spring; and that the groundwater levels in spring are dependent on winter rainfall, which appears to be increasing with climate change. We have made this point repeatedly in our response to previous Thames Water and

[21] CEH Monthly Hydrological Summary, October 2022

WRSE consultations. It is disappointing that no acknowledgement of the criticism was made in WRSE's response to the Emerging Plan consultation in May 2022. All WRSE's response says, presumably voicing Thames Water's opinion, in relation to widespread criticism of excessive deficit forecasts, including climate change allowances, is[22]:

> *"WRSE accepts that there are considerable uncertainties, particularly the further into the future the forecasts look. However, it considers that the forecasts produced and the scenarios that have been developed for the regional plan as a result are valid and robust representations of the range of futures that the South East could experience."*

The range of impacts on London's supplies from the climate change scenarios modelled by Thames Water is shown in Figure 13 [23]:



Note: DO (all CC scenarios are *variants* of the UKCP18 high RCP8.5 scenario)

Figure 13 - TW modelled impact of climate change scenarios on London

Thames Water has identified High and Low scenarios as follows[24]:

> *"Thames Water, aligned with the WRSE Regional Group, has considered a 'median' climate change scenario as the central forecast, and have considered the 6th and 7th (CC06 and CC07) of the 28 spatially coherent projections as 'High' and 'Low' climate change impact scenarios respectively."*

On that basis, Thames Water determined High, Medium and Low scenario impacts for each

[22] WRSE response to consultation on emerging regional plan, May 2022, paragraph 5.11, page 14
[23] Thames Water WRMP main report Figure 4-6
[24] Thames Water WRMP main report paragraph 4.176

zone as below[25]:

	London	SWOX	SWA	Kennet Valley	Guildford	Henley
High Impact (Ml/d)	-168	-13	-0.4	-1.9	0	0
Medium Impact (Ml/d)	-110	-8	-0.2	-1.5	0	0
Low Impact (Ml/d)	-39	-5	-0.1	-1.1	0	0

Table 8 - TW estimates of climate change impacts in each zone

It is important to realise that the terms 'high' and 'low' applied to the CC06 and CC07 respectively in Figure 13 apply to ***variants of the 'high' UKCP18 climate change scenario RCP8.5*** taken from a special 'spatially coherent dataset' released by the Met Office.[26] Thus the lower climate change scenario is not used, because no spatially coherent version is available for it.[27] Ofwat guidance[28] is that both high ('severe' or 'business as usual') scenarios such as UKCP18 RCP8.5, and low ('benign') scenarios such as RCP2.6, should be considered equally in the planning. Unfortunately, as Thames Water observe, regarding Environment Agency guidance:[29]

> "*Although the guidance sets out a number of points on data and methods, it does not set out specific instruction regarding the following:*
>
> - *Which emissions scenario(s) should be the basis of the 'main' supply forecast, and which emissions scenario(s) should be considered in uncertainty analyses*
> - *How to appropriately combine the requirement to determine a '1 in 500-year' DO with the requirement to assess the impact of climate change on DO."*

Each of the future scenarios has a probability spread, and the Ofwat recommendation is to take the 50th percentile for each. Thames analysis shows[30] that the different UKCP18 scenarios actually make very little difference to the 1 in 500 year DO deficit by 2070. The scenarios clustering between 140 Ml/d and 160 Ml/d. Thames use the lack of availability of '*spatially coherent projections'* of RCP2.6 (*'at the time of assessment'*) to concentrate on the high scenario RCP8.5. This has spatially coherent dataset, on which Thames place great emphasis. The so-called 'RCP8.5 GCM' dataset does yield a much higher 1 in 500 year DO deficit (289 Ml/d at 2070). Thames speculate, without any evidence, that this dataset might be more accurate than using the 'probabilistic' versions of RCP8.5 and RCP2.6. There is no back-up for this in the Met Office guide, and Thames's assertion that the spatially coherent

[25] Thames Water WRMP Table 4
[26] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---how-to-use-the-land-projections.pdf
[27] Ibid, page 6.
[28] Ofwat, 2022, PR24 and beyond: Final guidance on long-term delivery strategies, https://www.ofwat.gov.uk/wp-content/uploads/2022/04/PR24-and-beyond-Final-guidance-on-long-term-delivery-strategies_Pr24.pdf
[29] Thames Water dWRMP24 section 4, para 4.141, page 33.
[30] Ibid fig 4.8, page 39.

dataset might be more accurate[31]:

> *"The spatially coherent projections, however, include projections from the newest iteration of the Hadley model, while the probabilistic projections include projections from the previous iteration of the Hadley model. It may be that the newer iteration is more reliable."*

This is somewhat at variance, with the Met Office's own statement[32]:

> "*The probabilistic projections typically show broader ranges of outcomes than the global and regional projections. This enables assessments across a larger set of climate futures than relying on a small set of future outcomes, e.g. only using the climate models from the Climate Model Intercomparison Project (CMIP5) that fed into the 5th Assessment Report from the Intergovernmental Panel on Climate Change*".[note the CMIP5 scenarios form 13 of the 28 scenario versions of RCP8.5 shown in Figure 13]

It remains unclear as to why these spatially coherent data are used by Thames Water, as it seems that, from their own figures, the spread of DO effects between the 25th and 75th quartiles of each of the RCP2.6 and RCP8.5 scenarios, which are of order 160-200 Ml/d, is much higher than the difference between the RCP2.6 and RCP8.5 median projections (20 Ml/d as indicated above). The combination of the two probabilistic scenarios could have clearly been achieved, with some valid Monte Carlo randomisation to obtain a median value, without any delving into other datasets (or more accurately 2 separate datasets, as the CC01-15 and CC16-28 are taken from two separate model runs , which should really not, as Thames Water have done, be randomised together[33].)

In GARD's opinion, the 'Low' climate change impact scenario shown in Table 8 is much more likely than the 'High' scenario, based on the historic evidence in Section 2.4.2. We can see no justification for the 'High' climate change scenario being the central planning assumption for the climate change allowance in the preferred plan. We propose that it would be reasonable (ie reasonably cautious) to assume the 'Medium' scenario as the central planning assumption, with an allowance of about 110 Ml/d loss of London deployable output by 2075 and 8 Ml/d loss for SWOX zone.

The preferred plan assumes that the deployable output of London supplies has already been reduced by 46 Ml/d in 2023 (see Figure 9). In our opinion, this defies the evidence set out in Section 2.4.2 that there has to date been no adverse impact of climate change on London's supplies and, probably, a significant increase in deployable output. Therefore, we propose

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[31] Thames Water dWRMP main document, section 4, para 4.168.

[32] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---how-to-use-the-land-projections.pdf - page 5.

[33] To quote the Met Office guide: "*Note that the global* [ie. the spatially-coherent] *projections may not sample as broad a range of outcomes as the probabilistic projections and do not enable estimates of relative likelihood"*

that the allowance for climate change loss for London should start at zero in 2023, rising to the Medium scenario loss of 110 Ml/d by 2075. The value of 110 Ml/d is, coincidentally, roughly equal to the 'Ofwat-consistent' value for DO loss in 2070 from averaging over RCP2.6 and RCP8.5, minus the non-existent 46 Ml/d loss of DO predicted for 2023.

2.5 Improved resilience standard and safety margins

GARD accepts the need to increase the resilience of supplies to maintain supplies in a 1 in 500 year drought. Prior to WRMP19, supplies were planned to withstand a "worst historic" drought, roughly equivalent to a 1 in 100 year drought. The loss of deployable output due to switching from the 1 in 100 to 1 in 500 year resilience standard is shown in Table 9 [34]:

	London	SWOX	SWA	Kennet	Henley	Guildford
I in 100 DYAA DO	2313.0	324.3	184.3	142.3	21.6	69.7
I in 200 DYAA DO	2196.0	313.9	184.1	124.6	21.6	69.7
I in 500 DYAA DO	2047.0	304.3	184.0	107.3	21.6	69.7
DO loss 1:100 to 1:500	**266.0**	**20.0**	**0.3**	**35.0**	**0.0**	**0.0**

Table 9 - Deployable output losses from switch to 1:500 year resilience

The large deployable output losses occur in the zones where supplies are dependent on river water abstractions. For example, the Kennet Valley zone has a large direct river supply from the Thames near Reading. The zones supplied by groundwater have minimal losses of DO when switching to the 1:500 year standard.

In addition to the improved security of supply from the change to the resilience standard, the plans include target headroom as a buffer to deal with uncertainty in the supply demand balance. The allowances for target headroom are shown in Figure 14:

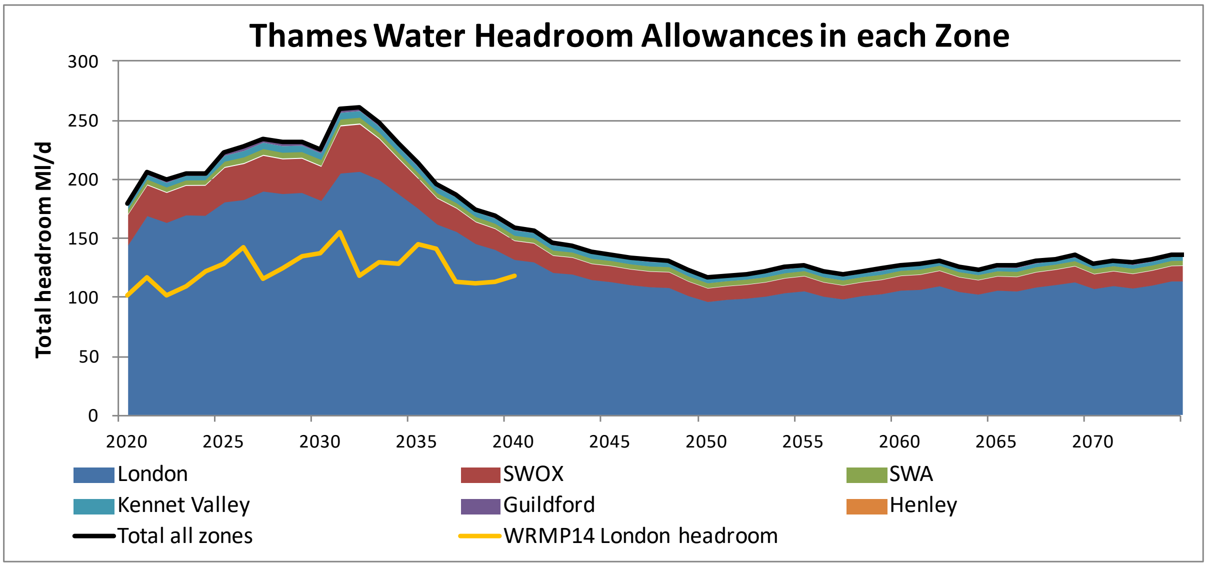


Figure 14 - Target headroom allowances in each zone

[34] Data from Thames Water WRMP tables 4.1, 4.3, 4.5, 4.7, 4.9 and 4.11

Figure 14 shows the large headroom allowances in the London and SWOX zones, corresponding to about 8% of present deployable output.

Figure 14 also shows the London zone headroom allowance in Thames Water WRMP in 2014[35]. This allowance was mostly about 50 Ml/d less than the latest London zone headroom. Moreover, WRMP14 only provided for the 'worst historic' drought, with the possibility of a drought more severe than historic allowed for in the headroom. This was probably the most important component of the headroom prior to adoption of the 1:500 year resilience standard. However, now that the resilience standard has been raised to 1 in 500 years, there is little need for headroom to accommodate the possibility of even more severe droughts.

Therefore, the increased headroom combined with the increased resilience standard, is a double provision of the safety factor against severe droughts. The assumed loss of 266 Ml/d in London deployable output due to the resilience change, combined with an increase in headroom, represents a very large increase in security of supplies to London.

In addition, Thames Water has yet more buffering in its preferred plan through:

- Assumption of the 'High' scenario for losses of DO for environmental improvements
- Assumption of the 'High' population growth scenario
- Assumption of the 'High' climate change scenario
- Assumption of downgrading of Gateway desalination plant output from 150 Ml/d to 100 Ml/d throughout the planning period
- Assumption of inability to meet the Government's 110 l/p/day PCC targets
- Lack of any attempt to meet the Government's 50% leakage targets outside London

Overall, this represents a huge over-provision of safety margins in Thames Water's plan.

2.6 GARD proposed revision of baseline supply demand balance.

2.6.1 Revision to London baseline deficit

Taking account of GARD's comments on population growth, environmental reductions and climate change, the drivers of the London baseline deficit would be as shown in Figure 15:

[35] Thames Water WRMP14 tables London zone Final Plan Supply worksheet

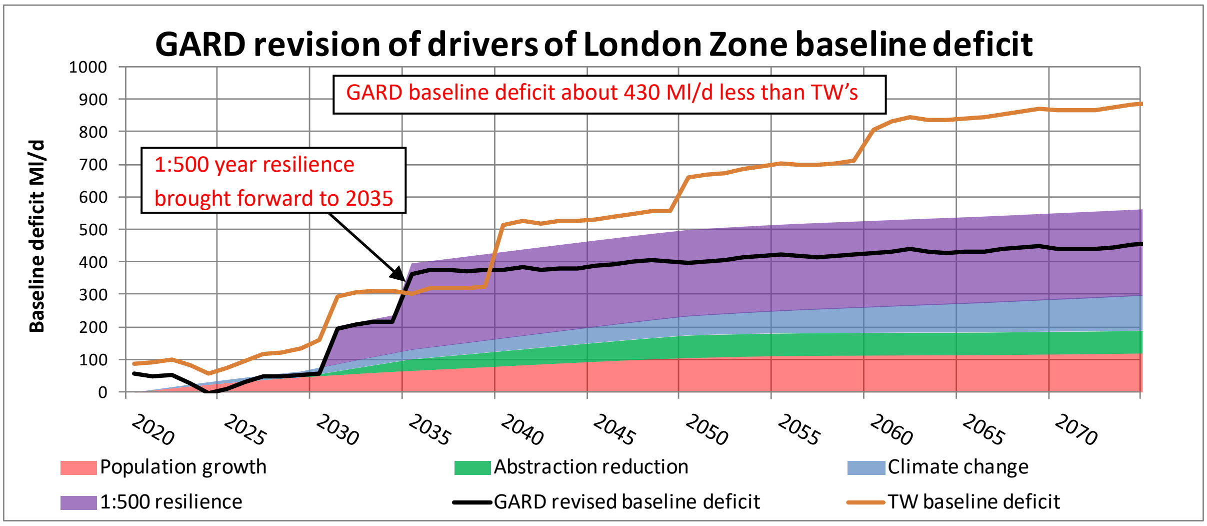


Figure 15 - GARD proposed revision to London baseline deficit drivers

The changes to the drivers of the London baseline deficit are:

1. Population growth reduced to be more aligned with ONS forecasts as in Section 2.3
2. Abstraction reductions as Table 7 and with sensitive chalk stream reductions brought forward as in Section 2.3
3. Climate change as per Section 2.4, ie as Thames Water Medium scenario, but starting with zero loss of deployable output due to climate change up to 2023
4. Resilience standard as per TW, but 1:500 brought forward to 2035

Overall, the ultimate need for new resources for London zone is reduced by about 430 Ml/d.

2.6.2 Revision to SWOX zone baseline deficit

GARD's revision of the drivers of the SWOX baseline deficit would be as shown in Figure 16:

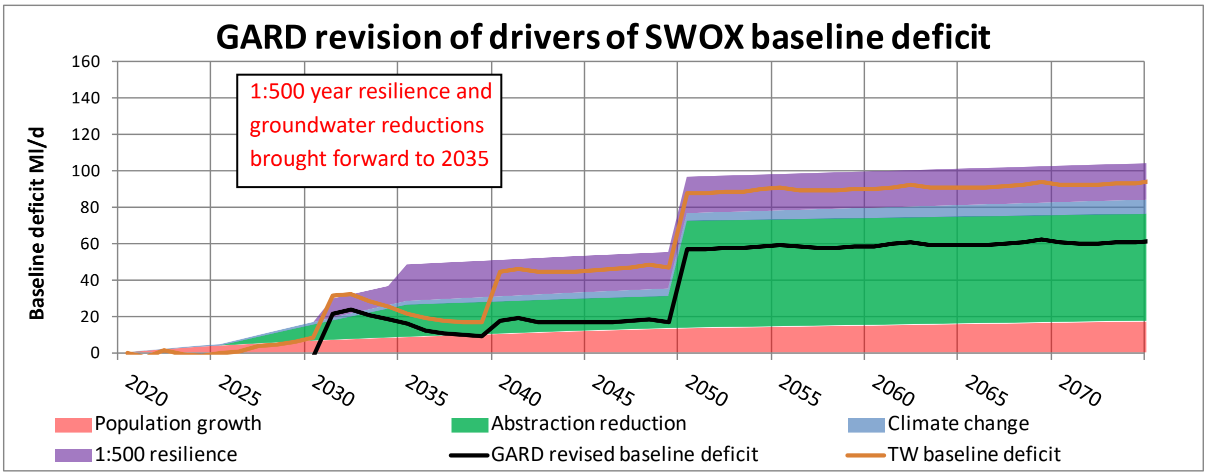


Figure 16 - GARD proposed revision to SWOX baseline deficit drivers

The changes to the drivers of the SWOX baseline deficit are:

1. Population growth reduced to be more aligned with ONS forecasts as in Section 2.3.
2. Abstraction reductions as Table 7 and with sensitive groundwater reductions brought forward to start in 2025 and complete by 2035 as in Section 2.3. Farmoor reduction still 35 Ml/d at 2050.
3. Climate change as per Section 2.4, ie as Thames Water Medium scenario, but starting with zero loss of deployable output due to climate change up to 2023
4. Resilience standard as per TW, but 1:500 brought forward to 2035

Overall, the ultimate need for new resources for SWOX zone is reduced by about 30 Ml/d.

2.6.2 Revision to Thames Valley zones baseline deficit drivers

GARD's revision of the drivers of the London baseline deficit would be as shown in Figure 17:

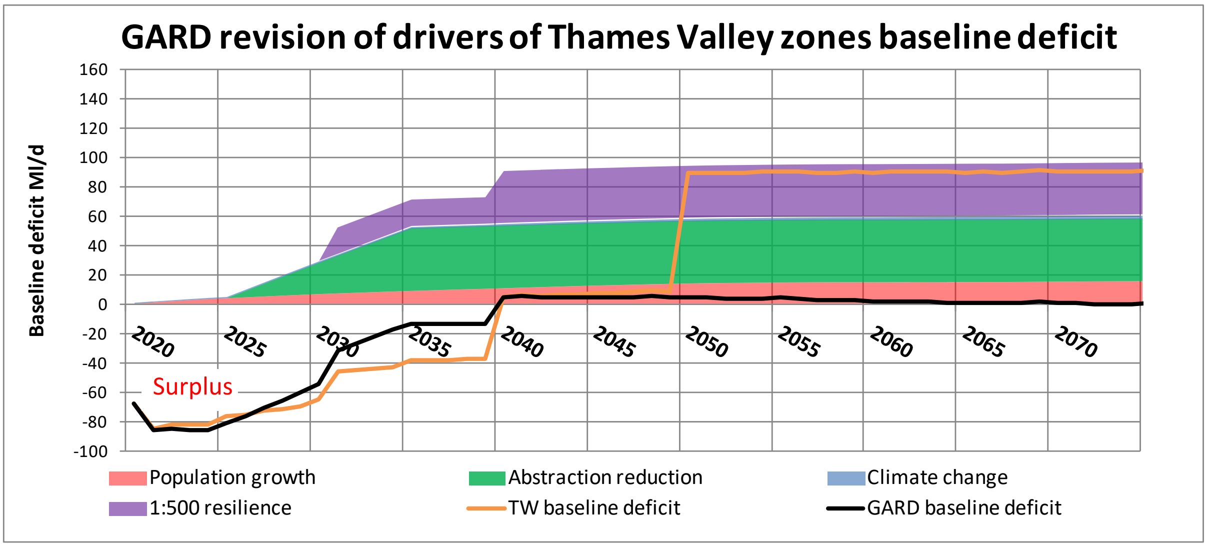


Figure 17 - GARD proposed revision to Thames Valley baseline deficit drivers

The changes to the drivers of the Thames valley baseline deficits are:

1. Population growth reduced to be more aligned with ONS forecasts as in Section 2.3
2. Abstraction reductions as Table 7, with sensitive groundwater reductions in the Rivers Wey, Misbourne and Enbourne brought forward to start in 2025 and complete by 2035 as in Section 2.3.
3. Resilience standard as per TW, but 1:500 brought forward to 2035

Overall, the ultimate need for new resources for the Thames valley zones is reduced by about 90 Ml/d.

3. The need for major new sources

3.1 The balance between demand reductions and new supplies

Chapter 2 of GARD's response has entailed a review of the four main drivers of the needs for major new water supplies – abstraction reductions for environmental improvements, population growth, climate change and improved drought resilience. Thames Water's needs for major new sources of supply will also depend on:

- planned additional PCC reduction
- planned additional leakage reduction
- the amount of planned export to Affinity Water
- the amount of planned export to Southern Water

The plans for these are reviewed in Sections 3.2 to 3.5, leading to re-assessment of the need for major new supplies in Section 3.6.

3.2 Proposed PCC reductions

The planned reductions in PCC in Thames Water's supply zones are shown below:

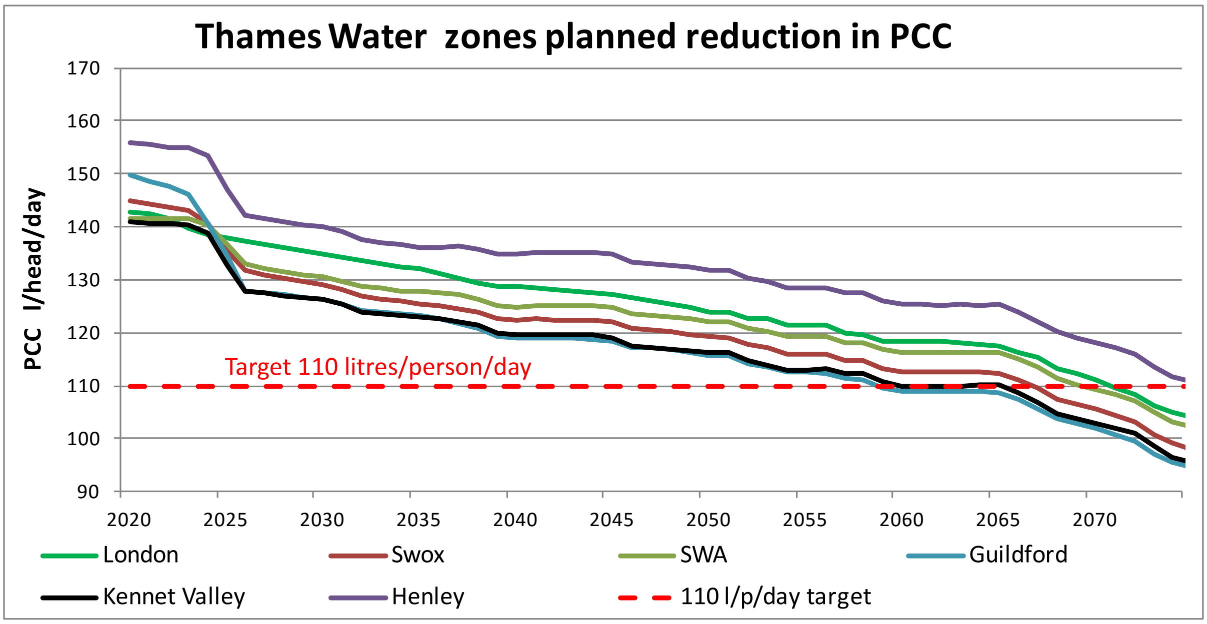


Figure 18 - TW planned reductions in PCC in each zone

WRSE's regional plan states that Government has promoted a national ambition for per capita consumption (PCC) to fall to 110 litres per person by day by 2050[36]. Thames Water misses this target in every zone. The six South East water companies' planned reductions in PCC are shown in WRSE's plan as below[37]:

[36] WRSE Technical Annex 2, paragraph 5.21
[37] WRSE Technical Annex 2, Table 5.2

Company	2017/18 Normal year PCC (l/person/d)	2050 Normal Year PCC (l/person/d)
Affinity Water	155	113
Portsmouth Water	147	109
SES Water	147	106
South East Water	144	107
Southern Water	129	106
Thames Water	146	121
WRSE	**145**	**115**

This is an error. The final plan PCC for Affinity Water's Central Region zones in 2050 is 127 l/person/day, as shown in Affinity's WRMP tables.

Table 10 - WRSE planned PCC reductions by 2050 for the six SE water companies

Thames Water falls far short of achieving the Government target of 110 l/person/day by 2050 and is largely responsible for the overall WRSE failure to meet the target. Much of Thames Water's failure to achieve 110 l/p/day by 2050 occurs in their London zone. This is shown in more detail below and compared with the planned performance of United Utilities' Strategic Zone, covering a comparably large and heavily urbanised region, including Manchester and Liverpool (data from WRMP tables):

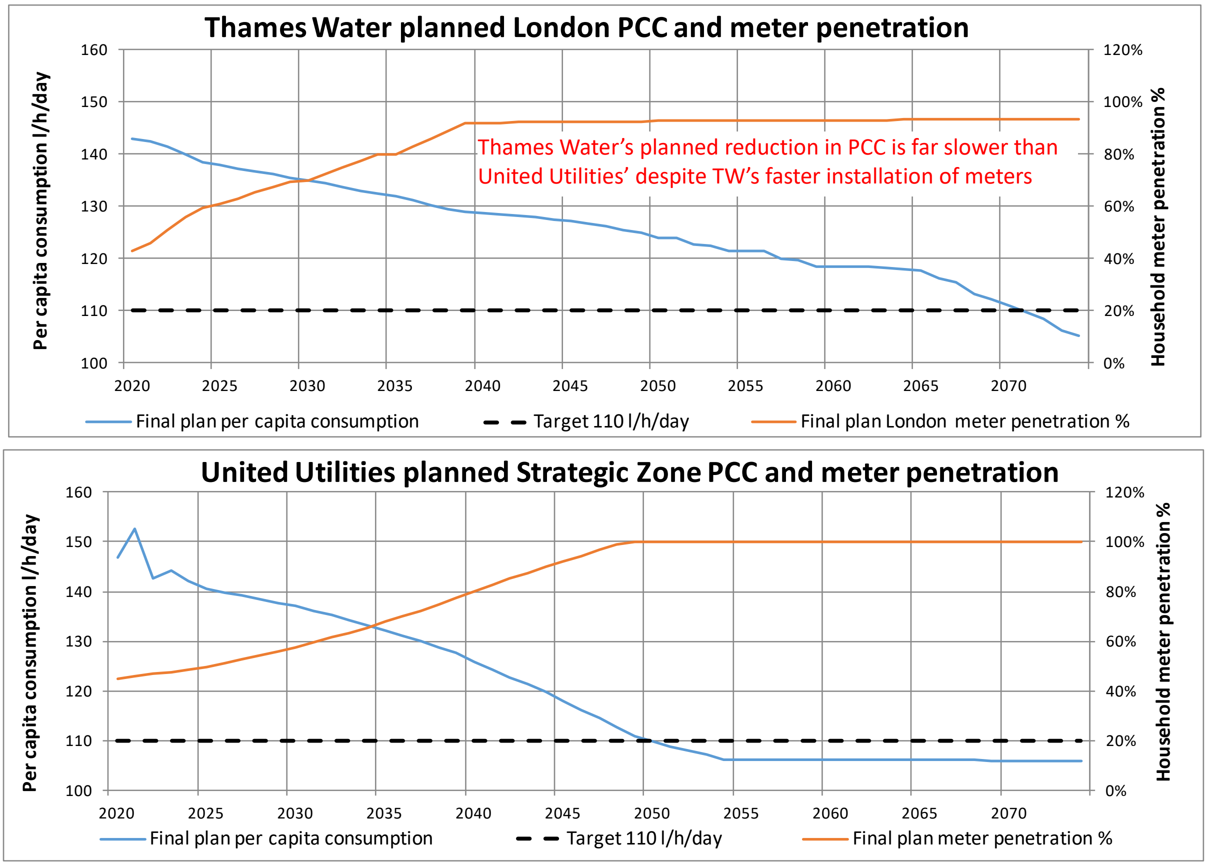


Figure 19 - Comparison of TW and United Utilities planned urban PCC reductions

Figure 19 shows a large disparity in the planned achievement of the 110 l/person/day target despite the similarity of the zones in terms of size and urbanisation. United Utilities plan to meet the target by 2050, whereas Thames Water's London PCC is still at 124 l/person/day in 2050, despite planned meter penetration of 90% by 2040.

Thames Water's planned meter penetration in all zones is shown in Figure 20:

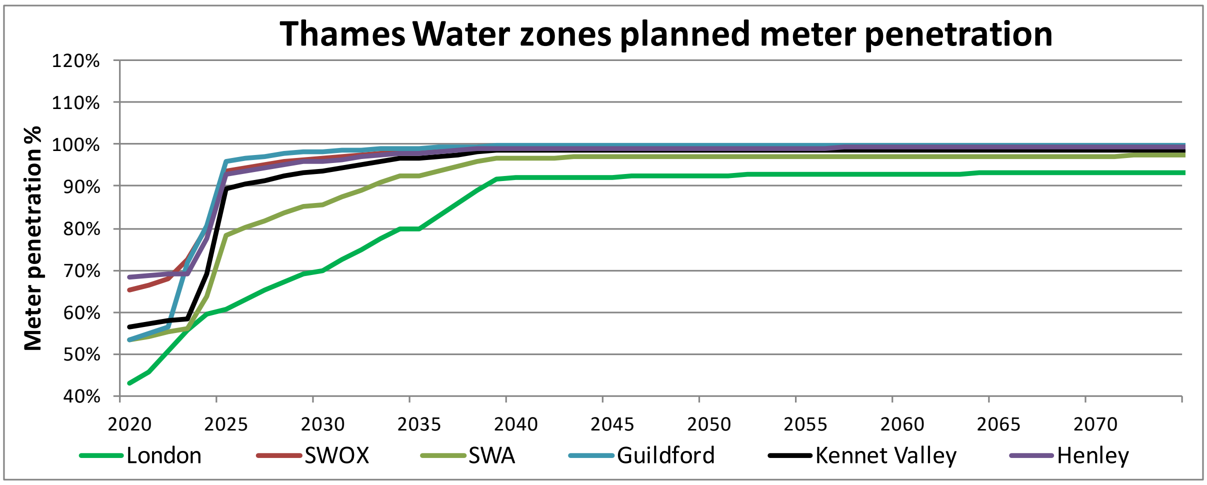


Figure 20 - Thames Water's planned meter penetration in each zone

This shows that Thames Water plan near total meter coverage in all zones by 2040, so the forecast failure to meet the 110 l/p/day target by 2050 seems unduly pessimistic. If TW say the target can be met in every zone by 2075, as shown in Figure 18, why can't this be achieved by 2050?

If Thames Water achieves the 110 l/person/day target in London by 2050, the need for new sources in 2050 is reduced by 134 Ml/d (assuming Thames Water's forecast London zone population of 9.55 million). Outside London in Thames Water's Thames valley zones, achievement of the 110 l/person/day target by 2050 would save a further 26 Ml/d compared with Thames Water's plan.

In GARD's response to Affinity Water's draft WRMP[38], we have shown that, if the Central Region PCC is reduced to 124 l/h/d by 2040 and 110 l/h/d by 2050, the Central Region demand savings would be 48 Ml/d by 2040 and 74 Ml/d by 2050 (assuming Affinity Water's population forecasts).

Thus if both Thames Water and Affinity Water meet the Government's target for reducing PCC to 110 l/person/day by 2050, the need for new supplies in areas potentially supplied from Abingdon reservoir would be reduced by a total of:

• Thames Water, London zone		134 Ml/d
• Thames Water, zones outside London		26 Ml/d
• Affinity Water, Central Region		74 Ml/d
	Total	234 Ml/d

[38] GARD response to Affinity Water draft WRMP24, Section 3.2

3.3 Proposed leakage reduction

The planned leakage reductions from AMP8 onwards (post-2025) in Thames Water's supply zones are shown below:

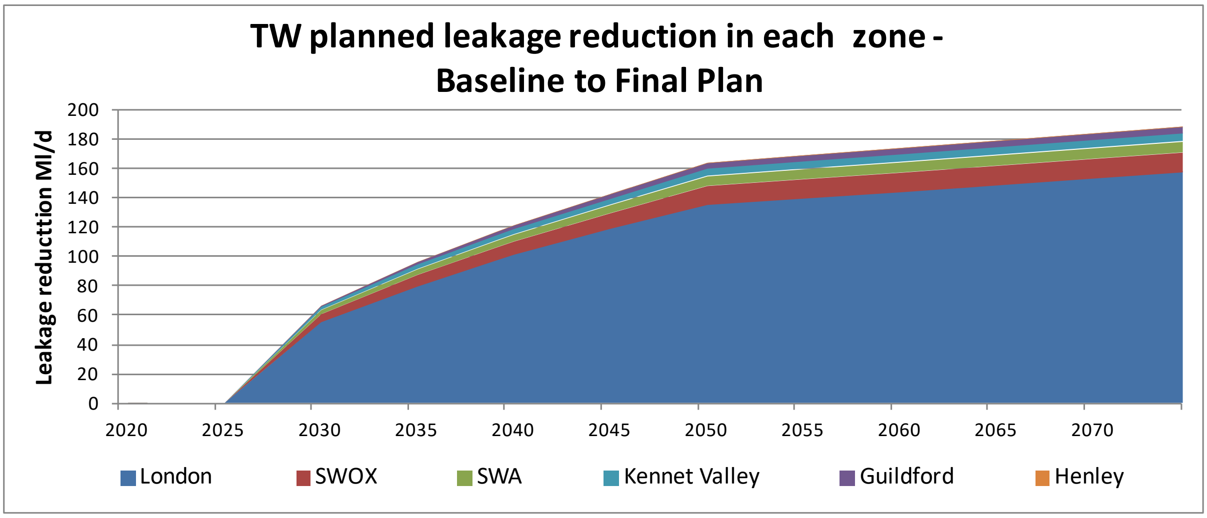


Figure 21 - Planned leakage reduction in Thames Water's supply zones post-2025

Ofwat have defined the Government's 50% leakage reduction target as follows[39]:

> *"Companies committed to the 50% reduction from 2017-18 levels in a letter from Water UK to the Secretary of State on 17/10/2018. The reduction was a recommendation from the National Infrastructure commission, 'Preparing for a drier future: England's water infrastructure needs', April 2018, p.13."*

Although Thames Water plan overall to meet the Government's target of 50% leakage reduction by 2050, there is a wide disparity in the % reductions in zones:

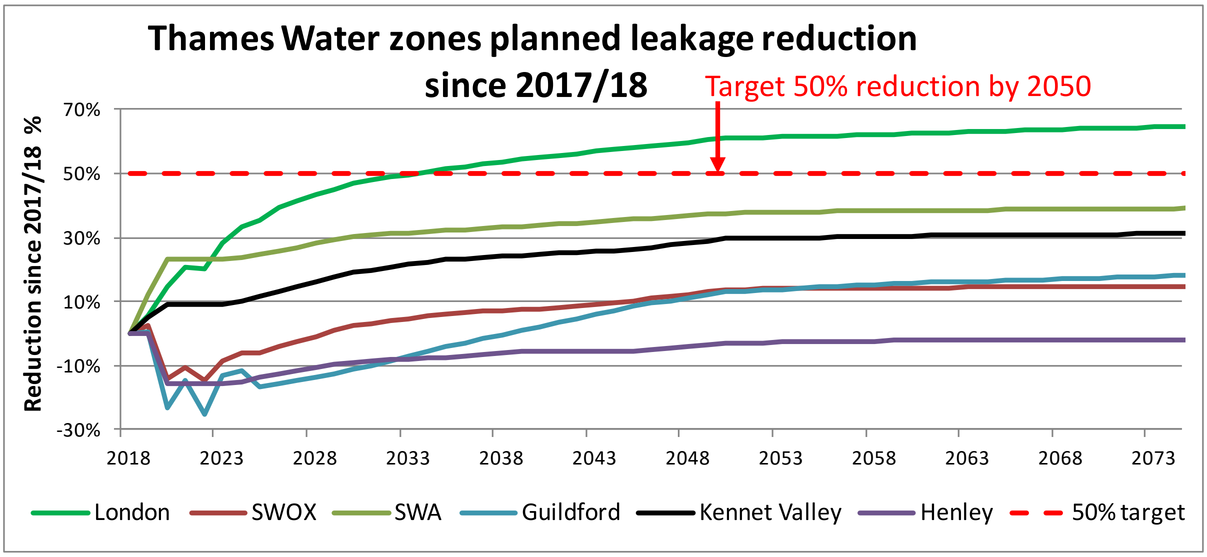
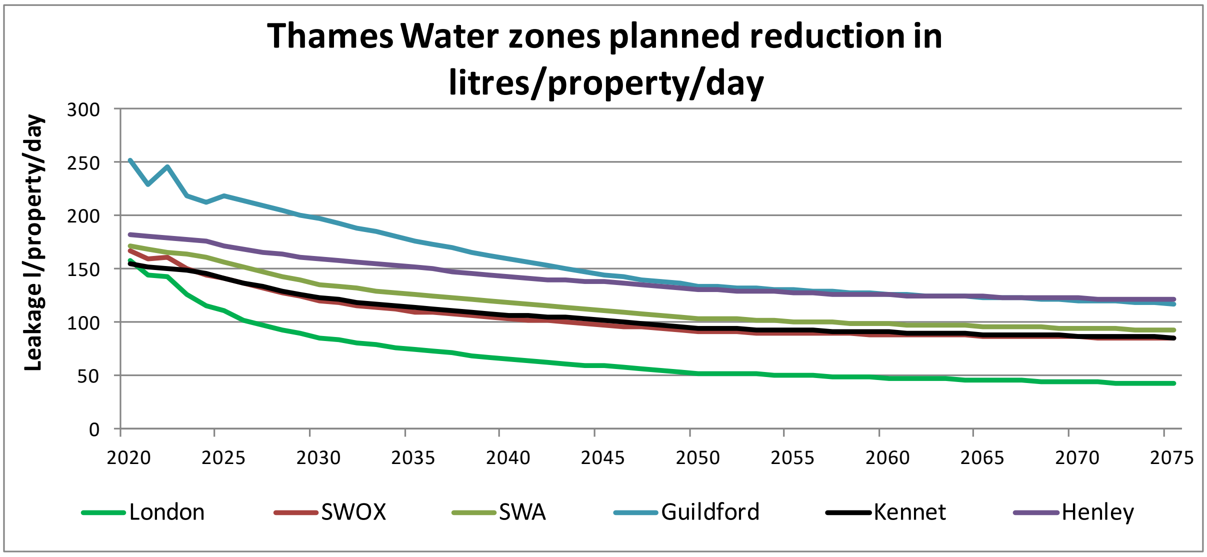


Figure 22 - Compliance with 50% leakage reduction target by zone

[39] https://www.ofwat.gov.uk/households/supply-and-standards/leakage/

Most of the planned leakage reductions are in London, where the planned gross leakage reduction is from 566 Ml/d in 2017-18 to 225 Ml/d in 2050, a reduction of 60% and well ahead of the Government's 50% reduction target. GARD welcomes this and notes that the planned leakage of 53 l/property/day in 2050 is slightly less than United Utilities' planned 56 l/property/day in their similarly urban Strategic Zone.

However, Thames Water's planned leakage reductions in the zones outside London are all well short of the 50% target. Although some zones would get closer to the 50% reduction target if the base date is moved forward to 2020, the planned leakages in 2050 are still in the range 90 to 135 l/property/day and far higher than the typical 40 l/property/day elsewhere in the South East[40] as shown in Figure 23:



Company	Total Leakage (% reduction)	2017/18 Leakage (l/property/d)	2050 leakage (l/property/d)
Affinity Water	53%	121	42
Portsmouth Water	50%	101	39
SES Water	56%	89	32
South East Water	51%	103	39
Southern Water	51%	90	36
Thames Water	50%	176	66
WRSE	**51%**	**140**	**52**

Figure 23 - Thames Water leakage per property per day reductions in zones

GARD proposes that leakage in Thames Water's zones outside London should be reduced to 40 litres/property/day by 2050 to be in line with the leakages planned in all other regions outside London. This would give a total saving of 74 Ml/d in SWOX and the other Thames valley zones compared to Thames Water's plan.

[40] WRSE Technical Annex 2, Table 5.1

3.4 Demands on London supplies from Thames to Affinity transfer

3.4.1 Affinity Water's need for the Thames to Affinity transfer

In GARD's response to the consultation on Affinity Water's draft WRMP, we show that Affinity Water's ultimate need for new resources is over-estimated by about 200 Ml/d. In our proposed revision to the baseline deficit, the changes relative to Affinity Water's baseline deficit are:

- Population growth is as per ONS forecast growth plus 20%[41]
- Environmental reductions exclude about 80 Ml/d of lower Colne reductions and bring all others forward for completion by 2035[42]

GARD proposes that 50 Ml/d of the Thames to Affinity transfer should be brought forward to the early 2030s, connecting Affinity Water to Thames Water's London supply system. Combined with early implementation of 'Connect 2050' (re-naming it 'Connect 2030'), the Thames to Affinity transfer and the Grand Union Canal transfer would together allow all the planned upper Colne and Lea chalk stream reductions to be in place by the early 2030s.

On this basis, we showed in our response to Affinity Water's WRMP that all their needs to 2075 could be met by a 50 Ml/d Thames to Affinity transfer combined with the GUC transfer and metering to achieve the Government's 110 l/p/day PCC target[43].

If flow recovery is realistically allowed for, the Thames to Affinity transfer doesn't need to wait for either Abingdon reservoir or the Severn to Thames transfer.

3.4.2 Flow recovery from abstraction reductions

The amount and timing of chalk stream flow recovery from Affinity Water's abstraction reductions is crucial to avoid excessive cost and long delays in flow re-naturalisation. If the amount of recovery is high and a good proportion of extra water from the chalk catchments is available to refill the Thames Water's existing reservoirs in droughts, there will be comparatively little additional water resource development needed. This would allow flows in the Chilterns chalk streams to be re-naturalised within a few years and at relatively low cost.

Affinity Water's plan assumes that only 17% of the flow recovery from abstraction reductions converts to increased deployable output from the London reservoirs[44].Consequently, the plan delays most of the environmental abstraction reductions until after 2040, because of the supposed need to wait for replacement supplies from Abingdon reservoir, which cannot deliver water to Affinity Water's supply zones until after2040.

[41] GARD response to Affinity Water WRMP, page 11 https://www.gard-oxon.org.uk/campaign%202023/GARD%20response%20to%20Affinity%20WRMP%2020%202%202023.pdf
[42] GARD response to Affinity Water WRMP, page 26
[43] GARD response to Affinity Water WRMP, Section 3.4 and Figure 18, page 25
[44] Affinity WRMP24, Annex 5.6, page 13

The Chalk Streams First report "Dealing with impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys"[45] examined in detail the evidence of measured flow recovery from abstraction reductions and the results of groundwater modelling. From reviews of measured flow recoveries, the conclusions were (with reference to the relevant pages in the CSF report):

1. Given sufficient time for flows to recover after genuine and maintained total abstraction reductions in a catchment, the measured flow gains will average about 80% of the abstraction reduction. The recovery will vary substantially across the range of flows, perhaps from less than 30% recovery in droughts to well over 100% recovery at times of high groundwater levels and flows (page 45).

2. This pattern of measured flow recovery is seen consistently in examples in several rivers:

   - The Friars Wash reduction in the River Ver in 1993 (pages 33 to 36)
   - Comparative flow and abstraction changes in the Rivers Chess and Ver (pages 37 to 39)
   - Comparative flow and abstraction changes in the Rivers Beane and Rib (pages 39 to 41)

3. There are no instances of flow recoveries failing to materialise when they might reasonably be expected after genuine and maintained abstraction reductions – several examples of supposed "disappointing" flow recoveries can be explained by the reductions being too small or insufficiently maintained:

   - The Bow Bridge reduction on the River Ver (pages 36 to 37)
   - The Fulling Mill reduction on the River Mimram (pages 42 to 43)

4. Short term signal tests are not a reliable way of assessing flow gains from abstraction reductions in these rivers:

   - Signal tests at Kensworth Lynch on the River Ver (pages 108 to 109)
   - Signal tests at Chesham on the River Chess (pages 197 to 201)

The CSF report reviewed modelled flow recoveries shown by the Environment Agency's Herts Regional Groundwater Model and its own lumped parameter models. These models all validate reasonably well when comparing modelled and measured historic groundwater levels and river flows (details in Appendices A to D in CSF report). As described in Chapter 4 of the CSF report, pages 46 to 52), both models show very similar patterns and amounts of flow recovery from abstraction reductions:

1. The patterns and amounts of modelled flow recoveries are similar to the measured flow recoveries described above.

[45] Dealing with the impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys, Chalk Streams First, January 2023 https://chalkstreams.org/flow-recovery-following-abstraction-reduction/

2. At average river flows, modelled river flow recoveries are in the region of 80% of the abstraction reductions. At extreme low flows, modelled flow recoveries are typically around 30-40% of abstraction reductions.

3. These conclusions are equally true in all four case study rivers (Chess, Ver, Mimram and Beane).

The modelled and measured flow recoveries are similar. They are far more than the 17% flow recovery assumed in Affinity Water's WRMP and in the draft regional plan of Water Resources in the South East.

Similar conclusions were reached in the RevIvel report on over-abstraction in the River Ivel[46]. If present abstraction of about 13 Ml/d abstraction was to stop, the modelling showed that flows in the River Ouse would rise by about 11 Ml/d on average (85% recovery) and about 6 Ml/d (45% recovery) in droughts. The increased flows in the River Ouse would boost inflows to Grafham reservoir, which could then provide replacement supplies to the areas currently fed from the River Ivel.

3.4.3 Benefits to London supplies from Affinity Water abstraction reductions

The Chalk Streams First Report, page 60, shows modelled flow recoveries from the total 151 Ml/d of CSF proposed abstraction reductions in the upper Colne and Lea chalk streams. The modelled daily Colne and Lea flow recoveries since 1920 have been added to the Teddington and Feildes Weir flow records to assess the increase in London deployable output, using the GARD model of the London supply system. Details of GARD's London supply model are given in Appendix F to the CSF report. In the 100-year period 1920-2019, with the enhanced reservoir inflows, the critical drought which governs London deployable output is July 1933 to November 1934 as shown in Figure 24:

[46] Alleviation of over-abstraction of chalk groundwater in the Upper River Ivel, page 41
https://www.revivel.org/app/uploads/2022/07/Ivel-report-21.6.21-BHs-redacted.pdf

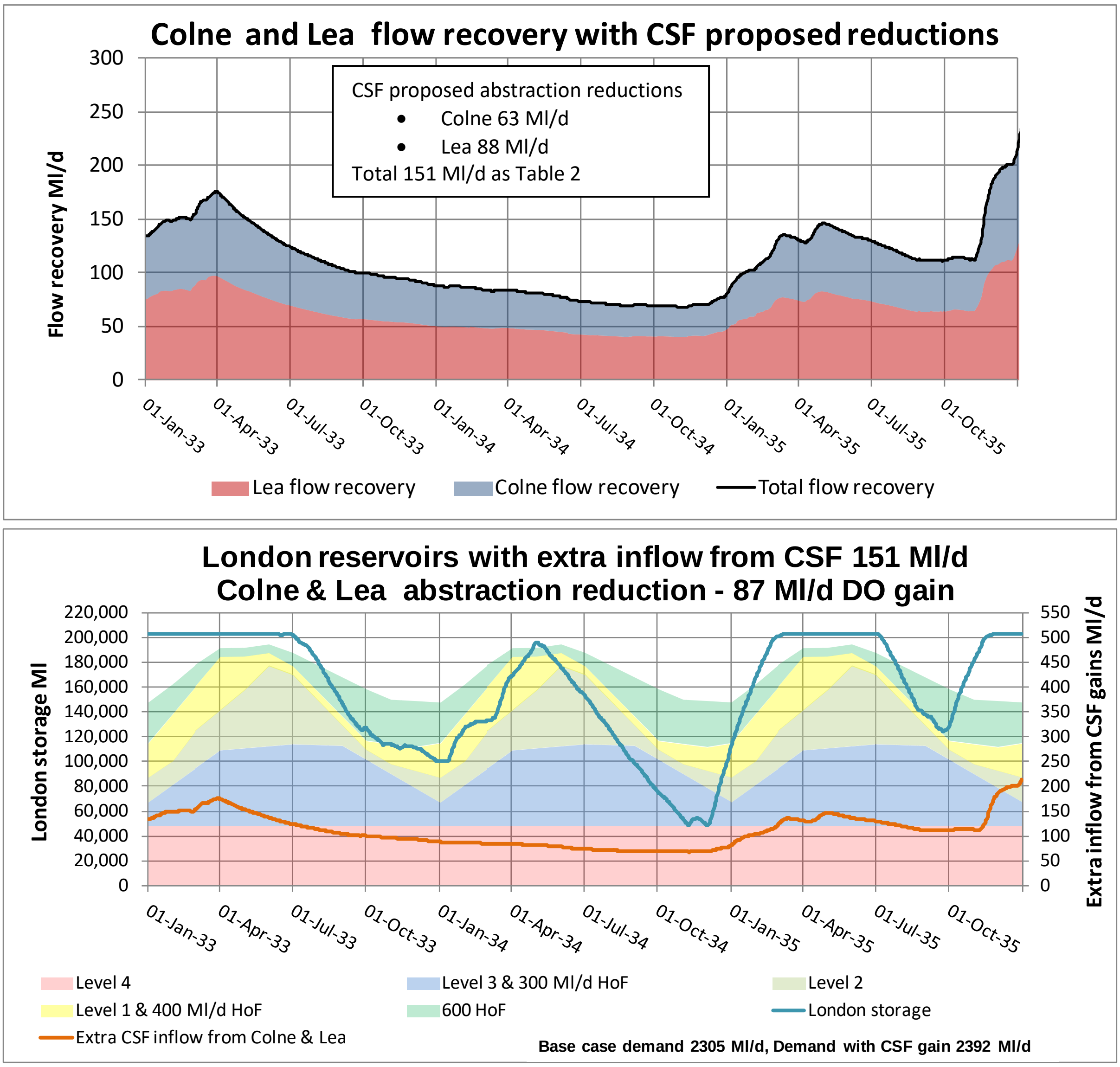


Figure 24 - Modelling of London DO gain from CSF proposed reductions in 1933-34

The modelled flow recovery in the 18-month drought starts at over 80% of the 151 Ml/d abstraction reduction at the start of the drawdown of the London reservoirs in July 1933. The modelled flow recovery percentage drops to around 40% when London storage starts to recover in November 1933. The modelled 87 Ml/d gain in deployable output is 58% of the 151 Ml/d abstraction reduction – a far higher gain than the 17% assumed in current draft water company WRMPs.

A similar analysis was carried out for the RevIvel report on alleviating Affinity Water's over-abstraction in the River Ivel, concluding that for Grafham reservoir there would be average 64% recovery of the abstraction reduction over the duration of the critical drought, which is also 1933/34[47].

It is concluded that when considering the amount of replacement sources needed for

[47] RevIvel report on Ivel over-abstraction, pages 55-57

Affinity Water's planned abstraction reductions in the upper Colne, Lea and Ouse chalk streams, the assumed deployable output recovery in the London reservoirs and in Grafham reservoir should be around 60% and not the 17% assumed in Affinity Water's plan.

GARD recognises that there is uncertainty in the amount of deployable output recovery for London from the enhanced chalk stream flows arising from the Colne and Lea abstraction reductions. An insurance against deployable output recovery being less than expected should be provided by introduction of WBGWS-type drought support schemes in the upper Colne and Lea chalk streams. This is considered further in Section 7.2.

3.5 The need for the Thames to Southern transfer

3.5.1 Planned use of the Thames to Southern transfer

Southern Water's expected use of the Thames to Southern transfer is shown below[48]:

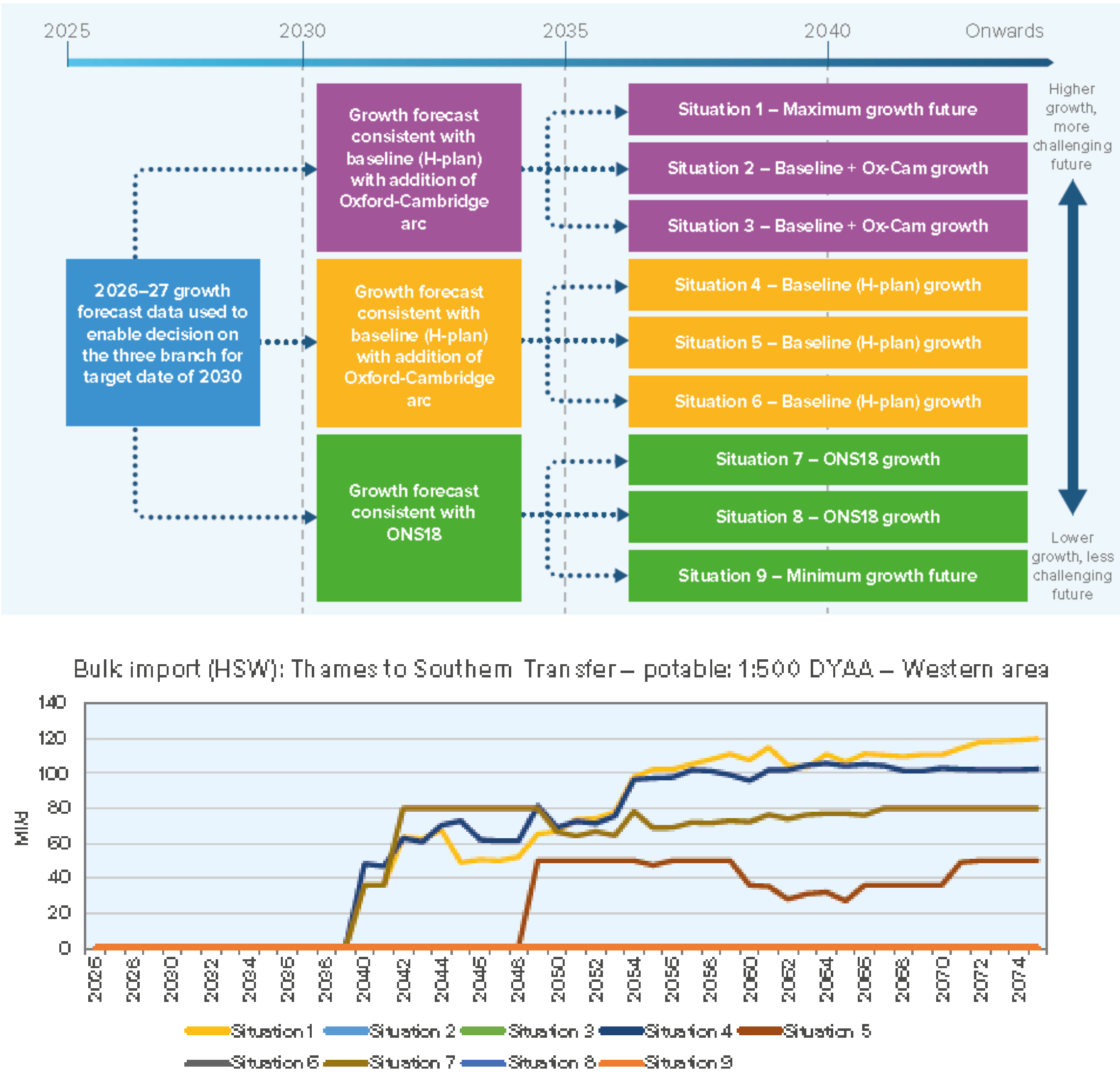
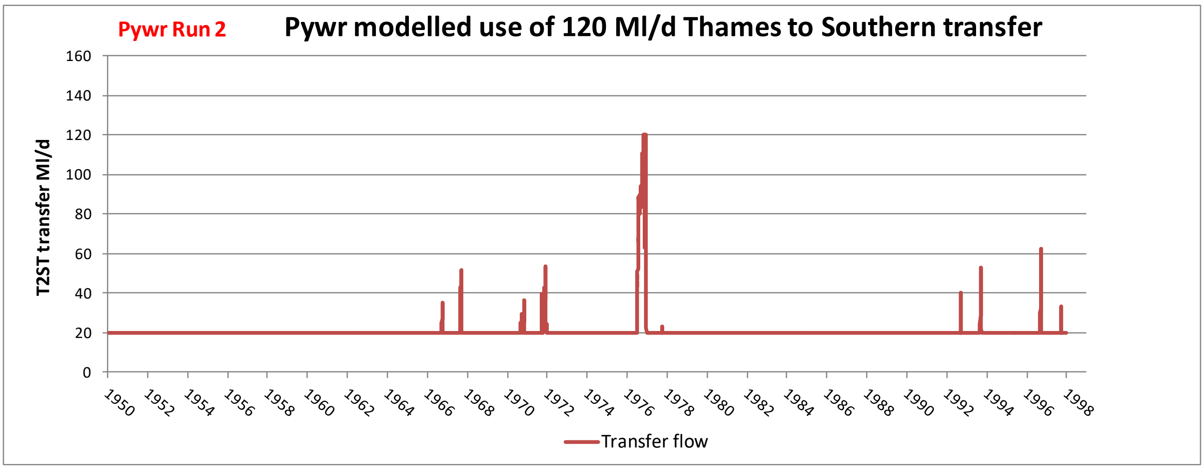


Figure 25 - Southern Water's expected use of the T2ST under different scenarios

48 Copied from Southern Water main WRMP report, Figures 5.22 and 7.11

An example of Thames Water's modelled frequency of use of the Thames to Southern transfer is shown in Figure 26 for a typical 48-year run of stochastic data and a typical worst drought within the 48 year run[49]:



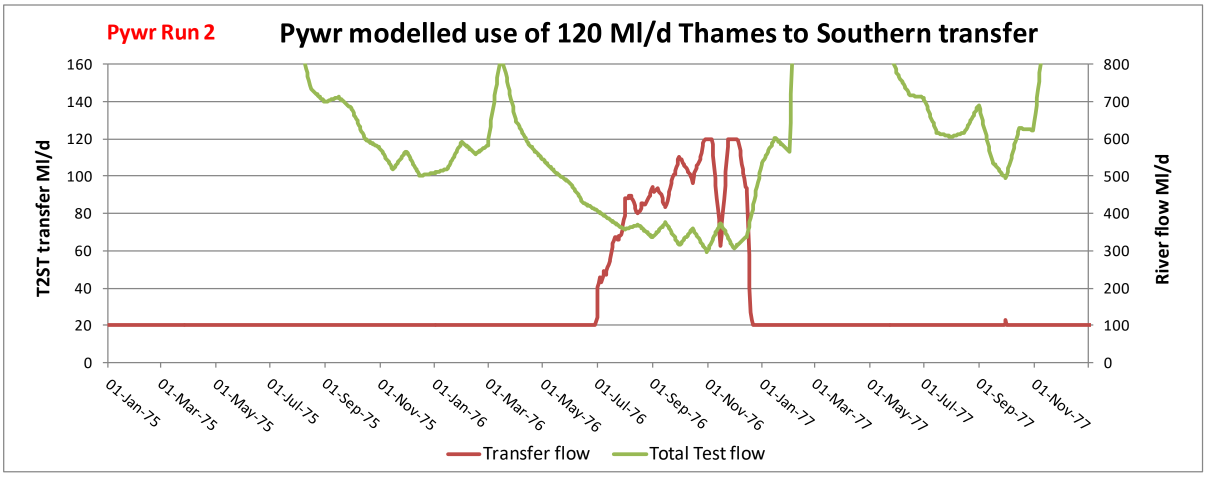


Figure 26 - Typical operational use of the 120 Ml/d Thames to Southern transfer

In major drought years, like 1976 in the example shown in the lower plot in Figure 26, the transfer could run for 6 months or more, triggered to comply with a total Test hands-off flow of 355 Ml/d, and peaking at the 120 Ml/d capacity for short periods. However, although the Pywr modelling shows drought use about once in 5 years on average, usually this will be for a relatively short period and at much less than the 120 Ml/d capacity.

At most times in most years, the transfer would run at a constant flow of 20 Ml/d. This seems too large an amount for a "sweetening flow", so it is assumed that the 20 Ml/d transfer would be for normal supply, probably to replace supplies lost through Southern Water's planned abstraction reductions in the Itchen valley.

[49] Pywr modelled output is from data supplied by Thames Water under EIR-22-23-390 and plotted total Test flow is the sum of stochastic data supplied by Southern Water for Testwood, Conager Bridge and Test Back Carrier

3.5.2 The need for the transfer to enable abstraction reductions

WRSE's data in file *'GARD-09 Additional Source Level Environmental Ambition Data.xlsx'* shows about 59 Ml/d of reduction in Southern Water's Test and Itchen abstractions – 43 Ml/d from the Itchen and 16 Ml/d from the Test, as shown in Table 11:

	All in Ml/d	WRSE High Scenario					WRSE	WRSE
Source	Catchment	2029-30	2034-35	2039-40	2049-50	2074-75	Medium	Low
Andover	Upper and Middle Test		4.0	8.0	8.0	8.0	7.2	8.0
near Whitchurch	Upper and Middle Test		1.4	1.4	1.4	1.4	1.4	1.4
Overton	Upper and Middle Test		0.0	1.0	1.5	1.5	0.0	0.0
Whitchurch	Upper and Middle Test		0.0	1.1	1.6	1.6	0.0	0.0
Romsey	Lower Test and S'ton Streams		3.5	3.5	3.5	3.5	3.5	3.5
Itchen GW, SW and Twyford	Itchen		0.0	13.7	20.5	20.5	0.0	0.0
Test Surface Water	Lower Test and S'ton Streams		0.0	0.0	0.0	0.0	0.0	0.0
Alresford	Itchen		1.8	4.5	4.5	4.5	4.5	1.8
Winchester	Itchen		4.9	12.1	18.2	18.2	8.3	4.9
All	**Total DO loss**	**0.0**	**15.5**	**45.2**	**59.2**	**59.2**	**24.8**	**19.5**

Table 11 – Southern Water's planned Test and Itchen abstraction reductions

The justification for the Itchen reductions is shown in Southern Water's main WRMP report as below:

Table 3.4: Other Environmental Investigations and Drivers reflected in our Ambition

WRZ	Source(s)	Regulatory Drivers	Comments
HWZ	Alresford Winchester	Habitats Directive and SSSI investigations including assessment of CSMG flow standards	Emerging outcome of our studies of the Candover Stream is that our Alresford source will need to stop operation and we currently assume this will occur in 2030 with interim mitigation and river enhancement. Implications for our Winchester source are presently uncertain but are primarily thought to relate to Habitats Directive and SSSI investigations rather than the CSMG flow standards which are potentially compliant on the affected reach.

Table 12 - Southern Water justification of Itchen abstraction reductions

Southern Water comments suggest that the abstraction reductions are not needed for compliance with river flow standards (EFIs). The CaBA analysis of abstraction as a % of recharge for the Test and Itchen catchments also shows no need for abstraction reductions in the Test and Itchen as in Table 13:

	Test catchment					Itchen catchment		
	Anton	**Bourne Rivulet**	**Upper Test to Chilbolton**	**Test to Anton confluence**	**Test to Timsbury**	**Candover Brook**	**Upper Itchen to Winchester**	**Itchen to Chandlers Ford**
Catchment area	185 km2	131 km2	453 km2	638 km2	978 km2	72 km2	280 km2	360 km2
Baseflow index	0.96		0.97		0.95			
Av. annual recharge	190.0 Ml/d	134.5 Ml/d	465.3 Ml/d	655.3 Ml/d	1004.5 Ml/d	73.7 Ml/d	469.8 Ml/d	604.1 Ml/d
Abstraction in 2017-19	12.9 Ml/d	0.9 Ml/d	5.9 Ml/d	18.8 Ml/d	24.8 Ml/d	2.8 Ml/d	13.8 Ml/d	41.6 Ml/d
A%R in 2017-19	6.8%	0.7%	1.3%	2.9%	2.5%	3.8%	2.9%	6.9%
Reduction to achieve A10%R	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**
GW consumptive licence total	0.0 Ml/d	5.7 Ml/d	27.9 Ml/d	33.6 Ml/d	61.5 Ml/d	4.5 Ml/d	18.2 Ml/d	55.7 Ml/d
Licence A%R	0.0%	4.2%	6.0%	5.1%	6.1%	6.2%	3.9%	9.2%
Licence reduction for A10%R	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**	**0.0 Ml/d**

Table 13 - Analysis of abstraction as a % of recharge for Test and Itchen catchments

The CaBA chalk stream group's A%R report concluded that no groundwater abstraction reductions were needed in the Itchen and Test catchments[50]. In the Itchen catchment, recent abstraction is only 2.9% of the average upper catchment recharge down to Winchester and 6.9% of the recharge of the catchment down to Chandlers Ford. In the Test catchment, recent abstraction is only 2.5% of the average catchment recharge. For both rivers, licensed abstraction is less than 10% of average recharge – the CaBA group proposed benchmark for acceptable abstraction. GARD concludes that the 59 Ml/d of deployable output loss planned for Test and Itchen groundwater sources is un-necessary and should be dropped, or at the very least, be given a low priority.

3.5.3 Need for Test and Itchen drought permits and orders

In addition to the 59 Ml/d of Test and Itchen abstraction reductions shown above, Southern Water's plans include the abolition of Test and Itchen drought orders and permits which are described in their drought plan as below[51]:

[50] A%R, Abstraction as a % of recharge in chalk streams, Figure 2, pages 52 and 63, December 2021 https://chalkstreams.org/ar-abstraction-as-a-of-recharge-in-chalk-streams/

[51] Southern Water draft Drought Plan, Table 4.11, page 143 https://www.southernwater.co.uk/media/4798/draft-drought-plan-2022.pdf

Type of action	WRZ	Summary of action	Likely benefit / saving	Risks, constraints and requirements[3]	Environmental impacts category[4]
Drought permit River Test (surface water source Drought Permit)[1]	HSE and HSW	Relax the Test Total Flow condition in the abstraction licence from 355Ml/d to 265Ml/d	80M/d max yield	Work closely with the EA when applying for, during the course of and after the end of a drought permit. EA determine the outcome of whether the drought permit is granted. Advertise drought permit and discuss with any impacted organisations. Equates to daily licence volume available if hands off flow is reduced	Up to Moderate
Drought order Candover Augmentation Scheme (groundwater source)[1]	HSE	Drought order to operate the Candover river augmentation scheme boreholes. To allow up to 27Ml/d and 3750Ml/year (20.8Ml/d over 6 months). This would enable additional DO at our River Itchen Works	14.37M/d in 1:200 drought at MDO	Work closely with Defra when applying for, during the course of and after the end of a drought order. Defra determine the outcome of whether the drought order is granted. Advertise drought order and discuss with any impacted organisations. 1 in 200 MDO benefit shown based on WRMP19 assessment, varies with drought severity	Up to Minor
Drought order Lower Itchen (SWS and PRT) (groundwater and surface water sources)[1]	HSE	SWS may need to apply for a drought order to reduce the flow condition controlling PRT's abstraction licence from 194Ml/d to 150Ml/d and reduce the flow condition in the River Itchen at Allbrook and Highbridge from 198Ml/d to 160Ml/d controlling SWS's Lower Itchen surface and groundwater sources.	38.0M/d from SWS's Lower Itchen sources	Work closely with Defra when applying for, during the course of and after the end of a drought order. Defra determine the outcome of whether the drought order is granted. Advertise drought order and discuss with any impacted organisations. Equivalent to reduction in hands off flow from 198 to 160Ml/d	Up to Moderate

Table 14 - Southern Water's current plans for Test and Itchen drought orders and permits

The primary need for the proposed 120 Ml/d Thames to Southern transfer is to eliminate the needs for these drought orders and permits, as explained by Southern Water in the summary of their WRMP, pages 24 and 27:

> *"However, we rely on drought orders and drought permits that allow us to continue abstracting water during dry weather. Our aim is to reduce our reliance on these measures and stop using them by 2040 at the latest. To do this, we need to find 120 million litres of extra water per day [page 24].*
>
> *Additionally, we are investigating a strategic pipeline which could transfer up to 120 million litres per day from Thames Water. This depends on new sources being developed in Thames Water's area, all of which are being considered through the SRO process. One of the new sources in Thames Water's area is the South East Strategic Reservoir, or SESRO. We've based our best value plan on WRSE's regional plan which includes an option for SESRO at 100Mm3, which would enable the strategic transfer into Hampshire. If the size and timing of SESRO changed it would impact our wider plans. For example, a larger reservoir could mean we need a smaller water recycling plant supplementing Havant Thicket reservoir. However, if SESRO was smaller or delayed, we may need to invest in alternative sources such as desalination or water recycling elsewhere in Hampshire [page 27]."*

In other words, up to 2/3rds of the Abingdon reservoir deployable output will be used via the Thames to Southern transfer to reduce drought impacts on Test and Itchen flows and salmon, perhaps substantially needed only once in 50 years (for example see Figure 26) and to enable the 59 Ml/d of abstraction reductions in the Test and Itchen catchments which the CaBA A%R analysis shows are unnecessary (see Table 13 and accompanying text).

The capital cost of the Thames to Southern transfer is £1.25 billion with total Opex costs of £1.1 billion, as quoted in Southern Water's draft WRMP[52]:

Thames to Southern transfer

Metric	
Capex [£m]	1,247
Financing Cost [£m]	2,071
Opex [£m]	1,139
Embodied Carbon [tCo2e]	192,811
Average operational carbon emissions [tCo2e/yr]	2,368
Total Carbon Cost [£m]	187
Average Incremental Cost (AIC) [p/m3]	105

Table 15 - Costs of Thames to Southern Transfer

GARD recognises the importance of the Habitats Directive protected chalk streams and their salmon, but there must surely be an issue of disproportionate costs and environmental impacts, if precious Thames valley water is to be exported to Southern Water via Abingdon reservoir or the Severn to Thames transfer. WRSE's options appraisal summary report states the following[53]:

> *"The Water Resource Planning Guideline recognises that in the short term companies may need to increase use of drought management options to achieve a 1:500 year level of resilience, but in the medium and longer term the guidance is that companies should, where appropriate, use drought permits and orders less frequently, particularly in sensitive areas. Water companies have engaged with the Environment Agency around those supply side drought options to include as options to achieve the 1:500 level of resilience."*

In other words, abandonment of drought permits is discretionary, not compulsory. The same point was made by Ofwat and referred to in WRSE's response to their emerging regional plan in Spring 2022[54]:

> *"Ofwat noted the commitment to not use drought orders or permits as options after 2040, except for events in excess of the 1 in 500 year return period. It considered that*

[52] Southern Water dWRMP Annex 13 https://www.southernwater.co.uk/our-story/water-resources-management-plan/draft-wrmp-24-technical-documents:
[53] https://www.wrse.org.uk/media/2xzjw425/wrse-options-appraisal-summary-report-with-appendices.pdf : page 18
[54] WRSE response to Consultation on Emerging Regional Plan, May 2022, paragraph 13.4, page 40

WRSE should explore the cost, benefit and option selection impact of retaining the use of some drought orders and permits beyond 2040. It stated this was important to avoid unnecessary costs from resource development and to avoid the associated environmental impact that the additional development likely to arise from ruling out the use of drought orders and permits could bring."

In response to this, WRSE said *"WRSE will look to provide additional information on the decision making around the drought options for the draft regional plan.*[55]" No such information was provided in WRSE's latest regional plan, which showed that the benefit of Test and Itchen compliance with the Water Framework Directive has been assessed as only £29 million[56], far short of the £2 billion cost of the Thames to Southern transfer.

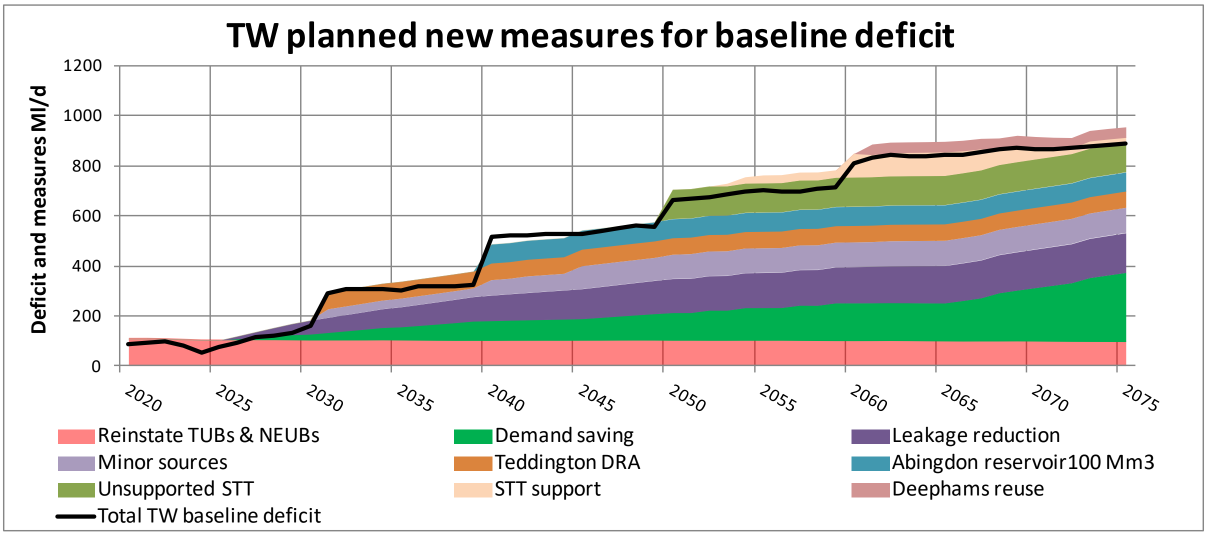
Therefore, GARD concludes that the Test and Itchen drought permits should be maintained and there should be no planned 120 Ml/d reduction of Southern Water's deployable output in 2040.

In GARD's opinion, the Thames to Southern transfer will never be needed. The 59 Ml/d of Itchen and Test abstraction reductions are unnecessary. The proposed abandonment of Test and Itchen drought permits would bring minimal and rare benefits. ***The T2ST scheme should be abandoned at Gate 2 due to its minimal benefit and disproportionately high cost.***

3.6 Need for strategic options

3.6.1 Need for strategic options for the London zone

Thames Water's plan for dealing with the London baseline deficit is shown in Figure 27:



Note: 1. Amounts and timing of sources taken from 'Options benefits' tab for 'preferred' scenario in WRMP tables
2. Small mismatch between deficit and total sources, because no allowance for minor changes to imports/exports

Figure 27 - TW planned measures for dealing with the London baseline deficit

[55] WRSE response to Consultation on Emerging Regional Plan, May 2022 paragraph 3.13, page 41
[56] WRSE regional plan, Technical Annex 2, Table 12.1

In Section 2.6.1 and Figure 16, we showed that Thames Water have over-forecast the London baseline deficit by about 140 Ml/d in 2040 and 430 Ml/d in 2075. The over-forecast primarily arises from over-estimation of population growth, unnecessarily conservative allowance for climate change and, especially, grossly excessive and unjustifiable allowances for abstraction reductions for “environmental improvements”.

In Section 3.2, we show that if Thames Water meets the Government’s PCC target of 110 l/p/day by 2050, the need for strategic resource options for London is reduced by a further 134 Ml/d.

In Section 3.4, we show that Affinity Water’s needs, including re-naturalisation of flows in the upper Colne and Lea chalk streams, can be met with a 50 Ml/d transfer via the Thames to Affinity strategic resource option, with a direct connection into the London raw water supply system.

Taking account of these factors on London’s supply demand balance, GARD’s proposal for closing the balance and new sources is shown in Figure 28:

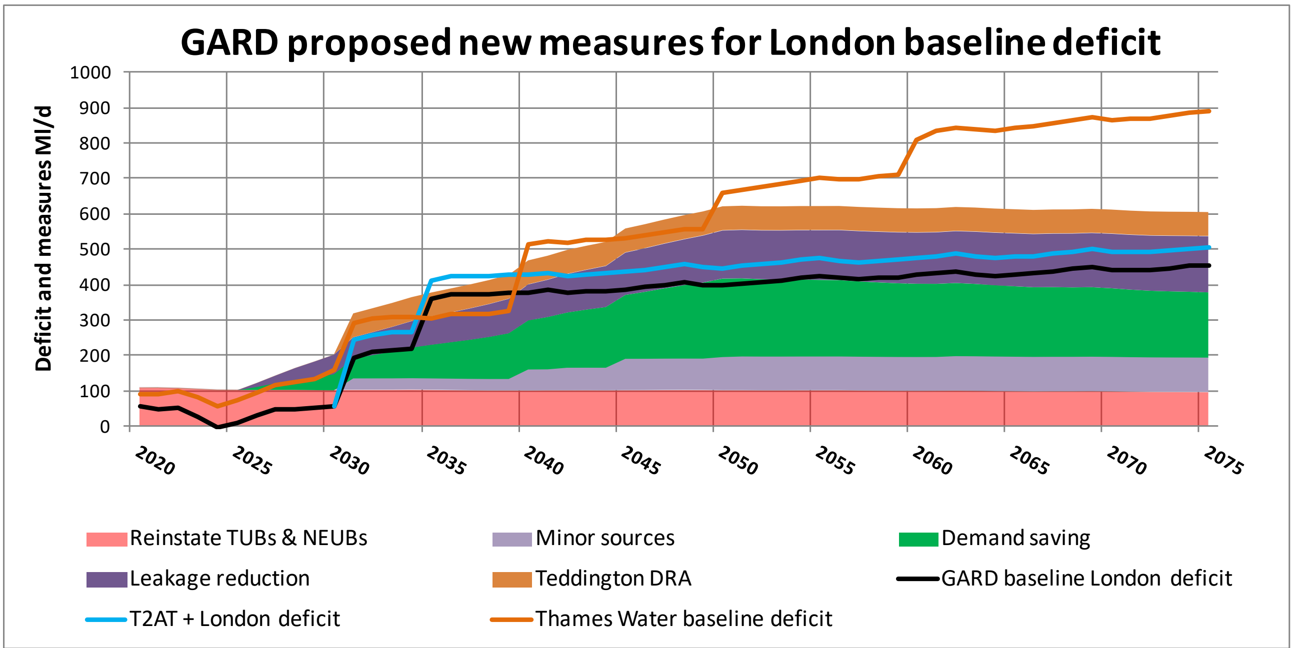


Figure 28 - GARD proposed measures for the London baseline deficit

The basis of the reassessment of London needs shown in Figure 28, including meeting Affinity Water’s needs via the Thames to Affinity transfer, is as follows:

- GARD baseline London deficit as Section 2.6.1 and Figure 15
- 1:500 year resilience brought forward to 2035

- 50 Ml/d transfer to Affinity by direct connection to a London reservoir and brought forward to 2031 for early chalk stream relief, as Section 3.4.1,
- Reinstatement of TUBs and NEUBs as per TW Final Plan
- Leakage reductions as per TW's final plan
- PCC reduced to 110 l/p/day by 2050, as per Government target, then remaining at 110 l/p/day until 2075 (the demand saving reduces after 2050 because TW assumed that the baseline PCC would continue to fall after 2050)
- Teddington DRA scheme by 2031 as per TW preferred plan
- Minor sources include various GW sources and Didcot licence reallocation as per preferred plan

Figure 28 shows that neither Abingdon reservoir nor the Severn to Thames transfer is required to meet the needs of London and Affinity Water, even bringing forward the 1:500 year resilience to 2035, apart from a small deficit between 2035 and 2040. Moreover, it should be noted that in the balance shown in Figure 28, no allowance has been made for additional recovery of deployable output from enhanced chalk stream flows, as discussed in Section 3.4.2. Nor has there been any allowance for the London recovery of deployable output from the 35 Ml/d loss of deployable output from Farmoor reservoir due to restriction of its refilling (see Section 2.3.3).

Even without either Abingdon reservoir or the Severn to Thames transfer, Figure 28 shows that there would be a surplus of about 150 Ml/d in London's supplies continuously from 2040, if leakage and PCC reduction are on a trajectory to meet the Government targets by 2050. This shows the danger of creating a costly and environmentally damaging white elephant, if a decision to build Abingdon reservoir is made in the current cycle of business planning.

On this basis there is an argument that there should be no *decision* on Abingdon reservoir or the Severn to Thames transfer before 2035. The potential needs of the area by 2050, from realistic population growth, prioritised environmental improvements (abstraction reductions) and reasonably cautious allowance for climate change, can all be met if Thames Water (and Affinity Water) meet the Government's PCC and leakage targets.

However, GARD recognises that there is uncertainty over the amount and timing of the leakage and PCC reductions, mainly arising from the performance of Thames Water in meeting targets in the past. Therefore, it could be prudent to provide extra supply capacity to the London and the Thames valley *as early as possible.* This has the maximum strategic, environmental and drought resilience impact and would give a cushion against accelerating climate change effects. It would also bring forward the date at which 'true' 1 in 500 year drought resilience is can be guaranteed (not done until post-2040 in Thames Water's plan).

On that basis, we propose the following schemes should go ahead, even if not strictly needed under our realistic assessment of reduced future needs:

By early 2030s:

- The Teddington DRA scheme (67 Ml/d), already planned to be due by 2031
- The first phase of the GUC transfer (50 Ml/d), already planned to be due by 2031
- The 50 Ml/d Thames to Affinity transfer to allow early chalk stream relief

By 2035/36:

- 1st phase of Severn-Thames transfer, only 300 or 400 Ml/d aqueduct, with Netheridge and, possibly, Minworth support
- 2nd phase of GUC transfer, or possibly included in the first phase GUC transfer

Thus about 300-400 Ml/d of 'over-provision' would be deployed early to bring forward environmental benefit, including lower priority abstraction reductions, and to provide a large 'hedge' against climate change or population growth being substantially higher than the ONS forecasts. Further considerations in the 2035-2039 AMP could decide on what, if any, additional new supplies would be needed up to 2050. The presence of the Severn to Thames transfer aqueduct from the early 2030s would allow additional support sources to be added relatively quickly, if eventually needed.

3.6.2 Need for additional supplies in the SWOX zones

The Thames Water and GARD assessments of the SWOX baseline deficit are discussed respectively in Sections 2.1.2 and 2.6.2, showing 2075 deficits of 94 Ml/d and 62 Ml/d respectively. Thames Water's plan shows the SWOX deficit being met as shown in Figure 29:

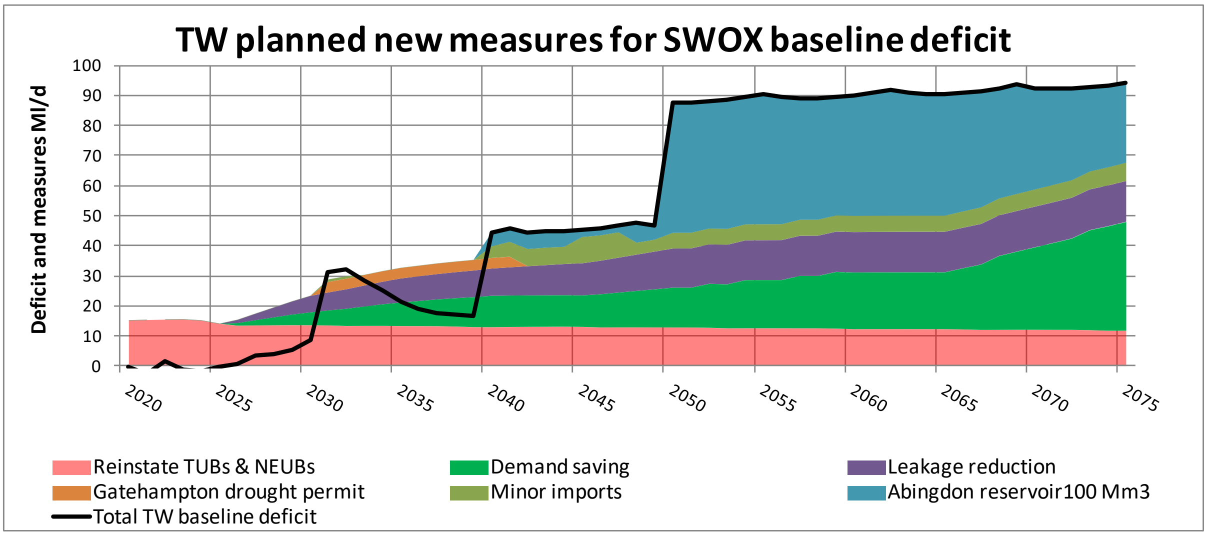


Figure 29 - TW planned measures for the SWOX baseline deficit

Apart from some minor imports from Wessex Water and the SWA/Henley zones and a small drought permit for the Gatehampton source, most of the deficit would be made up by Abingdon reservoir. The need for supply from Abingdon reservoir to supply SWOX is a maximum of about 50 Ml/d in 2050, after which the need falls as PCC continues to fall towards the target of 110 l/p/day.

All of the 62 Ml/d baseline deficit assessed by GARD can be met without any supply from Abingdon reservoir, if the Government's leakage and PCC targets are met in the SWOX zone, as shown in Figure 30:

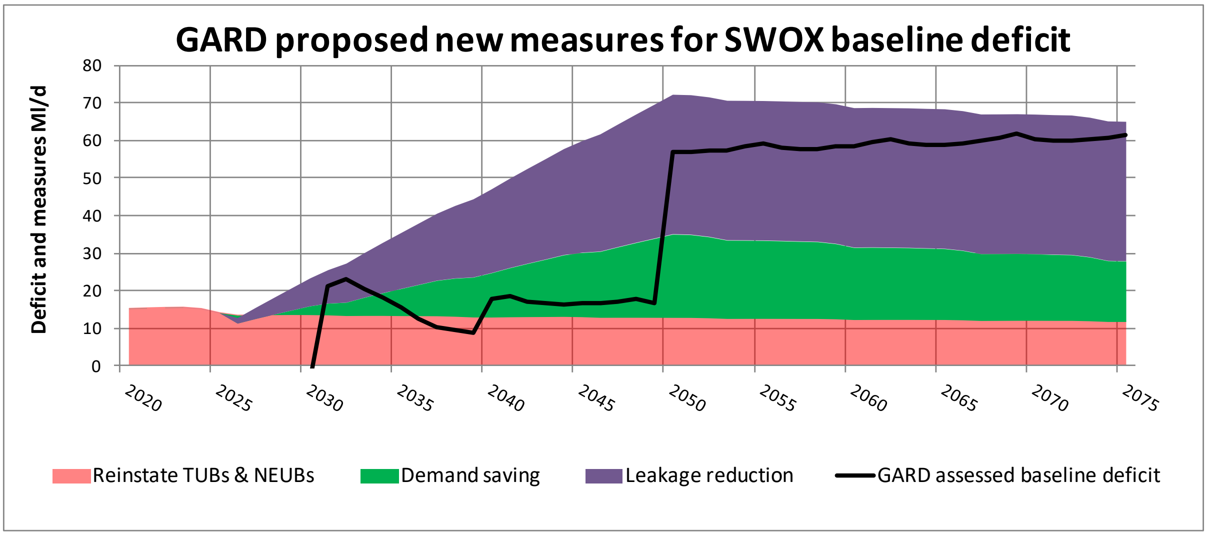


Figure 29 - GARD proposed measures for the SWOX baseline deficit

Even with the loss of 35 Ml/d due to the planned reduction in abstractions for filling Farmoor in 2050, there would be a surplus in SWOX zone if the Government's leakage and PCC targets are met. There would be no need for any supply from either Abingdon reservoir or the Severn to Thames transfer.

However, recognising the uncertainty over Thames Water's ability to meet these targets, the early construction of the Severn to Thames aqueduct with at least Netheridge support would provide insurance against Thames Water's failure to meet the targets, as we have proposed for the London zone.

3.6.3 Need for additional supplies in the Thames valley zones

Thames Water's baseline deficit in the Thames valley zones as shown on Figure 5 is a surplus up to 2050 and then a deficit of 90 Ml/d arising largely due to planned abstraction reductions. Thames Water plan to meet about half of this deficit through their planned PCC and leakage reductions and the remainder from imports of raw and potable water from SWOX zone.

GARD's reassessment shows that no new resources are needed for the Thames valley zones, even with the planned abstraction reductions in the Wey, Enbourne and Misbourne brought forward to 2025-35, as shown in Figure 17.

4. The proposed Abingdon reservoir

4.1 TW's proposed reservoir capacity

Thames Water's WRMP main report discussion of the best value plan poses this question[57]:

Question: Which size of strategic option to proceed with?

Answer: A SESRO of at least 100Mm^3 is required. Whether the 100 or 150Mm^3 size is chosen is close and is a key topic for this consultation

As we have shown in Section 3.6, if Thames Water's deficit is realistically estimated and Government leakage and PCC targets are met, neither size of reservoir is needed. We recognise that there is a risk that Thames Water will fail to meet to meet the PCC and leakage targets, which is why we have suggested early construction of the Severn to Thames transfer aqueduct, which then provides the ability to keep adding support sources if needed. If the additional supplies are not needed, the transfer will be little used, so it will have a low operating cost as well as a lower capital cost than Abingdon reservoir and far less environmental impact.

That said, we have reviewed Thames Water's assessment of the relative merits of the 100 Mm^3 and 150 Mm^3 reservoir options, which they compare in this table[58]:

SESRO 100Mm^3	SESRO 150Mm^3
Is a balanced choice based on the current understanding of risk	Is the size chosen most regularly by the model
Performs better in terms of environmental and social metrics (Natural Capital and BNG)	Performs marginally better in terms of resilience
Performs relatively better on BVP metrics	Allows for a better management of future system and under-performance risk
Has lower regrets if the future is better than predicted	Has lower regrets if the future is worse than predicted
Smaller footprint provides for more opportunity for landscaping and mitigation of visual aspects of the scheme	Maximises the water resources potential of the site (c.100 Ml/d higher output)
Maximises inter-regional interconnectivity	Maximises intra-regional interconnectivity
Provides the opportunity to balance local and regional concerns	Provides additional headroom for changes in environmental policy requiring further abstraction reductions or improved levels of service.

Table 16 - TW comparison of the 100 Mm^3 and 150 Mm^3 Abingdon reservoir options

Our comments are:

[57] TW WRMP24 main report, paragraph 11.231, 3rd bullet

[58] TW WRMP24 main report, Table 10 – 21

1. The supposed benefit that the 150 Mm^3 reservoir *"has lower regrets if the future is worse than predicted"* has little real value. Thames Water's forecasts assume High (ie virtually worst case) scenarios for abstraction reduction, population growth and climate change, as well as increasing headroom by about 50 Ml/d compared to WRMP14. It seems highly improbable that the future will be even worse than Thames Water's prediction. It is much more likely that the reservoir will never be needed and will be a costly and environmentally damaging white elephant.

2. The supposed benefit that the 150 Mm^3 reservoir *"Provides additional headroom for changes in environmental policy requiring further abstraction reductions or improved levels of service"* also has little real value. It seems to us inconceivable that the abstraction reductions will need to be more than the High scenario that Thames Water has assumed – it is much more likely that the overall reductions will be more akin to the Low scenario, once they have been prioritised and the cost and environmental impact of replacement sources is taken into account. Equally, it has hard to imagine that a service level more severe than the 1:500 years will ever be needed.

3. We agree that the 100 Mm^3 reservoir has *"lower regrets if the future is better than predicted"* and that the "*smaller footprint provides for more opportunity for landscaping and mitigation of visual aspects of the scheme".* However, the 100 Mm^3 reservoir would still carry a large risk of being a white elephant and it would still have a permanent and major visual impact.

4. We note that Thames Water has not pointed out in the table that the smaller reservoir would be less prone to failure to refill in dry winters and, therefore, a bit more resilient against multi-year droughts. Presumably Thames Water did not wish to draw attention to this fundamental weakness of the Abingdon reservoir, regardless of its size.

Although Thames Water maintained, for the last rounds of Stakeholder engagement, and at all stages of the WRMP19 process, that the 150 Mm^3 version of the Abingdon Reservoir was the only version which made sense, as it was 'best value' and most resilient to droughts, it is now the case that the WRSE draft Regional Plan[59] has chosen the 100 Mm^3 variant in the 'Best Value Plan'. Some consequences of this change are obviously beneficial: Thames Water's own analysis indicates that issues such as destruction of *pre-construction* site Natural Capital value and Biodiversity, and Embedded Carbon Footprint are relieved by a move to a smaller reservoir. Additionally, issues where Thames Water would sooner remain silent, eg. safety of surrounding communities in the event of a major dam breach, are also reduced in scale.

[59] https://www.wrse.org.uk/media/va1bz21z/10306a_wrse-bv-plan-2022final_online.pdf

However, the construction duration still remains at 9 years[60] and the disruption to the local environment and pollution problems of dust and fumes remain a huge burden on the locality. The land damage is virtually unchanged, as the move to a smaller project just means the construction layout is now more feasible with more space to fit in the various subsystems. The loss of agricultural land is still very significant, and the likelihood of restoring and enhancing biodiversity is still very contentious, as the area on which it is completely destroyed still amounts to many square kilometres, before any 'restoration' on the margins begins.

As we will show in Section 4.4, there are still many potential safety concerns about nearby villages (Steventon, East Hanney and South Drayton) in the event of embankment breach, and the consequences further afield have still not been evaluated by Thames Water. Furthermore, the project is still ***more expensive and has a larger embedded carbon footprint than an <u>equivalent</u> Severn-Thames Transfer scheme.*** Thames continues to compare a scaled-down Abingdon Reservoir proposal, with the full version of the STT. As shown in section 6, an equivalent (in terms of Deployable Output) STT scheme would be cheaper and lower carbon footprint than the 100 Mm^3 Abingdon reservoir. It would also be realisable on a quicker timescale and would be upgradable, properties that even the most fervent of Abingdon Reservoir proponents cannot claim.

Finally, we note that the tactic of switching to a smaller project version has been tried before by Thames Water just before a decision point, ie just before the 2010 Public Inquiry. The decision of the Inspector at that Inquiry was that the 100 Mm^3 proposal was not justified and a 30 Mm^3 version should be assessed, as well as proper consideration of the Severn to Thames transfer[61]: the present plan fails to demonstrate anything counter to that basic decision.

If an ill-judged decision was made to build a reservoir at Abingdon, we can see no valid reason for it to be the 150 Mm^3 version, apart from the benefits to Thames Water's shareholders that we highlighted in Section 4.6 of this response.

4.2 Deployable output and drought resilience

4.2.1 Availability of stochastic data and Pywr model output

In anticipation of the need to review the deployable output and drought resilience of the Abingdon reservoir and Severn to Thames transfer options, on 12th December 2022, GARD put in a request for the stochastic river flow data and Pywr model output that have been used in development of Thames Water's WRMP[62]. The request for data was similar to two previous requests made by GARD to WRSE and Thames Water on 18th January[63] and 19th

60 https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/SESRO-Gate-2-Main-Report-FINAL.pdf
61 2010 Public Inquiry Inspector's Report paragraph 15.1.5
62 Information request EIR-22-23-390
63 John Lawson email to WRSE and TW on 19.1.2022 headed "GARD data request No DR2: Stochastic data"

January 2022[64]. The original data request was partially met and the outstanding data were discussed at a meeting on 31st March 2022[65]. GARD's request in December 2022 request was largely a repeat of the previous request.

Some of the information requested in EIR-22-23-390 was provided by Thames water on 7th February 2023. However, much of the information (understood to comprise several Gigabytes) has still not been received, due in part to problems with Thames Water's Sharepoint system and, apparently, a generic problem with Microsoft.

Therefore, GARD has been unable to address various concerns relating to the deployable output of Abingdon reservoir, particular those related to its resilience to long duration droughts and, consequently, its deployable output.

4.2.2 Deployable output and resilience to long droughts

In the absence of the requested stochastic data and model output, we are unable to review the validity of Thames Water's estimated 185 Ml/d deployable output for the 100 Mm^3 reservoir. In our response to WRSE's emerging regional plan in March 2022, we used the limited data available at that time to review the deployable output in some detail, but still constrained by the limited data available at that time. Our analysis is shown in our response to the consultation on WRSEs emerging regional plan[66] and summarised as:

- We considered that the quoted deployable output of 293 Ml/d for the 150 Mm3 reservoir was much too high, because of lack of resilience to long droughts and inadequate emergency storage.
- The limited Pywr model output we were provided shows far fewer instances of long reservoir draw-down compared with previous modelling. We suspect this is due to 'training' the new stochastic data on the historic period 1950-97 which contained no major long duration drought like 1933/34.
- The Pywr model output showed a major error in computing reservoir re-fill – the Culham minimum residual flow was modelled as 450 Ml/d instead of 1450 Ml/d. This would have led to gross over-estimation of the speed of refill, especially in dry winters.

In the absence of the requested model data we cannot see whether these issues have been addressed, although we note that the deployable output of the 150 Mm^3 reservoir has been reduced from 293 Ml/d to 271 Ml/d[67].

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[64] John Lawson email to WRSE and TW on 19.1.2022 headed "GARD data request No DR3: Deployable output of existing and proposed London supplies"
[65] Note of Teams meeting on 31.3.22
[66] GARD response to WRSE emerging regional plan, pages 36 to 39
https://www.abingdonreservoir.org.uk/downloads/GARD%20WRSE%20final%20response%2014.3.22.pdf
[67] SESRO Gate 2 report, Table 4.1

4.2.3 Allowance for emergency storage

In our response to WRSE's emerging regional plan, we expressed our concern that the 9,000 Ml allowance for emergency storage in Abingdon reservoir was grossly inadequate, being only 6% of the live storage of 150Mm^3 [68]. Our understanding is that the 100 Mm3 reservoir would also allow 6% emergency storage, ie only 6,000 Ml. This issue has been repeatedly raised by GARD and it is disappointing that the matter is not addressed in the Gate 2 reports.

The average water depth in the 150 Mm^3 reservoir, when full, would be 28m, but it would reduce to only about 4.2m when the live storage is at the 6% emergency level. We understand that the reduced volume of the 100 Mm3 reservoir has been reached by reducing the area of the reservoir, so the depth of emergency storage would be similar to the 150 Mm^3 reservoir. The water quality in such a large shallow lake would probably be very poor and laden with algae. In our opinion, this would make the water unacceptable for discharge into the River Thames and re-abstraction for supply.

Thames Water's justify their 6% emergency storage provision by saying it complies with their policy of 30 days emergency storage, as for the London reservoirs. However, analysis of rates of depletion of London's reservoirs in severe droughts shows that the 24% emergency storage provision would maintain supplies for at least 60 days, not 30 days.[69]

In view of the high degree of resilience expected from London's supplies and the vulnerability of Abingdon reservoir to long duration droughts, GARD's 180-220 Ml/d yield estimates for the 150 Mm^3 reservoir, using previous stochastic data, allow for 20% emergency storage in Abingdon reservoir, ie 30,000 Ml. This would be a pragmatic risk management measure and in line with other UK reservoirs, for example:

- Clywedog reservoir — 13%
- Llyn Brianne reservoir — 14%
- Bristol Water (Chew, Blagdon) — 18%
- Welsh Dee system — 20% (of gross storage)
- TW London reservoirs — 24%
- TW Farmoor reservoir — 33%

If the emergency storage is increased to 20,000 Ml (20%), the yield gain is reduced by about 15%, ie by about 30 Ml/d for the 100 Mm^3 reservoir[70] substantially reducing its cost-effectiveness.

A larger emergency storage allowance would also address concerns about extremely poor quality water being released into the Thames from the last 6% of storage in the large flat-bottomed reservoir, with an average depth of about 4.2 m over a 6 km^{2}area, reducing to an

[68] GARD response to WRSE emerging regional plan, page 39
https://www.abingdonreservoir.org.uk/downloads/GARD%20WRSE%20final%20response%2014.3.22.pdf
[69] See GARD response to WRSE resilience consultation, page 34
[70] See GARD response to WRSE resilience consultation, page 36

average depth of about 1.5m when the storage is fully used. Thames Water has agreed that a water depth of less than 5m would be likely to lead to water quality issues.[71]

4.3 Environmental assessments

In this section, we cover the assessments of Abingdon reservoir against its impacts on Natural Capital and Biodiversity, on its Embedded and Operational Carbon footprints and the assessments under the Strategic Environmental Assessment (SEA) process.

We must emphasise at the outset, that the assessments of Natural Capital (NCA), of Biodiversity Net Gain (BNG) and of the SEA are all essentially desk-based, with no significant fieldwork, nor are they based on any detailed design proposal, which would seem to be a prerequisite. That this is the case 25 years into the proposal of this scheme is a scandal. There has been ample opportunity to develop the real-world data needed to allow stakeholders to properly analyse the proposal and conceptual design. This leads to the SEA, NC and the BNG analysis being all in terms of 'metrics' which, whilst useful as a first scoping out of the issues, should long ago have been superseded by more detailed approach. We remain concerned that, with the proposal as currently presented, Ministers may be 'bounced' into making a determination without the data they need to make a balanced decision.

4.3.1 Natural Capital Assessment of the Reservoir

The details of the Natural Capital Assessments (NCA) of program elements are given in Appendix AA of the draft Plan.[72] Here we will just concern ourselves with the Reservoir project, but will discuss comparisons with the STT in section 6.

In keeping with the metrics of DEFRA and similar bodies, the ecosystem services reviewed to assess the impact on natural capital include:

- Carbon Sequestration (Climate Regulation)
- Natural Hazard Management
- Water Purification
- Water Regulation
- Biodiversity and Habitat
- Air Pollutant Removal
- Recreation & amenity value
- Food production

The analysis then considers the site (or at least a 'database version') for the different types of habitat pre- and post-construction, and attributes metrics to the various habitat types

[71] Thames Water WRMP19 Resource Options. Reservoir Feasibility Report, Appendix V, July 2017, Thames Water Utilities Ltd

[72] https://thames-wrmp.co.uk/assets/images/documents/technical-appendices/AA-Natural-Capital-and-Biodiversity-Net-Gain-Assessment.pdf

against the particular ecosystem service. The Biodiversity and Habitat 'service' is analysed through the Biodiversity and Net Gain (BNG) metrics, as discussed in 4.3.2 below. The other services are either monetised (as can happen for Carbon sequestration, Recreational & Amenity value, Food production) or treated qualitatively, or, sometimes, scoped out.

The key problem with this analysis is the *state of the site post-construction* (which also applies to the BNG analysis). A great deal of fudging of the issue can, and we believe does, occur in the over-optimistic portrayal of the post-construction situation. This is particularly true of a reservoir project, and the larger the project, the more scope there is for the 'brochure culture' to take over. Recent presentations to local communities have heightened our concerns, with several presentations on potential amenities presented as fact, despite a complete lack of any supporting evidence as to how, or by who, these will be provided.

Two versions of the Reservoir NCA are relevant: the 150 Mm^3 version from what Thames Water label their '*Least Cost Plan*' (LCP) and the 100 Mm^3 version from what is labelled the '*Best Value Plan*' (BVP). As will be evident by now from our analysis and conclusions in Section 3, GARD accepts neither of these descriptions of the plans, but we adopt the Thames Water nomenclature here for convenience.

Table 3.9 from Appendix AA contains the following lines for the Abingdon 100Mm^3 project:

Natural capital stock	Area within option boundary pre-construction (Ha)	Stocks present within option boundary during construction (Ha)	Stocks present within option boundary post construction (Ha)	Change (Ha)
Reservoir Abingdon 100 (Lon) - Construction				
Coastal and Floodplain Grazing Marsh	68.01	0.00	93.73	25.72
Arable	1218.55	0.00	786.17	-432.38
Pastoral	52.20	0.00	0.00	-52.20
Orchards and Top Fruit	0.18	0.00	0.00	-0.18
Broadleaved, Mixed and Yew Woodland	36.76	0.00	54.51	17.75
Coniferous Woodland	2.21	0.00	0.00	-2.21
Active Flood Plain	351.18	93.73	93.73	-257.45
Lakes and Standing Waters	0.00	495.26	495.26	495.26
Ponds and Linear Features	2.68	2.68	6.41	3.73

Table 17 - TW Natural Capital stocks analysis, pre and post reservoir construction

This highlights a feature of all NCAs from reservoir projects, that the very creation of a '*Lake and Standing water*' (code for the Reservoir in this case) has a positive NC value. This 'special pleading' for Reservoirs is used whatever the form of the Reservoir, and whatever its actual *natural* state is. This comes from the positive value assigned to the '*Recreation and amenity value*' metric for an NCA on a particular proposal. The actual value attributed to this NCA item is not a straightforward value, and, as GARD highlighted in our response to the WRSE draft Regional Plan:

> "*The reality is that reservoirs do have very different possibilities of exploitation for 'Natural Capital'. It does not take much imagination to realise that large bunded reservoirs with all-round concrete walls and extensive rip-rap-enclosed shorelines and possible security and invasive species issues, have less Natural Capital possibility than 'classic' flooded valley reservoirs with more natural shorelines. Indeed, there seems to have been an acknowledgement of this to a certain extent in the WRSE figures...* [the WRSE report gives]… *comparison figures for the Havant Thicket Reservoir (described as a 'classic' reservoir) and the Abingdon 100 Reservoir. The values for Recreation and Amenity are quoted as:*

Havant Thicket	*£335,412*
Abingdon 100Mm^3	*£249,021"*

Havant Thicket holds 8.7 Mm^3 of water, and is in no way comparable to Abingdon on all other criteria, but the simple result that the NCA Recreation and Amenity for a small classic reservoir (with an area of 1.6 km^2 a construction phase of about 3 years,[73]) will result in 50% more Recreation and Amenity value than the Abingdon project with a capital cost more than 10 times higher, a construction phase 3 times longer and an area nearly 4 times larger. The implication of a result like this is that the NCA Recreation and Amenity value of Abingdon reservoir is nowhere near as high as a much smaller classic reservoir, and would, on its own, be regarded as rather poor value for money.

We also note the existence of positive values for '*Broadleaved, Mixed and Yew woodland*', '*Coastal and Floodplain grazing marsh*' and '*Ponds and Linear features*'. All of these are dependent on plans for the site which are completely aspirational (some might argue unrealistic) at this stage, and there is no way, in this analysis, to allow for the fact that, particularly in the case of woodland, there will be a 2 or 3-decade gap before this fulfils its Natural Capital metric use and values. We note currently that the farming community on the land is beginning to take advantage of District Council grants to create wetland habitats – something which is being achieved with investments of the order of £100k or less, so there really is no need to spend £1.8 Billion and ten years to achieve the same end.

Finally, there is, apparently a 'plan' to reinstate some food production on the area. Quite how this would be achieved, after a 10+ year period where the farmers on the land had been forced to take the compulsory purchase money and leave, is stretching the bounds of credibility. This restoration of food production is, of course, necessary to keep the monetised

[73] https://havant-thicket-reservoir.uk.engagementhq.com/planning-and-construction/widgets/44605/faqs#question13305

loss of the food production to a positive value. This is shown in the following extract from Table 3.10 in Appendix AA:

Table 3.10: BVP - Quantitative detailed assessment of the unmitigated predicted permanent impacts on the provision of ecosystem services

Natural capital stock	Baseline value (£/year)	Estimated value post construction (£/year)	Temporary impact from construction (£/year)	Total future value (£/year)	Overall change in value (£/year)
Reservoir Abingdon 100 (Lon) - Construction					
Carbon storage	20,631.10	0.00	-20,631.10	16,427.61	-4,203.49
Natural hazard management	Scoped out	Scoped out	Scoped out	Scoped out	Scoped out
Air Pollutant Removal	Scoped out	Scoped out	Scoped out	Scoped out	Scoped out
Recreation & amenity value	0.00	0.00	0.00	249,021.00	249,021.00
Food production	1,700,000.00	0.00	-1,700,000.00	1,557,400.00	-142,600.00
Total	1,720,631.10	0.00	-1,720,631.10	1,822,848.61	102,217.51

Table 18 - TW monetised values of Abingdon reservoir Natural Capital stocks

It is not clear, and is nowhere explained, why the loss of 65% of the food production land, has only resulted in an 8.5% drop in the food production value. This must surely be an error.

One can also see that, even with the mature woodlands hypothesis, there is still a net loss of carbon sequestration values as a result of the building of the reservoir. We also note that reservoir waters are now recognised as a source of Greenhouse Gases, which is nowhere accounted for in the analysis. We shall return to this in Section 4.4.

On the 'scoped out' criteria, there is some qualitative assessment of the Natural Hazard Management in the document. For Natural Hazard Management, the lack of a proper flooding assessment by Thames Water impedes claiming any credit for the reservoir plan, and the Best Value Plan results in a loss of this capital, however:

> *"….the change is expected to bring additional water flow regulation to the environment due to the addition of a reservoir."*[74]

This is another evidence of unfounded optimism biasing a supposed metric-based assessment. The document admits:[75]

> *" The loss of stocks will increase negative impacts to the ecosystem service. The provision of water flow regulation services of contributing stocks will be lost during construction."*

and:

[74] dWRMP24, Appendix AA, page 81.
[75] dWRMP24, Appendix AA, table 4.3

"The loss of contributing stocks has the potential to impede water flow on site."

However, it maintains:

> *"The addition of a reservoir will regulate flows, control water movement and maintain water supplies in dry periods, enabling a resilient supply of water to consumers,"*

before going on to admit:

> *" however the loss of existing stocks will require a Level 2 WFD. As such, the impact of the option on water flow regulation cannot be assessed at this stage."*

In spite of this admission of inability to assess the effects at this stage, it goes on to award a '*Major Beneficial*' rating to the scheme for water regulation. GARD has seen, and has raised before, the issue of beneficial ratings being awarded in assessments that are not supported by the text. It is disappointing to see this tactic creeping back in.

GARD's overall conclusion of the Natural Capital Assessment of the Reservoir is that it is:

- based on aspirations/assertions about the future configuration of the site post-construction;
- takes no account of the large scale and long timescale for destruction of NC and its postulated improvement;
- is not transparent; and, possibly because of this
- is riddled with unexplained inconsistencies.

We conclude the Natural Capital Assessment is not fit-for-purpose.

4.3.2 Biodiversity Net Gain Assessment of the Reservoir

The assessment of Biodiversity Net Gain in the draft plan, has many of the shortcomings attributed above to the NCA. There seems to be no attempt to discuss the effects of '*scale-length*' of habitat destruction, or '*time-duration*' of disturbance. Both are important when considering the prospect of returning 110% of the pre-construction site biodiversity (necessary for a net gain of 10% to comply with DEFRA guidelines). Clearly the site bio-diversity is completely shattered for a decade, and over a scale-length that is large compared to the radius of most invertebrates and small mammals. The 2-3 km scale-length of destruction will be much harder to reverse than a 25m scale width of a pipeline water transfer project. The time-duration omission was admitted as not being taken into account by the WRSE draft Regional Plan[76]:

> *"The duration of disturbance and timeline for habitat creation has not been included in the assessment. Durations of disturbance, including proposals for creating habitats in*

[76] https://www.wrse.org.uk/media/gfbbnqjn/wrse-draft-regional-plan-sea-er-natural-capital-assessment-and-biodiversity-net-gain.pdf -section 2.3.

advance of disturbance, will need to be refined with greater design detail at later stages to refine the accuracy of the BNG calculations for each option".

With these caveats, we see that the BNG assessments in the dWRMP are not actually consistent with the Gate 2 documents submitted on the Abingdon reservoir strategic option to the RAPID process. These are essentially contemporary with the dWRMP, though conversations with Thames Water representatives at 'drop-in' sessions[77] have led to the information that the RAPID Gate 2 submissions are 'more up-to-date' than the dWRMP in many respects. There does indeed appear to be some discussion of concepts of 'time to maturity' for a habitat which is to be created, in the supplementary Appendices of the RAPID Gate 2 documents. Table 6.5 in the Abingdon Reservoir RAPID Gate 2 document is reproduced below[78].

Table 6.5 Summary of BNG assessment

Reservoir Option	Biodiversity Units	Total Net Unit Change	Total % Change
150 Mm³	Habitat Units	1629	33%
	Hedgerow Units	-96	-22%
	River Units	70	16%
125 Mm³	Habitat Units	1768	37%
	Hedgerow Units	-86	-20%
	River Units	102	24%
100 Mm³	Habitat Units	2005	45%
	Hedgerow Units	-52	-13%
	River Units	99	25%
75 Mm³	Habitat Units	2196	52%
	Hedgerow Units	-43	-11%
	River Units	129	35%
100+30 Mm³	Habitat Units	2265	46%
	Hedgerow Units	-85	-19%
	River Units	74	17%
80+42 Mm³	Habitat Units	1942	39%
	Hedgerow Units	-105	-24%
	River Units	64	15%

Table 19 - BNG gain/loss for Abingdon Reservoir versions from RAPID Gate 2 submission

The results show that the BNG improves as the Abingdon Reservoir size reduces down to 75 Mm^3, and the main net loss item (Hedgerows) becomes of less importance. Irrespective of the accuracy of the BNG habitat improvements, at least these results have the value that they are logical, and point in the direction that local residents have always insisted upon, that *the larger the Reservoir the more destructive the biodiversity loss and the more difficult the restoration and improvement will be.* The dWRMP on the other hand, purports to show (tables 3.4 and 3.12 of Appendix AA) that the 150 Mm^3 Reservoir produces more habitat gain than the 100 Mm^3 version! Please issue a correction to whichever document is incorrect

[77] Eliot Simons, Project Manager, SESRO, statements at drop-in session, Steventon, 18th February, 2023.
[78] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/B-6---SESRO-BNG.pdf

The critical analysis of the BNG and NCA results in the RAPID Gate 2 documents is beyond the scope of the current documents. GARD will be submitting analysis in our response to the RAPID Gate 2 'draft Decisions' which will be produced by RAPID on 30th March.[79] For now we note that the RAPID Gate 2 documents show in many places that the dWRMP documents are full of errors and unjustified favourable comments about the NCA and BNG of the larger Abingdon Reservoir configurations. Just one example is the statement in the RAPID documentation,[80] regarding the BNG issues for the 150 Mm^3 reservoir:

> "*Under the current proposals for the scheme, 45.39 ha of lowland mixed deciduous woodland will be lost and only 17 ha will be retained. This equates to a loss of 939.57 units of habitat which have not been accounted for within the metric. As the metric Trading Summary states that habitats of high distinctiveness must be replaced with the same habitat type (taking into account the risk multiplier), only planting of lowland mixed deciduous woodland would rectify this issue. As there is no space within the site to create 939.57 units of this woodland type, the habitat may need to be created off-site or habitat units bought to compensate for the loss.*"

Once again, the situation is better for the smaller reservoirs, but the reader of the NCA/BNG appendix of the dWRMP would be given to understand that the creation of this habitat was a foregone conclusion for the 150 Mm^3 version[81].

We conclude that:

- the Biodiversity Net Gain assessment suffers from many aspirational and unfounded assertions of habitat creation;
- in the case of the dWRMP documents, there are many inconsistencies and errors;
- there is a lack of transparency in the BNG documents (it should not be necessary for stakeholders to plough through XL spreadsheets of values to get an informed view of the issues);
- at least some of the errors and inconsistencies, and some of the opaqueness is removed if the stakeholder reads the RAPID Gate 2 documents.

Thames Water should be asked to revisit this work and make it consistent with the RAPID Gate 2 documentation in accuracy and transparency.

[79] https://www.ofwat.gov.uk/regulated-companies/rapid/the-rapid-gated-process/timetable-for-the-rapid-gated-process/
[80] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/B-6---SESRO-BNG.pdf para 4.25
[81] TW dWRMP24 Appendix AA, Table3.1

4.3.4 Strategic Environmental Assessment of the Reservoir

GARD is not explicitly commenting on the SEAs of the Reservoir, except where comparisons with the Severn to Thames Transfer are concerned. This is partly because aspects of the SEAs are doubly analysed and counted in other assessments, eg. those covered in sections 4.3.1 and 4.3.2 above, or by carbon footprint and sequestration analyses as discussed in 4.4 below. It is also because, as GARD has observed on many occasions, there are hopelessly exaggerated and optimistic assessments of any possible benefit of the Reservoir (eg. the ability to walk a dog round it), coupled with a sharp tendency to downplay any dis-benefits (eg, the very long and disruptive construction period). In spite of GARD's comments over the years, this has never been acknowledged or seriously addressed. In any case, a point by point comparison with the STT is the best way of highlighting this situation.

4.4 Carbon Footprint of the Reservoir

4.4.1 The Gate 2 assessment of reservoir carbon footprint

We focus our analysis of the Carbon Footprint of the Reservoir on the RAPID Gate 2 documents, which, as we have seen in the previous sections are more up-to-date than the dWRMP material. We have not cross-checked to see any anomalies between the two sources. Indeed, it is obvious from a text search on 'carbon' or '*decarbonisation*' or '*carbon sequestration*' through the main dWRMP reports, that the mentions are almost entirely of the aspirational or corporate aims type, and not useful for analysis.

Straightforwardly, the Abingdon Reservoir is the project which has the largest carbon footprint in the construction phase ('*Embedded carbon*' or '*capital carbon*') and the 150 Mm^3 version has the largest of these footprints. Moreover, it is clear that Abingdon is a single project, and should only be compared with a '*like for like*' deployable output (DO) scheme. If the overall scheme in the comparison is one which can be implemented in stages, then a feasible first stage with DO equal to the version of Abingdon, should be the one entered in the comparison. The Severn Thames Transfer (STT) is, as we will show in sections 5 and 6 (and as is admitted by Thames Water) such a phaseable scheme. However, Thames Water avoid, wherever possible, a direct comparison, tending to compare the *whole STT network* with Abingdon Reservoir.

As the RAPID Gate 2 report on the Abingdon Reservoir shows[82], the various versions of the project have the Embedded carbon breakdown as Figure 30. The carbon footprint is dominated by the construction of the embankment works, which includes all earth moving equipment emissions and transport to site of materials such as rip-rap. This forms about 70% of the $150Mm^3$ version and around 60% for the Best Value Plan choice of the 100 Mm^3 version.

[82] SESRO Gate 2 report – Figure 6.1 https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/SESRO-Gate-2-Main-Report-FINAL.pdf

Operational carbon is low for the Reservoir and is shown in Figure 31 (copied from figure 6.2 of the Gate 2 report). The carbon budget is dominated (66%) by the energy needed to pump the water from the River Thames into the Reservoir. This energy is partially recovered by using low-head electricity generation turbines on the release of the water. Of course, with the intermittent use of the Reservoir, this is a balance over the lifetime of the Reservoir, rather than a within-year balance, but the comparison over the '*lifetime*' (calculated over 2022-2101) is a valid one.

Figure 6.1 Capital carbon emissions for SESRO options

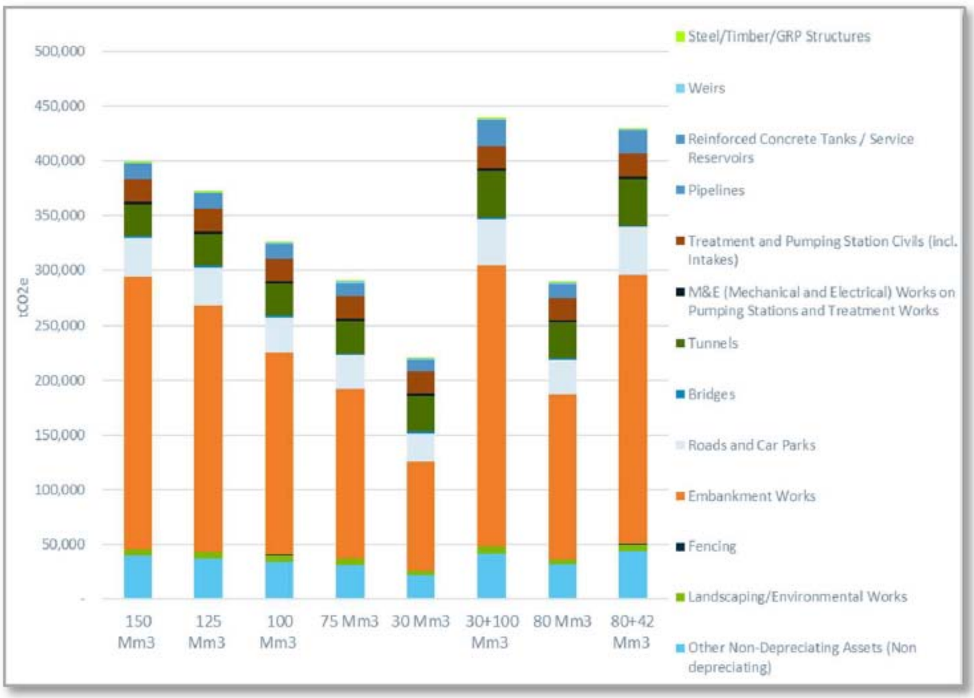

Figure 30 - Embedded or capital carbon budget

Figure 6.2 Total Annual Operational Carbon for all options (at 2040)

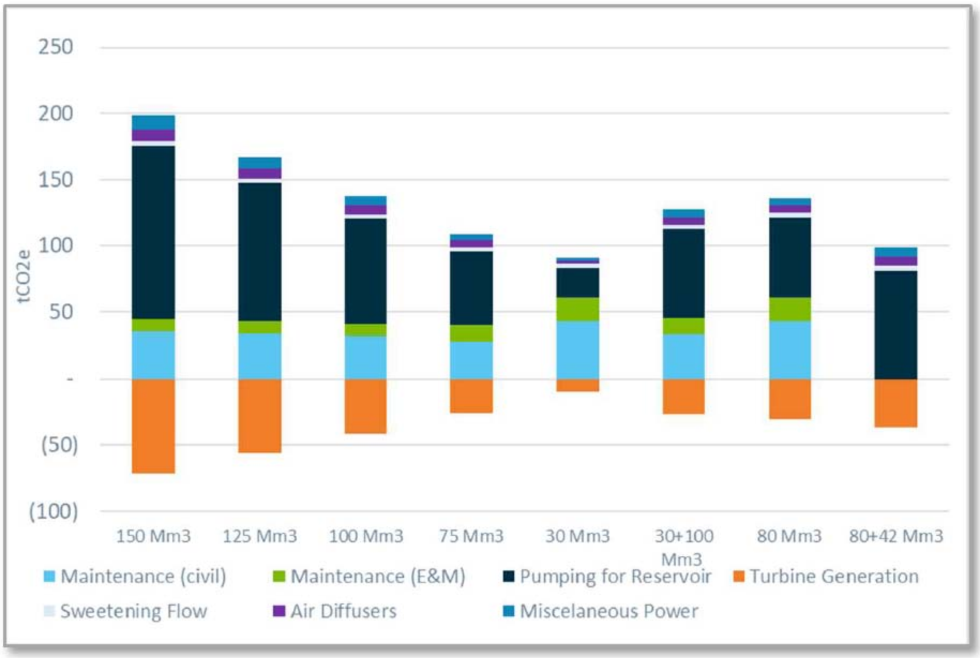

Figure 31 - Lifetime operational carbon budget of the Reservoir variants

Finally, when adding in the maintenance/replacement requirements, the whole-life carbon budget of the Reservoir versions is given by the RAPID Gate 2 documents as in Table 20 (taken from table 6.7 of the Gate 2 report)

Table 6.7 Summary of the whole life carbon emissions and net present value whole life carbon costs

Option (Mm³ storage)	150	125	100	75	30	30+100	80	80+42
Whole life Carbon footprint (tCo2e) – ***based on estimated long-term average utilisation, as discussed in Section 8***								
Capital and Replacement Carbon	479,939	451,378	403,152	366,035	285,762	507,413	362,222	504,747
Operational Carbon	5,624	5,103	4,664	4,114	3,286	5,913	4,464	6,057
Total	**484,356**	**455,498**	**407,008**	**369,522**	**288,777**	**511,810**	**366,046**	**508,860**
Whole life Carbon footprint (£M) – ***based on estimated long-term average utilisation, as discussed in Section 8***								
Total whole life carbon	**87**	**82**	**73**	**65**	**50**	**82**	**65**	**86**

Table 20 - Whole life carbon estimates for Reservoir versions

4.4.2 Attempts at carbon offsetting or carbon budget reduction

There are various attempts to claim potential reduction in the carbon budget figures. They can be divided into Technological Developments and Carbon sequestration possibilities.

Technological developments

The carbon strategy for the Abingdon Reservoir is discussed in a '*Carbon Report*' Technical Annex to the Gate 2 report. [83] There are various attempts to claim potential reduction in the carbon budget figures. They can be divided into Technological Developments and Carbon sequestration possibilities.

The Carbon Report addresses this by citing[84] the '*All Company Working Group (ACWG)'* study. GARD has already assessed this in its response to the WRSE draft Regional Plan.[85]

WRSE state in section 11 of Annex 2 of the draft Regional Plan

> *"As most of these* [strategic resource] *schemes will not be built until several years from now, time is available to work with the supply chain (e.g. steel and concrete manufacturers) to find new lower carbon solutions to construction. The All Company Working Group (ACWG), made up of the water companies with Strategic Resource Options (SROs), have engaged with the supply chain to estimate just how much progress with reducing emissions might occur over the next 60 years. This engagement has produced emission reduction estimates for most facets of construction, ranging from the types of construction equipment moving around on site, to the type of steel that might be used in future pipelines. Three different scenarios have been produced, a worst case, middle case and best case scenario; to allow for the industry moving slower or faster than expected."*

The All-company working group report can be accessed at,[86] and whilst such an exercise is genuinely to be welcomed, the conclusions drawn by WRSE (note, not necessarily by the ACWG itself) are very over-optimistic.

GARD's response covers the over-optimism on construction materials such as steel (for pipelines) and concrete. This of course applies to all SRO projects, but the fundamental issue is the lack of any *timetabled technology-development roadmap* for any of these materials.

Again, WRSE cite the Low Carbon Concrete Routemap,[87] but this has few dates in it and, whilst it can point to the existence of some materials, the roll-out to industrial capability is largely aspirational. This routemap at least has the major benefit that it assesses development according to *Technology Readiness Level* (TRL) and *Commercial Readiness Level* (CRL), but even the highest TRL9 grading ('*System Approved*') only corresponds to the stage CRL2 ('*small scale commercial trials'*). There are still stages after that for progress to

[83] SESRO Carbon Report https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/A-3---SESRO-Carbon-Report.pdf

[84] Carbon Report section 5.3

[85] https://www.gard-oxon.org.uk/downloads/Final%20GARD%20Response%20to%20WRSE%2022%202%2023%20v4.pdf, section 4.4.1

[86] https://www.wrse.org.uk/media/muvl5thv/acwg-low-capital-carbon-alternatives.pdf

[87] https://www.ice.org.uk/media/q12jkljj/low-carbon-concrete-routemap.pdf

CRL4 and 5, where commercial competition ensures good value for project contracts. The Figure 4.2 of the Routemap shows only one 'low-carbon' cement of the 27 cement types 'existing' is qualified to BS standards (effectively TRL8 stage).

The third major area of the ACWG report concerns large-scale earthworks and the emissions from heavy petrol and diesel-fuelled quarrying/construction/transport vehicles involved which dominates the embodied carbon for a reservoir.

The breakdown of sources of embedded carbon in the ACWG report differ in details from those in the Abingdon Gate 2 report, but this is presumably because the earlier ACWG study did not have the conceptual Reservoir design to hand. Nevertheless, the qualitative conclusions about embankment realisation dominating the embedded carbon is maintained.

Although the reader can see GARD's conclusions in our WRSE response, it is worth repeating them here, if only to show that the ACWG's highly dubious conclusions are still the state of the art.

The ACWG report purports to analyse how the embodied carbon might be reduced in the project, but the 'analysis' is woefully lacking in substance and hopelessly optimistic. It is also uneven in quality and philosophy when compared to that carried out for the pipe material and cement cases in the report. There are thus no details of technology existing (as with the pipework and cement), or industry-accepted roadmaps, or TRL discussion (as with the cement), or indeed of anything that could not be found from a Google search. Instead, anecdotal discussions are cited with two manufacturers *"…indicate that prototype* [hydrogen powered] *large excavators (21T and 35T) and dozers are being developed and <u>potentially available</u> in the next 2 years*" (ie. the *prototype* might be available). Such 'analyses' are used to derive an astounding (for its *chutzpah*) conclusion that a '*mid-case*' scenario (the one taken by WRSE) could result in a 60% reduction in embodied carbon in the 2025-2040 timeframe. This analysis excludes an analysis of transport by rail (currently diesel along the Great Western Line identified for bringing the 5+ megatonnes of Rip-rap to the site), as it only mentions HGVs in the text. It depends on the availability of Hydrogenated Vegetable Oil (HVO) fuelled vehicles, to provide 50% of the fleet, in spite of the fact of admitting that:

> *"Currently the UK's supply of HVO is underdeveloped. Although construction plant technologies operating with HVO are available, the risk of a secure supply of HVO may limit its applicability nationwide".*

All this to 50% market penetration by 2027! There are currently no diesel train fleets with HVO-powered vehicles. The changeover to HVO, not even considering the expensive need to write off plant which is far from life-expired, will not even start on any scale until the HVO fuel supply-chain is settled.

There are even more risible items in the '*analysis*. This whole section of the ACWG report has the air of being written by a Reservoir fanatic (something shared quite commonly across the Abingdon 100 Mm^3 analyses). We conclude that this is not worth consideration, as although it shows the steps required, the only possible conclusion can be that Reservoir construction is best delayed until at least 2035 -2045 timeframe.

We conclude that the RAPID Gate 2 report team do themselves no favours by citing this dubious material, and there is really no support for their attempt to use this material to derive an alternative 'low carbon' construction phase for the Abingdon Reservoir variants. (see for instance Figure 5.1 in the SESRO Carbon Report).

4.4.3 Carbon Sequestration

Claims are made for the carbon sequestration possibilities of the post-construction period, and improvements over the 'present' site (from a 'desk-based' assessment). Para 8.1 of the RAPID Gate 2 report asserts:

> *"The NCA analysis also includes an assessment of the impacts of the reservoir proposals on carbon sequestration. In qualitative terms, arable land is generally considered to be a source of carbon emissions rather than a sink. Each option involves a substantial area of land, particularly arable and horticulture, being taken out of agricultural use and partially replaced with land capable of sequestering carbon. Woodland is likely the most substantial carbon store and carbon sequestering habitat present. Net losses of woodland habitat are expected under each option, though the carbon impacts are likely to be counteracted by the potential for the creation of new habitats, such as the substantial area of floodplain wetland mosaic and native species-rich hedgerow with trees. This can be seen from the indicative Gate 2 Master Plan."*

[GARD highlighting]

Once again, a great deal of emphasis is placed on the *possible* gains post-construction, and the post-construction site descriptors are tending to the 'brochure speak' level, even in this relatively dispassionate document. We make the following observations:

1. The post-construction carbon sequestration 'natural capital' is, even on this optimistic assessment valued at only £1.9m for the Abingdon 150 Reservoir, against the whole life carbon budget of £87m for the project (see Table 20). Even for the 75Mm^3 version, the sequestration against impact is only £3.1m to £65m (Table 20). This is therefore just a few percent effect.

2. Even the sequestration will only begin to be effective with a 5-10 year delay, following a 10 year construction period.

3. The '*species rich*' hedgerows merely replace a linear amount of hedgerow lost during the construction[88] It is of course, at a very modest cost, possible to make the existing hedgerows just as 'species rich' as the post-construction site. On a 'desk-based' analysis it is in any case hard to see how the assessors can give any quantification to the species value of the site. In a similar vein, as noted in section 4.3.1, currently the farming community on the land is beginning to take advantage of District Council grants to create wetland habitats – something which is being achieved with investments of the order of £100k or less, so there really is no need to spend £1.8 Billion and ten years to achieve the same end.

4. Reservoir waters themselves are now known to be a source of Greenhouse Gas Emission (See below).

We conclude that the carbon sequestration 'opportunities' are limited and uncertain, and not larger than local initiatives (funded by new DEFRA rules and Local Authorities) could achieve.

4.4.4 Sources of the net carbon footprint omitted in the reports

1. We conclude that the carbon sequestration 'opportunities' are limited and uncertain, and not larger than local initiatives (funded by new DEFRA rules and Local Authorities) could achieve.

2. Whilst it is GARD's view that the latter scheme should not be progressed, this is not what the Thames Water draft Plan policy assumes. It is also the case that water treatment of returned water to the Thames might be needed. There is, as GARD has previously highlighted (most recently in section 4.2.3 above) a risk that the water quality in Abingdon after prolonged high drought would be very poor indeed and laden with algal bloom.

   GARD calls for the carbon budgets for the Abingdon Water Treatment Works to be included with the Reservoir budget, as the justification of the Reservoir requires this item as part of the Baseline case.

3. Around 40 MW of solar farm generating capacity is torn up by the construction site of the Abingdon Reservoir. The Gate 2 reports make it clear[89] that there is no intention to re-site these on the post-construction site. There had previously been an assumption by local residents that a floating solar farm would be created on the Reservoir, but this is now ruled out be Thames Water.[90] It now seems that the '*Master Plan*' includes the creation of islands in the South-west corner of the

[88] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/B-2---SESRO-EAR-Terrestrial.pdf table 9-6.
[89] Table 6.8 of SESRO Gate 2 main report
[90] Statements (by Phil Stride of Thames Water) at the Thames Water 'drop-in', Steventon, 18th February 2023.

Reservoir surface, in order to attempt to create enough bio-diversity net gain. The generating loss caused by the destruction of the solar panels needs to be factored into the carbon balance for the project (it is unlikely that the panels can be usefully located to another site, and may well end up being scrapped).

Recent research has shown[91] that reservoirs are net carbon sources, and their calculated carbon footprint can be increased by over 50%. The recommendation of other supporting references[92] is that Greenhouse Gas (GHG) Emissions from reservoir surfaces should be included in the anthropogenic emissions of the operational reservoir cycle. The evidence is increasing that reservoirs do not sequester carbon. These issues are completely absent from consideration in both the Thames Water dWRMP documents and the RAPID Gate 2 reports.

GARD will return to this last point in our response to the RAPID Gate 2 draft Decisions, but here we give an idea of the magnitudes. The study by Harrison et al.[93], (2020) provides an average annual "per-unit-reservoir-per-area" GHG production rate. For the Abingdon reservoir latitude of 152-1000 g CO_2e for the 6.75 km^2 surface area of the Abingdon reservoir this is 1026 – 6750 tonnes CO_2e per year. This is (from Table 30) up to 150% of the operational carbon from pumping. From the same study, the distribution of CO_2 and methane emissions from temperate latitude reservoirs was effectively 50:50. This distribution, compared to high boreal and tropical latitudes, is due to temperature and solar radiation differences between the regions. The composition between degassed and ebullient methane production is also different for different latitudinal zones, with temperate zones having just 5% of total methane emissions from degassing, the remainder from methane ebullition.

While CO2 diffusion from reservoirs is the single dominant flux, CO2 ebullition and more importantly, methane degassing and ebullition is by far the major GHG CO_2e per area of reservoir.

Several recent studies[94] [95] [96] have reported strong correlations between primary production

[91] *Global carbon budget of reservoirs is overturned by the quantification of drawdown areas*, Keller, Marce, Obrador, Koschorreck, Nature Geoscience 14, 402-408 (2021),

[92] *Greenhouse Gas Emissions from Reservoir Water Surfaces: A New Global Synthesis* by B R Deemer, et al, BioScience, Volume 66, Issue 11, 1 November 2016, Pages 949–964]

[93] Harrison, J.A., Prairie,Y.T., Mercier-Blais, S. & Soued, C. (2021). Year 2020 reservoir CH4 and CO2 emissions as predicted by the G-res model. Zenodo https://doi.org/10.5281/zenodo.4632428.

[94] Beaulieu,J.J., DelSantro,T. & Downing, J.A. (2019). Eutrophication will increase emissions from lakes and impoundments during the 21st century. *Nature Communications* https://doi.org/10.1038/s41467-019-09100-5.

[95] Deemer, B.R., Harrison, J.A., Li, S., Beaulieu, J.J., DelSantro,T., Barros,N., et al. (2016). Greenhouse gas emissions from reservoir water surfaces: A new global synthesis. *BioScience* http://doi.org/10.1093/biosci/biw117

[96] DelSontro, T., Beaulieu, J.J. & Downing (2018). Greenhouse gas emissions from lakes and impoundments: Upscaling in the face of global change. *Limnology and Oceanography Letters* **3:3**, 64-75. https://doi.org/10.1002/lol2.10073.

and methane emissions. There is a causal link for this, by providing organic Carbon and creating the anoxic (oxygen deficient) conditions that favour methane production, any plant production in reservoir surface waters will fuel higher rates of methane emission, leading to higher emissions from eutrophic (increase in plant and other nutrients) systems than oligotrophic (lack of nutrients and oxygen rich) systems. The continuing dumping of raw sewage into UK rivers, including the Thames, the pumping of those waters into the reservoir, will provide the labile carbon and nutrients (eutrophication) for both the production of surface algal and vegetation matter, and as the detritus sinks to the bottom of the reservoir, it becomes the source of extra GHG emissions – mainly methane. The creation of algal blooms will have a devastating effect on the biodiversity of both the reservoir and those visiting the reservoir (insects, birds, etc). When detritus from the algal bloom descends into the water column, bacteria communities rapidly increase which initially creates CO_2 emissions, but as the water oxygen is exhausted, reservoir inhabitants (fish, insects) will die and the emissions become largely methane. This process in stagnant water can produce the toxin producing blue green cyanobacteria harmful to many species including humans who drink the water or use its facilities[97] (www.nhm.ac.uk – see below). This threatens the design aim that the original landscape biodiversity will be replaced by a new "wetland" biodiversity.

GARD calls for the GHG emissions for the Abingdon Reservoir to be included with the Reservoir budget, and a statement regarding the treatment of water pumped into the Reservoir and the policy for extraction from the Thames at times of sewage spills to be explicitly stated.

4.5 Reservoir Safety Issues

4.5.1 GARD's concerns about reservoir safety

In GARD's response to the WRSE draft Regional Plan[98] we expressed concern that certain important issues that may have direct and serious public impact have not been addressed. These obviously include things such as the health and safety of, and risks to the welfare of SE communities. Here we address the more detailed issues on Reservoir Safety to Thames Water, who, as prime movers for the reservoir proposal, bear the responsibility for investigations. Our comments and conclusions also apply to Affinity Water, but we address them here, rather than in our Affinity dWRMP24 response, as Affinity are relatively late to the proposal. ***In short, we believe that Thames Water has failed in its duty of due diligence in safety matters***.

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[97] www.nhm.ac.uk(https://www.nhm.ac.uk/discover/news/2021/november/the-deadly-effects-of-sewage-pollution-on-nature.html

[98] https://www.gard-oxon.org.uk/downloads/Final%20GARD%20Response%20to%20WRSE%2022%202%2023%20v4.pdf, section 4.5

The issues we raise should clearly have been investigated by Thames Water in its case for the Abingdon Reservoir proposal, especially as it has been on the table, essentially in the current format, for at least 15 years. It is simply not good enough to argue that these are for detailed examination at a later stage of the processes (the current destination of the procrastination being the RAPID Gate 3 process). As water infrastructure, reservoirs, and especially those of the size of the Abingdon proposal, have unique dangers and design issues which should be established at the stage of draft Plans. That scoping studies, costing only a few thousand pounds have not been done (or at least remain secret) is a real scandal and cannot be allowed to go unchallenged.

GARD's examination of the Reservoir Safety Issues are given in some outlines below, in the hope of jolting TW and the Regulators into action on this.

We emphasise at the outset that we are not expert Reservoir engineers, but we have carried out a thorough scoping exercise, done by doctorate-level scientists and engineers with big-project experience in other fields. We have, in addition, used the relevant literature sources and guidelines to examine quantitatively the problems. We are certainly not encouraged to a view that safety has been adequately addressed following our review.

4.5.2 Overview of Safety Issues involving Abingdon Reservoir

A list of issues related to Reservoir Safety is given in the Appendix 1 'Concept Design Report' (CDR) of the RAPID Gate 2 submission on the Abingdon Reservoir[99]. Some of the key design features relating to safety, which by implication are not yet sufficiently investigated, are:

- *Internal filtering and drainage – to safely manage dam seepage flows whilst preventing these eroding the dam internally.*
- *No buried engineered fill / structure interfaces. Instead, all water conveyance would be via a tunnel excavated through the foundation clay, or via siphon pipes over the dam crest.*
- *Provision of pipework to enable an emergency drawdown at an initial rate of 1m/day – this is the maximum recommended installed rate within current UK guidance for reservoirs and matches that adopted at all other major Thames Water reservoirs.*
- *A wide embankment crest and measures to prevent uncontrolled vehicular access to limit the risks of damage induced by persons.*
- *Provision of a comprehensive control system to prevent overfilling.*

[99] https://A-1 - SESRO Concept Design Report.pdf, section 2.2.2.1

- *Wave erosion protection – the inner face of the embankment would be protected from wave erosion capable of protecting against extreme storm winds.*
- *Sufficient freeboard (difference in level between maximum operating level and top of wave wall / dam crest) to take account of long-term settlement of the dam, and the risk of large waves breaking over the dam*.
- *Monitoring and surveillance – A comprehensive, automated system of instruments would be installed within the dam. Such readings would supplement on-site monitoring by operatives trained in reservoir safety surveillance.*

When questioned by GARD members and local residents at 'pop-up' or 'drop-in' sessions on the Abingdon Reservoir, Thames Water staff usually fall back on assertions about safety, rather than point out actual work which has been performed to quantify safety issues. The assertions repeat the text in the CDR that "*The reservoir would be designed and constructed in compliance with the applicable reservoir safety legislation (The Reservoirs Act 1975, as amended). In accordance with this Act, the design and construction of the reservoir would be supervised by a Construction Engineer, namely a competent and highly experienced dam engineer already appointed to the 'All Reservoirs Panel' by the Secretary of State. It would also be overseen by an independent expert engineering panel for additional scrutiny appropriate for a large reservoir such as SESRO*". This just states the obvious legal position, and is not necessarily a guarantee that the reservoir is the Best Value Option, as, if some of the aspects above are left to a late stage, and revisions arise due to *evaluated* safety considerations, there will be inevitable cost and schedule escalation, and perhaps even loss of deployable output, in the final plan if approved.

Of course, some issues covered in the bullet list above, are properly covered in later stages of the design process. Others however need explicit early coverage. In GARD's view these are:

1. Issues around Safety in the case of detected major fault in the dam wall, and the extent of the Emergency evacuation of the surrounding population and the Emergency Drawdown of the reservoir. This includes, but is not limited to, the design of the Emergency Drawdown system of the reservoir alluded to above.
2. Issues around the threat from terrorism to the reservoir security – this is alluded to obliquely in the bullet list as "…. *measures to prevent uncontrolled vehicular access to limit the risks of damage induced by persons.* "
3. Issues of the basic height of the freeboard and the related issue of the protection of the inner face of the embankment against wave-erosion.

In all these cases a scoping exercise would establish the scale of the concept design measures, and help to crystallise issues around realising some of the 'Natural Capital

Benefits'.

4.5.3 Major Dam wall fault and Emergency evacuation/drawdown

The *Likelihood* of a major fault developing in a dam wall constructed under modern practice is regarded as '*unlikely' or 'rare',* but nevertheless given the *high impact* of such a fault, the *Risk* (as usually evaluated as a 'product' of *Likelihood x Risk*) has to be evaluated, and there is an obligation for owners proposing to build dams to establish the effects of a major catastrophic breach on the local population and infrastructure. Dams are classified as '*High Risk*' in the Reservoirs Safety Act 1975 (as amended by the Flood and Water Management Act 2010) if they have an above-ground volume of greater than 10,000m^3. In this case the process has to involve the provisions of the Reservoirs Act of 1975, as cited in the WRSE text above. The 100 Mm^3 Abingdon reservoir design has an above-ground water volume of at least 67 Mm^3 (taking the Thames Water quoted 'borrow pit' in the Conceptual Design), so it clearly is a '*High Risk*' facility within the terms of the Act. However, the DEFRA advice on assessing safety on 'small dams'[100] (<25,000m^3 as defined in the Reservoirs Safety Act) contains formulae and procedures which can be used to scope out the situation for larger dams. GARD has employed these formulae and procedures which give an idea of the area and severity of damage for a catastrophic dam wall breach (as defined in the Reservoirs Safety Act). The DEFRA procedure very quickly moves to recommend that:

> "*Larger dams are likely to have greater engineering input into their siting and design, such that this rapid screening would be of less value*".

In the absence of any published 'greater engineering input into … siting and design' regarding safety, the best GARD can do is to use DEFRA's Simplified Method to make an assessment of the risks and impacts of the reservoir ourselves.

The special issues which make the Abingdon Reservoir a higher-than-normal safety hazard regarding reservoir-wall breach are:

- the much longer perimeter impounding wall of this reservoir (around 8.7 Km for the Abingdon 100 Mm^3 design) compared to most impounding wall dams[101];
- the size of the above-ground water volume compared to the majority of reservoirs, exacerbating the length of the Emergency Drawdown, and period of Emergency evacuation;
- the issue of accelerating climate-change and its rising temperatures on the micro-fissure creation in the embankment;

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[100] Small reservoirs simplified risk assessment methodology, Defra, January 2014 https://assets.publishing.service.gov.uk/media/603390fc8fa8f54334a5a673/small_reservoirs_simplified_risk_assessment_methodology_guidance.pdf

[101] Most earthdam wall reservoirs have only a front wall of only 400-500. Even the only other comparable size reservoirs (Kielder and Rutland Water) have impounding walls of around 1 km length.

- the relative proximity of some surrounding communities, especially when one considers the '*all-round*' nature of the possibility of a breach

Details of the procedure used are given in Appendix B.

The procedure takes the simplified analysis developed by HR Wallingford for DEFRA.[102] The procedure uses equations from Froehlich,[103] and assumes for each breach position, that water flows out with a quantity (Q_p) over a width (W) as defined in the Froehlich flow equations, with 'typical' friction applied to the flow. The procedure takes an extreme breach, but this is necessary to define what is the worst *deterministic* accident. In this sense, the DEFRA procedure has a similar philosophy to a Nuclear installation '*Design Basis Accident*'[104], an assessment necessary to define the off-site consequences, and hence precautions, for a catastrophic incident.

The procedure has been used to establish the quantity DV (Depth x Velocity) of the flow from a catastrophic breach opposite various communities around the reservoir. The value of this parameter would then be used in the DEFRA procedure to establish level of casualties in each location (assuming no warning).

As GARD's calculations are still in a relatively simple form, we do not intend to publish detailed maps of the calculated flooding/damage/fatalities. However, we note our main conclusions from Appendix B1 are:

1. Several locations are at '*High Risk*' (defined as DV > $3m^2$/sec) from a breach, as to be expected, these locations are the 'perimeter communities' nearest the Reservoir crest (the edges of Steventon, East Hanney and the South Drayton houses south of the A34).***The situation for these communities should be modelled by Thames Water with some urgency.***

2. Many locations can be defined as safe from either flood or damage, by simple equations considerations and on examination of the area contour map. Most of this 'safe' labelling arises because of the inability of even catastrophic flood to flow a significant distance 'uphill'.

3. There are areas where '*Medium Risk*' (3 > DV > 2 m^2/sec), or '*Flood risk*' (without fatality) where DV is less than $2m^2$/sec but greater than zero. These are, in general, communities at a greater distance than the peripheral communities, but where the water from a breach in general has to flow 'downhill'. The situation with such communities, given the duration of the flow from a catastrophic breach (over 3

[102] H.R.Wallingford Ltd. 'Small reservoirs simplified risk assessment methodology: Guidance Report. '(2014) and 'Research Report '(2013), For DEFRA and the Environment Agency.

[103] Froehlich, D.C. (1995) Peak outflow from breached embankment dam. *ASCE Journal of Water Resources Planning and Management* 121(1), 90-97.

[104] Essentially, if something *can happen* this DEFRA analysis assumes it *will happen*, irrespective of probability.

hours) is such that flooding, without high damage, cannot be ruled out. ***The situation for these communities should be modelled by Thames Water with some urgency.***

4. Finally, there is a very significant set of communities where the flood water will have to flow via the River Ock and into the Thames. Appendix B makes comments about these (South Abingdon, Culham, Sutton Courtenay, Appleford). These communities will almost certainly be in the flood-affected zone, but the situation, with curved trajectories, and with competing gravitational acceleration of the flood fighting against a complex friction force slowing over variable terrain and through built-up areas, is simply too complex for the models used in Appendix B. Indeed, Appendix B procedures are emphatically ***not*** the way of addressing the problem. ***The situation for these communities should be properly modelled by Thames Water with some urgency*.**

The problems outlined i1-4 above and in Appendix B can only be, and should already have been, addressed fully by Thames Water in consultation with qualified reservoir engineers. It is their responsibility to define the extent of risk and provide appropriate mitigating design features and procedures. We see no sign of that happening.

The communities covered in paras 1,3 and 4 above will almost certainly lie in the Reservoir Flood Risk Area, as defined in the EA's maps.[105] It is these areas which would have to be evacuated in the event of a major fault being detected. Such an event happened in the case of a much older earth dam at Whaley Bridge, Derbyshire[106] in 2019. The 1500 population of the town of Whaley Bridge spent 6 days out of their homes whilst the threatened breach was made safe.

From the initial studies, given in more detail in Appendix B the communities in the 'long list' in danger of some level of flooding or damage from a major breach somewhere around the 'Abingdon 100' perimeter, would include Steventon, East Hanney, Drayton, Marcham, Milton, parts of South Abingdon, Culham, Sutton Courtenay and Appleford.

All the communities listed in the 'long-list' are expected to be in a potential Flood Risk Area.[107] Flood zones for major reservoirs can be very extensive. The Figures 32 and 33 show the area for Rutland Water, taken from the Gov.uk site.

[105] https://check-long-term-flood-risk.service.gov.uk/map

[106] https://www.bbc.co.uk/news/uk-england-derbyshire-53580768

[107] Clearly, a breach would affect communities in an arc opposite the breach, thus a breach opposite South Abingdon would leave Steventon, East Hanney, and Milton largely unscathed, but the Flood Map must take into account all possible locations

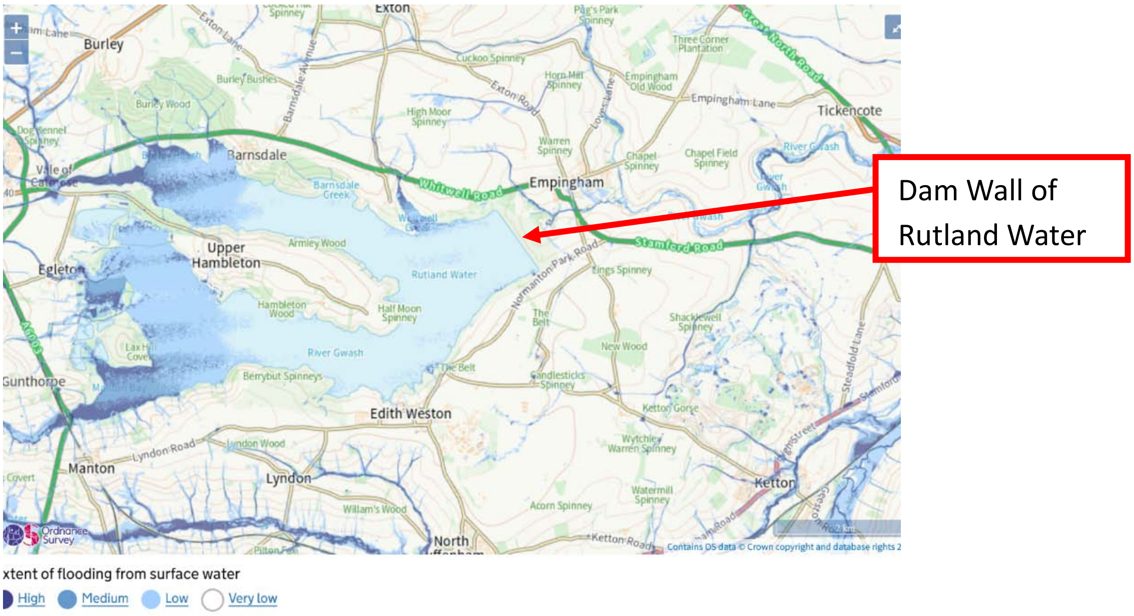

Figure 32 - Rutland Water: showing areas susceptible to river flooding[108]

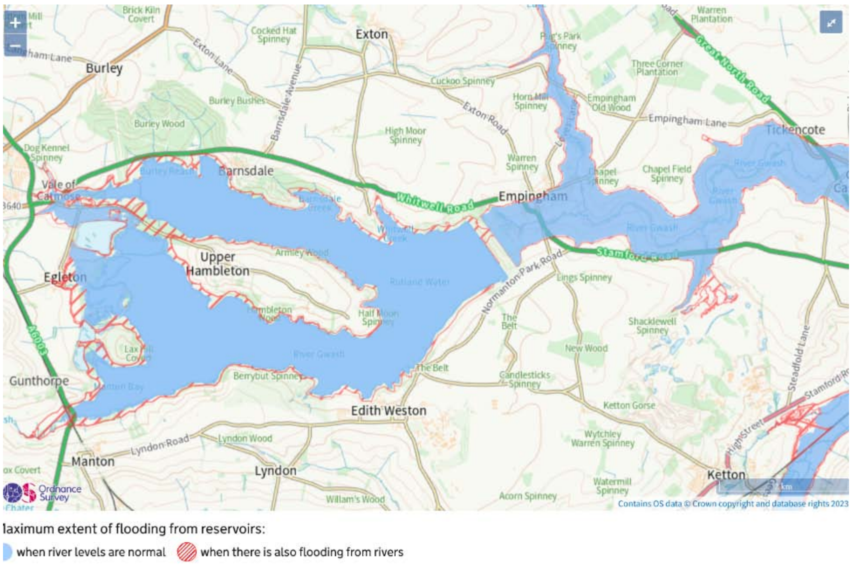

Figure 33 - Rutland Water: showing areas in the Reservoir Flood Risk Area

Note this map only shows the zones within a radius of around 5 km – the risk area extends for a considerable downstream distance (source as Figure 32).

The evacuation duration for a community threatened by the major breach would be potentially long (the Whaley Bridge episode lasted much longer than anticipated). At an Emergency Drawdown rate of 1 m per day, as quoted above, it would take 10-15 days to bring the reservoir water level to something which could be regarded as safe. Thus, in the worst case, 10-20,000 people would have to be provided with emergency accommodation for up to a fortnight. ***GARD is calling for a full assessment of the Flood Map to be made***

[108] Government flood risk mapping https://check-long- term-flood-risk.service.gov.uk/map)

before Abingdon Reservoir is allowed to pass the RAPID Gate 2 process.

4.5.4 Emergency Drawdown capability

As a corollary, we note that the amount of water passing through the pipes in an emergency drain-down is around 63 m^3/sec, assuming a 1 m per day drawdown of the 100 Mm^3 reservoir. This is more than the natural flow-rate of the Thames at Sutton Courtenay for about 85% of the year.[109] Indeed, if the flow were released between December and March, about 20% of the time the resulting flow in the Thames would be close to historical maxima, and flooding would almost certainly result. Thus, the flooding effect of the Emergency Drain-down itself needs evaluation at this stage.

The issue of Emergency Drawdown itself cannot be taken as a solved problem for a reservoir as large as Abingdon 100. Rutland Water was commissioned in 1975. In 2005 a study[110] concluded that the Emergency Drawdown should be 50% in 10-20 days. By 2011, the calculations on the Emergency Drawdown system for Rutland Water concluded drawdown would take 75 days. The situation was not rectified until after 2016. Thus the Emergency Drawdown of one of the most modern dams in England was inadequate for at least 40 years. This shows the dangers of not considering the safety systems at an early stage.

4.5.5 Terrorism as a threat to the Reservoir security

The issue of a terrorist threat to the Reservoir, as to all water infrastructure, is not something that should be taken lightly. One would expect Thames Water to have sought advice on this from the relevant authorities, even at this stage. Whilst one might not expect the advice to be made public, there are nevertheless aspects which one would expect to see informing the Conceptual Design, even at this stage. The most important of these aspects, from the point of view of Thames Water trying to paint the Reservoir as part of a 'Best Value Plan', relate to the effect on visitor access to the reservoir site, something which figures heavily in Thames Water's attempts to attribute positive '*Natural Capital*' outcome to constructing the reservoir. As was admitted in the RAPID Gate 1 documents for the Abingdon Reservoir[111]:

> The reported positive change in natural capital value is primarily due to the significant increase in Recreation value expected for the site, which outweighs the decrease in ecosystem value of food production – although improvements in all the other services are also reported in comparison to the baseline, without recreation they are insufficient both alone and in combination to outweigh the loss in Food production value;

The positive Natural Capital assessment is essential to the Best Value argument, and even

[109] https://nrfa.ceh.ac.uk/data/station/meanflow/39046

[110] https://britishdams.org/2012conf/papers/Construction-newdamsandupgrades/Papers/6.6%20Tam%20-%20Improving%20Anglian%20Waters%20emergency%20response%20for%20reservoir%20safety.pdf - references therein.

[111] https://www.thameswater.co.uk/media-library/home/about-us/regulation/water-resources/strategic-resource-solutions/new-reservoir-in-oxfordshire/environmental-assessment-report.pdf – sect 11.1.5, p 163

more to Thames Water's attempts to spin a positive view of the reservoir (always seen in juxtaposition with pictures of sailing boats).

There are occurrences of the access to the London Thames Water reservoirs for sailing being restricted at the height of the IRA campaigns in the 1980s. GARD has taken advice from an expert in counter-terrorism issues relating to infrastructure. Although this briefing is 'off the record', we include the outline of it here as part of GARD's Thames Water response. From now we would like to note:

- The ***National Risk Register*** *rates* potential hazards such as diseases, major accidents and societal risks in terms of their *Impact (I)(Severity) and likelihood (L)(probability*) in terms of a 5 x 5 matrix with 1 being the lowest score and 5 the highest. The current National Risk Register[112] rates an attack on infrastructure as I = 3 and Likelihood of L = 2. UK Govt definitions are not stated in the document but typically:

- An impact score of 3 would indicate limited loss of life, structural damage and long-term delays to delivery. A Likelihood score of 2 would suggest that such an event would be unlikely to occur but there are examples of this sort of event. This would suggest a risk score of 2 x 3 = 6, a typical definition would suggest that the risk is ***tolerable*** where resources are not available to treat or mitigate (but ***the risk should be entered into an appropriate risk register for future treatment/mitigation)***[our emphasis].[113] It is intended to allow recreational sailing (and fishing) in the reservoir. Of concern is the vulnerability of the bund. Particularly of concern would be a Vehicle Borne Improvised Explosive Device (VBIED) this could be say a 500kg device of Home-Made Explosive

- [Referring to the Conceptual Design Report – fig 2.1]**,** a freeboard of 1.0m looks inadequate, more appropriate for a dam on a rural farm (we shall further discuss this below). Although a legitimate terrorist target, the risk would be assessed as low (currently) and *terrorist considerations alone would not preclude construction*. Having said that a medium sized VBIED could easily cause a breach at the dam crest, with subsequent rapid erosion of a section of the downstream earthfill and total embankment breach, with resulting loss of life and publicity and so sensible mitigating features should be included.

Recreation is seen as a key benefit. However, even if the project assessment requires that boats should be able to be launched and recovered from the bund, the Terrorist threat considerations could well specify this should be done only from specific locations and that, ***apart for maintenance, vehicles should not be permitted on the bund.*** Access to vehicles and plant onto the bund could well be physically restricted, and any slipways provided should be

[112] UK_National_Risk_Register_2017.pdf
[113] Note that this risk is to infrastructure in general and not specifically for water related assets.

designed to prevent breach from a VBIED and access controlled: this would be a challenge.

GARD's view is that the freeboard of the bund is indeed too low in the current design (for the issue of wave-overtopping in high winds, as discussed in section 4.5.5). It is also our view that the issue should be investigated and that the project's Natural Capital assessment, and social use definition ***must*** be settled, including the knock-on effects on design and cost, before the project is allowed to pass through this stage of either the draft Regional Plan, the dWRMP24 or the RAPID Gate 2 process.

4.5.5 Freeboard and upstream face wave protection

Figure 2.1 of the Conceptual Design Report shows Reservoir cross sections and indicates that the crest of the reservoir will have the following characteristics:

> Crest 8m wide with cycle/footpath, low
> wave wall available for seating. Crest level
> 1m higher than maximum water level.

As usual in the Thames Water documents on Abingdon Reservoir design, more attention is paid to the issue of where visitors will sit or ride their bikes than how safe the design is. As indicated in the section on terrorism above, the height of the crest above maximum water level is thought to be too low. This opinion has also been expressed by ex-Reservoir Panel engineers to whom we have shown the design.

Minimising the crest height is important to the aspirations of Thames Water because of the criticism of the imposing height of the reservoir overlooking the surrounding housing, and the need to have launch sites for sailing and areas for fishing. It is GARD's view that these have been more important than the design to avoid wave overtopping in high winds.

GARD has consulted the design advice document from HR Wallingford relating to reservoir crest design.[114] In common with other sources, the design recommendations cover design against overtopping in a period of subjection to the "*50-year wind*", ie the wind conditions expected (from historical measurements) to occur once in every 50 years. At present, there are no clear predictions from climate change models about the frequency of high winds, so we adopt this standard. There are (SR459, equation 2.3) factors to apply to the wind values according to:

- the '*fetch*' or distance over open water of the wind before it reaches the retaining wall (as wind speeds up over open water) – this figure is significant for Abingdon reservoir, as there are distances of around 2.5 km or more over open water;

[114] *Reservoir Dams: wave conditions, wave over-topping and slab protection,* A J Yarde, L S Banyard and N W H Allsop, HR Wallingford report SR459 (1996)

- the '*duration*' of the wind speed (20-30 mins is considered appropriate for reservoirs – the wind speed map being quoted as averaged over one-hour) – shorter durations give higher waves;
- the '*altitude'* of the reservoir (wind speed maps are at ground level);
- the '*repeat time*' of the significant wind (we take 100 years as reasonable considering the reservoir lifetime, but this only results in a 5% increase);
- the *'direction'* of the prevailing wind, relative to the measurement direction (relative to 240°, or WSW) – this is irrelevant for an 'all-round embankment like Abingdon.

The combined effects of these factors is to change the wind speed for consideration of the *significant wave height* from 20 m/s to 27 m/s (=U)[115]. From this, the significant wave height becomes (equation 2.6 of SR459)

$H = 0.00178\sqrt{F}/\sqrt{g}$ metres where F is the fetch length (metres) and g is the acceleration due to gravity (m/s^2).

Giving $H = 0.67m$.

SR459 considers that a factor for '*no wave surcharge carry over'* of 1.67 should be applied to the significant height giving a wave design height of 1.15 m.

This value can be lowered by facing the run up with rip-rap (as in the Conceptual Design) and, for a 1 in 6 slope (as CDR) with rip-rap a factor of 0.6 is used (figure 3.1 of SR459) leading to a final wave design height of H_D = 0.69 m.

If we take from SR459 fig 3.4, the value for 'safe' overtopping of the wall as 2 l/s/metre wall length, and apply formulae as in Box 5.3 of the document, we derive a freeboard height of around 1.5 m. This still seems low (and we should bear in mind the comments regarding Terrorist threats above), but is higher than the CDR value.

We make the following observations:

- even at this value 'safe overtopping' value, there would be an overtopping of around 7.2 tonnes (7.2 m^3) of water per hour over a 100m stretch of wall where the wind speed might exist – the downstream slope of the bund needs to take this into account;
- the freeboard height minimisation is heavily dependent on the use of rip-rap protection. This is foreseen in the conceptual design, but we note that the 'brochure' and 'Facebook picture' depiction of a smooth concrete slope for launching boats is at variance with

[115] This corresponds to the upper end of Storm Force 10 on the Beaufort Scale. It is somewhat higher (10-20%) than the *mean* inland wind speeds recorded in the south-east in the October 1987 Storms.

what a rip-rap protected slope actually looks like. Sailing boat launching over a 'rip-rap field' of considerable extent with such a shallow slope would not be a simple task.

Whilst these figures have been established in a relatively rudimentary fashion, we believe that Thames Water need to justify explicitly their selection of a 1.0m high crest. We believe that this has been selected with leisure activities, rather than safety against high waves, in mind.

4.6 Benefits to TW shareholders and impacts on customer bills

4.6.1 Regulatory incentives to build capital projects

The 'costs' of Water Resource Management Plans, and hence of Regional Plans never include a discussion of the effect of including ***Regulatory Capital Value (RCV)*** of Companies in the charges to water customers, according to the formulae set up by the Regulator (Ofwat). We cover this in some detail in Appendix C. In short, the inclusion of RCV-related items in Ofwat's Pricing has the following effects:

1. There is a fundamental and extremely perverse incentive in the Water Industry regulatory regime that encourages investment in "big concrete" projects as the solution to any and all problems.

2. All expenditure by a Water Company that can be classified as being of a capital nature, including for example, building a reservoir and including the cost of developing proposals for a such capital asset, is added to the water company's ***Regulatory Capital Value (RCV)*** *and the company has a statutory right to make a real return on that RCV in all future years.*

3. These perverse incentives in the regulatory environment specifically *favour very long-life assets such as a reservoir in contrast to alternative methods of securing water for the southeast.* The alternatives to the reservoir include the Severn to Thames Transfer, desalination and fixing leaks. All these alternatives involve lower capital expenditure and shorter life assets. Consequently, these alternatives look less attractive from the perspective of Water Company shareholders.

4. If the reservoir were to go ahead, Water Company shareholders would still be earning their guaranteed return on the reservoir in 250 years' time. The asset lifetimes used for regulatory return calculations (and for accounting depreciation) significantly favour reservoirs (250-year life) over tunnels, pipelines and other water network assets (80 – 100 year lives).

5. Almost all Water Companies have highly geared balance sheets with very high levels of borrowings. These borrowings which have all been incurred since privatisation have largely been used to fund payments to previous shareholders. As a consequence of their corporate structures and high borrowings, most Water

Companies have paid very low levels of corporation tax, if any at all, for many years. As an example, the accounts of Thames Water will be analysed in this dWRMP response.

4.6.2 GARD's Financial Model

GARD created a financial model using cost and other data contained in the RAPID Gate 2 document for the Abingdon Reservoir and the Thames Water dWRMP. The model also used data from the Competition and Markets Authority's (CMA) determination on the elements of WACC. GARD have used this model to calculate the cashflows arising from over the 250-year life of the reservoir, 2022 to 2285. We will be giving more detail in our response to the Thames Water dWRMP24, but we note briefly:

- *The increase in Shareholder Value that would immediately arise and benefit the Shareholders* in the three Water Companies who would jointly own the reservoir if the Abingdon 100 Mm^3 were to be given the go ahead (Thames Water, Affinity Water and Southern Water), would be £846 million. This arises from the return on the increase in Regulated Capital Value (RCV) resulting from the £1,878 million Capital Expenditure on the reservoir, and discounted back to the present. All these numbers are fixed in 2022 currency.

- GARD separately calculated the increase in Shareholder Value that would arise if the same amount of money identified as the initial construction cost of the reservoir, £1,878 million, were instead to be spent on increased operating expenses over the same period, to reduce leakage and to reduce demand. We believe that the answer is zero.

- There is therefore a ***staggering £846 million incentive*** within the Regulatory Regime to build the reservoir rather than to accelerate the reduction of leakage and the reduction of consumption.

- Additionally, Water Company customers would pay a huge cost for the reservoir: we calculate £4,829 million over 80-year WRSE planning horizon and £13,673 million over the 250-year life of the reservoir. Again, all these numbers are fixed in 2022 currency.

- In contrast, the additional cost that Water Company customers would pay for an additional £1,878 million of operating expenditure to reduce leakage and to reduce demand is only £1,878 million. ***The reservoir would therefore cost customers an additional £3,041 million over the 80-year planning horizon of the WRSE process.***

GARD have used £1,878 million here to illustrate the differing financial consequences to customers of the same value of expenditure on different things. These aspects of costs to consumers need to be:

- made explicit in any evaluation of dWRMP and Regional Plans (and the only way this can be done is if they are transparently laid out by WRSE and the companies in these plans;
- *used in a metric* as input to the establishment of a Best Value Plan. In some senses the '*Inter-generational Equity*' (IGEQ) metric could be a place to start. However, at present, the explicit use of a IGEQ metric seems not to be in the Thames Water Best Value Plan calculation, whilst the use of IGEQ in WRSE's Plan only includes costs based on NPV discounting[116]. GARD has previously called for inclusion of the financial effects of RCV in the IGEQ metric[117] . ***We re-iterate this call here.***

Our findings re-iterate our view that the building of the reservoir is on all measures worse than the alternative examined here of reducing leakage and consumption: it is more expensive and specifically more expensive for customers, has a materially worse carbon footprint, is more environmentally damaging, is less resilient and, specifically, less drought resilient.

[116] https://www.wrse.org.uk/media/1g3jh5vs/wrse-best-value-plan-doc-final.pdf
[117] See response to Thames Water dWRMP19: https://www.gard-oxon.org.uk/downloads/GARD%20%20response%20to%202nd%20Consultation%20on%20TW%20draft%20WRMP%20Rev%2029.11.18.pdf

5. The proposed Severn to Thames transfer

5.1 Thames Water's planned deployment of the STT

In Thames Water's preferred 'Best value' programme, the Severn to Thames transfer would be deployed as follows:

> *"Our preferred programme, which sets out options required under a 'High' future scenario of licence reductions, includes the development and construction of the STT for use from 2050 onwards, with the scheme likely to initially be used in a largely 'unsupported' form, with phased introduction of 'support' sources. Used in this way, the STT provides a modular, adaptable source of water, whereby water from support sources can be introduced as and when necessary, rather than being relied upon to provide a large 'baseload' source under which conditions the high operating costs and emissions make the scheme less favourable."*

We have shown in Section 3.6 that, if Thames Water's deficit is realistically estimated and Government leakage and PCC targets are met, no major new sources like Abingdon reservoir or the STT are needed to maintain target headroom in the South East water company supplies. We recognise that there is a risk that Thames Water will fail to meet to meet the PCC and leakage targets, which is why we have suggested early construction of the Severn to Thames transfer aqueduct, which then provides the ability to keep adding support sources if needed.

Therefore, we do not agree that the STT should be delayed until 2050. As Thames Water say above, the STT provides a modular, adaptable source of water, whereby water from support sources can be introduced as and when necessary. We propose that the STT transfer aqueduct should be built as quickly as possible, initially with only a small amount of support sources, but with the capability of adding new sources as needed.

We also think it should be recognised that there is a strategic need to transfer water from the relatively wetter and less populated north and west of the country to the dry and heavily populated South East. This need has been a primary conclusion of every strategic water resource study of the past 50 years including the strategies of the Water Resources Board in the early 1970s, the National Rivers Authority in 1994, Water UK in 2016 and the National Infrastructure Commission in 2018. By delaying the Severn to Thames Transfer to 2050, Thames Water is removing the possibility of any major transfer into the South East for another 30 years.

5.2 Aqueduct capacity

With the realistic, but still reasonably cautious deficits we have shown in Section 3.6, we think that the proposed initial STT aqueduct capacity of 500 Ml/d is too high. We think it inconceivable that this amount of transfer would ever be needed, especially if abstraction reductions for improved river flows are properly prioritised, with account taken of the costs and environmental impacts of replacement sources, as we have advocated in Section 2.3.2.

We suggest that a 300 Ml/d aqueduct capacity, or at most 400 Ml/d, would be sufficient for a reasonable insurance against climate change and population growth being much worse than expected.

A 300 Ml/d aqueduct could be provided by the Cotswold canal transfer, with its potential for a lot of secondary benefits through the canal restoration. This potential is recognised in the Gate 2 report on the STT as follows[118]:

> *"The assessment also recognised that the canal options have the potential to deliver a dual-purpose multi-sector scheme, not only to provide a mechanism for water transfer but also supporting the restoration of the Cotswold Canals for navigation. As a result, a 'potential futures' study was undertaken to consider whether the selection of this option would be a better outcome for society and the environment than a pipeline transfer. The conclusion of the study was that, despite the increased monetizable benefits attributable to scenarios where navigation is enabled, they did not significantly reduce the higher cost of a canal transfer. When qualitative factors such as resilience and environmental impacts were considered, the pipeline was also shown to be the preferred option. It should be noted that these are the findings for Gate 2 only: they will be further developed alongside stakeholder consultation for Gate 3."*

We strongly support the Cotswold canal transfer scheme being given further consideration for Gate 3. However, we recognise the operational difficulties that it might bring and feel that from a purely water supply perspective the pipeline option can probably be built faster and carries less risk, both for construction and in operation.

5.3 Deployable output assessment

As for Abingdon reservoir, GARD's ability to comment on the assessed deployable output of the STT is severely limited by the lack of stochastic flow data and Pywr model output requested by GARD on 12th December 2022 under EIR-22-23-390. We will respond in more detail on this aspect when the requested data is eventually received and we have had time to review it, including the use of the stochastic river flow data in our own models.

The Gate 2 report on the feasibility of the STT includes the following table of deployable outputs of the 500 Ml/d STT and its various potential support sources in the order they are planned for introduction[119], with the derivation of the deployable outputs coming from the

[118] STT Gate 2 Feasibility Report, paragraph 6.25
[119] STT Gate 2 feasibility report, November 2022, Table 4-2

plot below the table, which is taken from the Pywr modelling report for the STT[120]:

Table 4-2. Summary of STT maximum capacity and average and peak DO potential

Source element sequence	Element	Max flow (Ml/d)	Incremental flow (Ml/d)	Loss before Deerhurst (%)	Max flow at Deerhurst (Ml/d)	Average DO at WRSE (Ml/d)	Peak DO* at WRSE (Ml/d)
1	Netheridge	35	35	0	35	24	34
2	Unsupported flow – 500Ml/d pipe	500	500	0	n/a	134	134
3	Vyrnwy Release	50	50	15	43	29	41
4	Vyrnwy Release	75	25	15	21	14	20
5	Vyrnwy Release	100	25	15	21	14	20
6	Vyrnwy Release	135	35	15	30	20	29
7	Vyrnwy Release	155	20	15	17	9	12
8	Vyrnwy Release	180	25	15	21	17	24
9	Minworth	58	58	10	52	35	50
10	Minworth	115	57	10	51	35	49
11	Mythe	15	15	0	15	10	14
12	Shrewsbury Redeployment	25	25	15	21	14	19
Max unsupported flow at Deerhurst					500	134	134
Max support options at Deerhurst					328	221	313
Total DO received in the south east						354	447

*Peak DO at WRSE accounts for assumed losses in the interconnector at 2% and losses in the River Thames at 2%.

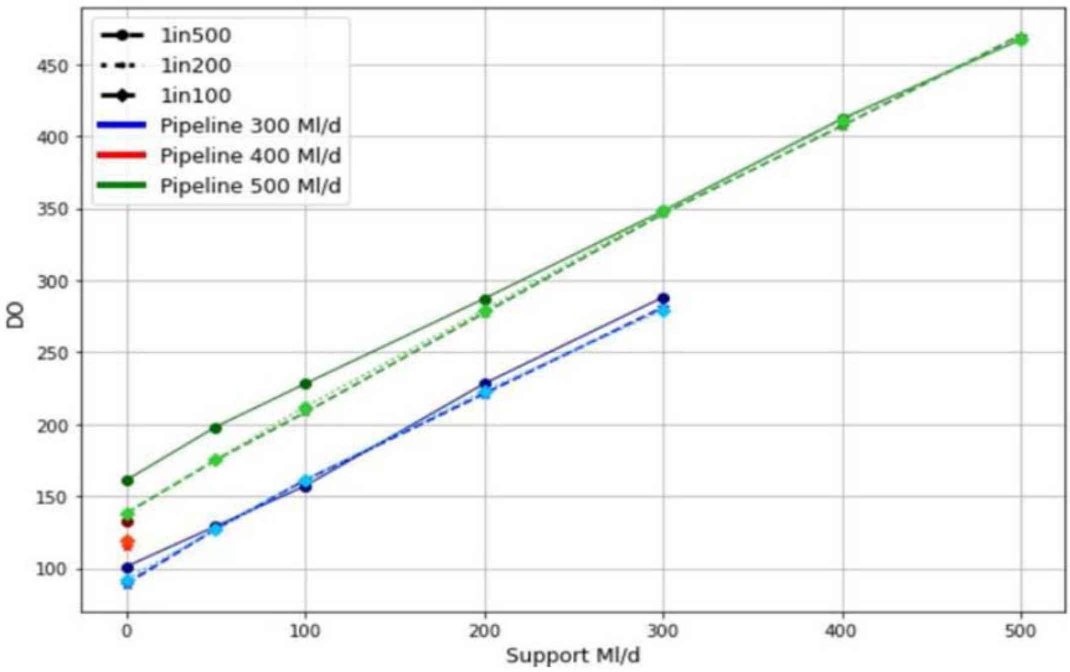

Figure 34 - Pywr assessed deployable outputs for STT variants and support sources

[120] Pywr modelling report for STT Figure 2-1

We have some initial comments on the DO assessments shown in Figure 30:

1. The numerous increments of support flows are a good illustration of the adaptability of the STT scheme to accommodate rising demands, once the initial aqueduct has been constructed.

2. We are surprised at the sequence of introduction of support sources shown in the table in Figure 20. We would have expected the Minworth support to have been introduced before the Vyrnwy support option, bearing in mind that enhanced treatment of Minworth effluent is proposed in AMP8 to provide support water for the Grand Union Canal transfer.

3. We would have expected the unsupported deployable output for the 500 Ml/d aqueduct to be somewhat more than 134 Ml/d, although it is not clear whether this includes the DO arising from the sweetening flow. We will look further at this with our own modelling once the requested stochastic river flow data are available.

4. The unsupported 134 Ml/d DO for the 500 Ml/d aqueduct is not consistent with the data shown in the following table from the report on STT Pywr modelling:

Table 2-1 - Summary of the planning DOs for STT scheme variants from the WRSE Pywr model (Ml/d)

STT scheme variant[4] (pipeline capacity and support at Deerhurst)	1 in 500 DO of STT (previous Pywr results) (erroneous[5])	1 in 500 "Planning" DO of STT (latest Pywr results)	Difference (1 in 500)	1 in 200 "Planning" DO of STT (latest Pywr results)	1 in 100 "Planning" DO of STT (latest Pywr results)
300Ml/d unsupported	146	101	-45	89	92
300Ml/d + 50Ml/d support	178	129	-49	127	127
300Ml/d + 100Ml/d support	197	157	-40	161	161
300Ml/d + 200Ml/d support	247	228	-19	221	223
300Ml/d + 300Ml/d support	284	288	3	281	279
400Ml/d unsupported	192	132	-60	115	119
500Ml/d unsupported	229	161	-68	138	138
500Ml/d + 50Ml/d support	256	198	-58	175	175
500Ml/d + 100Ml/d support	287	228	-59	208	212
500Ml/d + 200Ml/d support	339	287	-52	277	279
500Ml/d + 300Ml/d support	385	348	-37	346	348

Table 21 - Pywr modelled DO assessments for STT variants[121]

This table shows the unsupported 500 Ml/d transfer to have a DO of 161 Ml/d, as compared to 134 Ml/d in the Gate 2 report. The Gate 2 report is dated November 2022, so it post-dates the DO assessments from the modelling note as copied in Table 21. The difference could be due to up-dated modelling, but there appears to be no explanation in either report of factors that account for the difference.

[121] Summary note describing Pywr modelling of STT, 17th June 2022, Table 2.1

We also note that Table 21 shows deployable output increasing as the droughts become more severe. We have found no explanation of this surprising result and suspect that it may be an error. If the result is genuine, it carries the important implication that the STT is resilient against extreme droughts, so it surprising that it has not been explained and emphasised in the reporting.

Overall, we consider there to be a number of significant inconsistencies in the assessed deployable outputs of the STT options and we will comment further when the requested Pywr model outputs are available and we have had time to study them and conduct our own modelling.

5.4 Deployable output of GARD proposed first phase of the STT

GARD's proposed first phase of the STT, as proposed in Section 3.6, would comprise (with TW's deployable output values from Tables 20 and 21):

	Deployable output
• The 300 Ml/d aqueduct (either by pipeline or canal)	101 Ml/d
• Netheridge support	24 Ml/d
• First and second phase Minworth support	70 Ml/d
Total DO	195 Ml/d

The costs and impacts of this first phase are compared with the 100 Mm^3 Abingdon reservoir in Section 6. The deployable outputs could increase following GARD's review of the Pywr model output, when available.

6. Comparison of Severn to Thames transfer vs Abingdon reservoir

6.1 Cost Evaluation of Abingdon Reservoir against STT

The choice between Abingdon reservoir and the Severn to Thames transfer as the next major new source in the South East, if needed, has been the big undecided issue ever since the Public Inquiry into Thames Water's WRMP in 2010. The comparative cost of the two options is, therefore, of fundamental importance to the outcome of the last 5 years of Ofwat's £470 million investigation into strategic resource options. In our opinion, Thames Water's WRMP and WRSE's regional plan have utterly failed to provide the clear cost comparison that is needed.

There is a lot of cost data available in the Gate 2 reports on each strategic option, scattered in separate cost and carbon appendices to the reports, which can be found, for the Abingdon Reservoir and the various component systems of the Severn Thames Transfer (STT) via these links:

https://www.thameswater.co.uk/about-us/regulation/strategic-water-resource-solutions
https://affinitywater.uk.engagementhq.com/strategic-resource-options
https://www.severntrent.com/about-us/our-plans/sro-plans/gate-2-documents
https://www.unitedutilities.com/corporate/about-us/our-future-plans/water-transfers/
https://www.southernwater.co.uk/our-story/our-plans/water-for-life-hampshire/other-strategic-regional-options

There are also cost data presented in the WRMP tables for each company, giving the strategic option costs attributed to each company. For Abingdon reservoir, the total costs in the WRMP tables are split consistently 41/30/29 between the WRMP tables for Thames Water, Affinity Water and Southern Water. The presentation of costs in the WRMP tables is much more detailed than in previous WRMPs and is in a similar format to that previously proposed by GARD. We note this with satisfaction, and are grateful for RAPID's efforts to make this happen. However, making cost information available is not the same as presenting it transparently to justify choices between options. Failure to present the cost comparisons clearly is just as bad as failing to provide cost data at all.

Furthermore, there is a £90 million discrepancy between 100 Mm^3 Abingdon Reservoir capital costs in the Gate 2 cost report[122] and the data shown in the water company WRMP tables:

[122] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/south-east-strategic-reservoir/gate-2-reports/A-2---SESRO-Cost-Report.pdf

Item	In Gate 2 cost report	In WRMP tables
Initial construction cost	£1,244 million	£1,169 million
Costed risk	£286 million	£292 million
Optimism bias	£347 million	£326 million
Total capital cost	£1,877 million	£1,787 million

Table 22 - Differences between Abingdon reservoir costs in Gate 2 reports and cost table

Following the fact (cited in section 4) about the RAPID documentation being more up-to-date than either the WRSE draft Plan or the dWRMP24, we will use the RAPID Gate 2 costs for all of our own comparisons of costs.

6.1.1 Transparency

Initially, all the STT costs have were deleted from the WRMP tables, and following interventions by stakeholders and RAPID, this was reversed, but, there has always been a lot of STT cost information in the Gate 2 cost reports, including some tables presented as annual costs spread over the 80-year planning period, in the same format as the WRMP tables. Although there is now a fair amount of cost detail available for the strategic options, there are no option cost comparisons to justify the selection of options and their sequence of development. These comparisons might be expected to be prominently available in regional plans and the WRMPs, as like for like comparisons of the STT and Abingdon reservoir, with the same starting date and the same deployable output. These would enable a genuine examination of whether STT or Abingdon reservoir is developed first, but there are none to be seen.

In addition, as noted above there is confusion between NPC and NPV and a further lack of information on what the number is that is used to evaluate the cost of each option as well as information as to how that number is calculated. We requested information to allow us to understand the option costs for Abingdon and STT on 15th January 2023, but have not received information to allow us to understand and confirm the correctness of the calculation of option cost. ***This appears to be a major failing in transparency.***

From a number of perspectives, the selection of Abingdon reservoir ahead of the STT is the major outcome of the regional plans and WRMPs. WRSE's plan page 29[123] says:

> *"Our work shows both SESRO and STT are needed but the reservoir is a better first option. This is because the reservoir has lower running costs. The plans with the reservoir developed first are less expensive and have lower carbon emissions."* [GARD does not accept the OPEX carbon costs argument – see Section 4.4]

And also on page 29:

> *"For the reported pathway, a plan without SESRO would cost £500 million more than the*

[123] https://www.wrse.org.uk/media/va1bz21z/10306a_wrse-bv-plan-2022final_online.pdf

best value plan and have significantly higher carbon costs. "

GARD could find no further justification anywhere in WRSE's main report or technical annexes. For the details of our criticism of WRSE's program selection criteria, including costs, see our WRSE draft Regional Plan response.[124]

Thames Water's summary of the WRMP, page 25[125], justifies the selection of Abingdon reservoir ahead of the STT as follows:

> *"A new reservoir has lower running costs than a regional water transfer, so it makes sense for it to come first. Also, the plans with a reservoir first are less expensive and have lower carbon emissions overall."*

The exact opposite of this argument should be used. There will be little need to use either the STT or Abingdon reservoir as demands slowly rise so it makes sense to first develop the STT because it has a lower capital cost.

However, as we have already quoted in Section 5.1, Thames Water cite the following, for their decision to implement the STT *after* the Abingdon Reservoir:[126]

> *"Our preferred programme, which sets out options required under a 'High' future scenario of licence reductions, includes the development and construction of the STT for use from 2050 onwards, with the scheme likely to initially be used in a largely 'unsupported' form, with phased introduction of 'support' sources. Used in this way, the STT provides a modular, adaptable source of water, whereby water from support sources can be introduced as and when necessary, rather than being relied upon to provide a large 'baseload' source under which conditions the high operating costs and emissions make the scheme less favourable."*

Thus, Thames Water cite many of the major advantages of the STT: it is modular, it is adaptable, and can be introduced as an when necessary. They omit the further list of attributes which make STT a contender as first choice: these specifically are its earlier realisation than the Abingdon Reservoir, its obvious advantage at bringing new water into the Thames catchment, and its lower embedded carbon footprint, when compared to equivalent versions of the Abingdon reservoir. GARD also does not accept the attribution of '*high emissions'* to the project in the scenario of a decarbonised grid and questions the cost estimates which seem to include very high usage for the STT support, whereas the RAPID Gate 2 documents show its operation at high flow would only happen between 20-25% of the time over the planning period.

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[124] https://www.gard-oxon.org.uk/downloads/Final%20GARD%20Response%20to%20WRSE%2022%202%2023%20v4.pdf
[125] https://thames-wrmp.co.uk/assets/images/documents/non-technical-summary.pdf
[126] dWRMP24 Technical Documents, section 11, para 11.136

6.1.2 Indirect cost comparisons

Direct comparison of option costs are not given in either the WRSE draft Plan, or the Thames Water dWRMP. There are '*sensitivity tests*' given which purport to show that it is neither '*Least Cost*' nor '*Best Value*' to implement an STT scheme before an Abingdon Reservoir. Of course, as the Reservoir, of any sort, has a fixed implementation date of 2040, this requires quite a lot of dexterity to try to 'hobble' the STT. In any case, these sensitivity tests are compromised as the change from one program to another does not just involve anything akin to a 'like for like' interchange of Abingdon and STT. Examples are shown by sensitivity tests in Section 10 '*Programme Appraisal*' of Thames Water's WRMP,[127] as shown below:

Table 10 - 12: Sensitivity run outputs – option availability (SESRO and Teddington DRA)

Metric	Least Cost	No SESRO	SESRO 125 Only	SESRO 100 Only	SESRO 75 Only	No Teddington DRA
	Pathway 4					
Cost	15.37	15.94	15.45	15.44	15.67	15.82
Carbon	5,610,401	6,041,727	5,532,038	5,676,794	5,501,756	5,756,145
Natural Capital	7,494,195	6,477,558	6,094,152	10,847,786	9,678,647	7,736,003
Bio Net Gain	-258,496	-351,987	-294,132	-305,256	-296,398	-252,201
SEA Env +	84,475	85,359	85,461	85,385	84,836	83,795
SEA Env -	115,629	122,912	118,090	115,662	119,687	118,320
Cust_preference	32,452	32,894	32,472	32,457	32,532	32,225
Reliability	38	36	38	37	36	37
Adaptability	19	18	19	19	18	18
Evolvability	27	27	27	27	26	26
Large Options First Utilisation Date	Teddington (2031)	Teddington (2031)	Teddington (2031)	Teddington (2031)	Teddington (2031)	Beckton Reuse 50 (2031)
	SESRO 150 (2040)	STT300 (2038-49)	SESRO 125 (2040)	SESRO 100 (2040)	SESRO 75 (2040)	SESRO 150 (2040)
	STT300 (2050-60)	Desalination Beckton 150 (2050)	STT500 (2050-61)	STT500 (2050-60)	Desalination Beckton 150 (2040)	Desalination Beckton 150 (2050)
	Deephams (2061)	Re-use Beckton 150 (2060)		Deephams (2060)	STT300 (2050-61)	Beckton Reuse 100 (2058)
						STT300 (2060)

Table 23 - Sensitivity analysis on size of Abingdon Reservoir

[127] https://thames-wrmp.co.uk/assets/images/documents/technical-report/10-Programme-Appraisal-and-Scenario-Testing.pdf

Table 10 - 13: Sensitivity run outputs – option availability (STT)

Metric	Least Cost	STT300 in 2040	STT400 in 2040	STT500 in 2040
	Pathway 4			
Cost	15.37	15.64	15.93	16.04
Carbon	5,610,401	5,731,952	5,810,849	5,842,753
Natural Capital	7,494,195	7,473,972	7,340,154	7,349,998
Bio Net Gain	-258,496	-252,253	-260,667	-264,743
SEA Env +	84,475	85,251	85,011	85,611
SEA Env -	115,629	114,815	119,684	119,211
Cust_preference	32,452	32,333	32,749	32,616
Reliability	38	38	38	38
Adaptability	19	19	19	19
Evolvability	27	27	27	28
Large Options First Utilisation Date	Teddington (2031)	Teddington (2031)	Teddington (2031)	Teddington (2031)
	SESRO 150 (2040)	SESRO 150 (2040)	STT400 (2040-61)	STT500 (2040-63)
	STT300 (2050-60)	STT300 (2050-65)	SESRO 150 (2045)	SESRO 150 (2045)
	Deephams (2061)			

Table 24 - Sensitivity analysis on STT option availability

The 'cost' shown in these tables is the total NPV cost in £ billions *for the entire WRSE programme, ie the costs of all six SE water companies and all new sources and other measures, including metering and leakage control*. '*Pathway 4*' is the second highest future deficit scenario considered by TW (see Figure 10-7) and is the preferred scenario assumed in TW's plan. It corresponds to local authority housing plans, '*high*' environmental ambition (principally referring to the level of Sustainability Reductions) and '*high*' climate change assumption. Under this scenario, both Abingdon reservoir and STT would be needed. Under the scenario which GARD will advocate – ONS population growth, prioritised Sustainability Reductions and realistic climate change – only one or the other of STT and Abingdon reservoir would be needed and then mainly as an insurance against population growth and climate change being much worse than reasonably cautious estimates..

We can draw the following limited conclusions that can be drawn from TW's option comparisons in their Tables 10-12 and 13:

- Without Abingdon Reservoir, TW say the programme would be £500 million more costly (£15.94 billion less £15.44 billion for the 'SESRO 100' cost in Table 10-12). This corresponds to the £500 million extra cost which WRSE say will be the result of excluding Abingdon Reservoir. However, there is a difference in the accompanying programmes (Beckton Desalination and Re-use schemes, and STT300 in the 'No SESRO' case vs STT500 and Deephams re-use in the 'SESRO 100' case) which makes direct comparison problematic to say the least.

- Constructing the 300 Ml/d or 400 Ml/d STT versions instead of the 500 Ml/d STT would save £400 million or £110 million respectively (see Table 10-13). That being the case, it is difficult to understand why TW have assumed the eventual construction of the 500 Ml/d STT rather than the smaller versions.

However, the information provided in TW's Tables 10-12 and 10-13 gives no explanation of why the STT is said to be £500 million more costly than Abingdon reservoir.

The real agenda, that of not countenancing a start to STT until the Abingdon reservoir is safely 'off the blocks' can be seen by looking at a subsequent table in the '*Program Appraisal*' section of the dWRMP. This is table 10-15, which purports to show a sensitivity analysis of the delivery date of 1 in 500 year Drought Resilience

Table 10 - 15: Sensitivity run outputs – Drought resilience delivery dates

Metric	Least Cost (1:200 in 2030 1:500 in 2040)	1:500 in 2035	1:500 in 2045	1:500 in 2050	1:200 in 2034
	Pathway 4				
Cost	15.37	15.40	14.96	14.47	15.16
Carbon	5,610,401	5,428,533	5,323,291	5,274,253	5,316,851
Natural Capital	7,494,195	7,416,757	6,638,086	7,366,676	7,599,741
Bio Net Gain	-258,496	-240,002	-233,651	-236,180	-246,110
SEA Env +	84,475	86,204	85,294	83,452	84,665
SEA Env -	115,629	121,563	116,252	116,330	119,260
Cust_preference	32,452	33,040	32,493	32,524	32,716
Reliability	38	38	38	36	37
Adaptability	19	19	19	18	19
Evolvability	27	27	27	25	26
Large Options First Utilisation Date	Teddington (2031)	Teddington (2031)	Teddington (2031)	Teddington (2031)	
	SESRO 150 (2040)	Trade with Affinity linked to GUC100 (2035)	SESRO 150 (2045)	SESRO 150 (2050)	SESRO 150 (2040)
	STT300 (2050-60)	SESRO 150 (2040)	STT300 (2050-61)	Beckton Reuse 50 (2053)	Desalination Beckton 150 (2050)
	Deephams (2061)	STT300 (2050-61)		Desalination Beckton 100 (2060)	Teddington (2053)
				Deephams (2061)	Deephams (2060)

Table 25 - Sensitivity analysis on STT option availability

This table has the fault of tables 10-12 and 10-13 shown above, ie. that the difference between the competing programs involves switching of several large programme options, but it is very noticeable that the STT, which could deliver the 1 in 500 Year Drought Resilience by 2035, is not anywhere tested at an early date. This shows that the interest of Thames Water is only directed at preserving their long-time favourite project (Abingdon) at the expense of not allowing the full flexibility that can be achieved by STT. A proper sensitivity analysis should be done concentrating on the effect of those systems capable of early delivery, ie. comparing STT with the GUC 100, and also with accelerated Demand Management options. Instead, the concentration on the latter part of the programme (which is evident from the number of schemes mentioned above whose delivery date is *after* the 1 in 500 delivery year) is not giving a true picture, and this thinking is not robust to scenarios with climate change involving more frequent extreme events at an earlier stage.

6.1.3 Direct Cost comparison of versions of Abingdon Reservoir and STT

Due to the lack of information just described, we are unable to compare directly the costs of WRSE's preferred STT and SERSO options. We have therefore done the closest we can with the available information. As an example, we use a version of STT which we will define as '*STT Phase* 1'. This concentrates on a configuration (see section 5.4) which implements the 300 Ml/day STT pipeline and which relies for support on:

- the Minworth STW Strategic Option (with 115 Ml/d max capability);
- the Netheridge STW

This combination gives a deployable output of 195 Ml/d, as derived from Table 4-2 of the STT Gate 2 feasibility report [128]

- 101 Ml/d for the unsupported transfer
- plus 70 Ml/d from Minworth and 24 Ml/d from Netheridge,

This option is compared with the 100 Mm^3 option for Abingdon ('SESRO 100'), which has a stated deployable output of 185 Ml/d.[129]

It is appreciated that this STT option does not appear in either the TW or WRSE sensitivity tests, but GARD believes it forms a fair comparison, as it is close in deployable output, and one option, if taken first, rules out the other for at least a decade. The choice of 'STT Phase 1' has the following advantages:

- the costs of the Vyrnwy replacement sources are omitted – there is not complete certainty from United Utilities as to when Vyrnwy support will be available;
- it is conservative, as the virtually cost-free Vyrnwy direct release of 25 Ml/d (see Gate 2 STT cost report)[130] could be added on a very short timescale, without the construction of the Vyrnwy bypass;
- the choice of the Minworth STW support has the advantage of being 100% resilient against climate change or extreme droughts;
- the option to upgrade Minworth to 115 Ml/d STT support in one go in combination with the upgrade to support Grand Union Canal (which GARD supports as an early

[128]https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/water-transfer-from-the-river-severn-to-the-river-thames/gate-2-reports/STT-G2-S1-001-STT-Detailed-Feasibility-and-Concept-Design.pdf

[129] Note GARD would dispute this amount in our response to Thames Water's WRMP, as we believe that the Emergency storage allowance in all SESRO concepts is too low, but we go with the 'official' estimates for now.

[130] STT Gate 2 cost report Appendix A, section 1.2.

part of the WRSE and Affinity Plans) is expected to save some £40 - £50million in CAPEX costs, as shown in table 8.1 of the Minworth SRO Gate 2 report.[131];

- for future upgradability, GARD also believes that replacement sources will be much less costly than stated by United Utilities, if a realistic view is taken of the need for environmental reductions in the North West – this would make less expensive local sources available for transfer, instead of being needed as replacement sources for unjustified environmental reductions;
- the limiting of the implementation to the 300 Ml/d pipeline option still ensures upgradability to take another 75 Ml/d of Vyrnwy bypass sources, should the need arise at a later date. Note that GARD's modelling shows that the 400 Ml/d pipeline option would take all the eventual possible Vyrnwy sources.

The costs of these options have been copied from the WRMP24 format cost tables in various Gate 2 documents[132 133 134 135]. The summary of the cost comparison is shown below:

	Abingdon reservoir 100 Mm3	300 Ml/d STT with Minworth and Netheridge
Initial Capex	£1,878 m	£1,171 m
Opex in Gate 2 report	£4.3 m/year	£43.7 m/year
GARD modelled opex	£4.3 m/year	£18.3 m/year
NPV with Gate 2 opex	**£1,301 m**	**£1,544 m**
NPV with GARD opex	**£1,301 m**	**£1,165 m**

Note: the Capex and Opex are at 2020/21 prices with no discounting

Table 26 - Comparative costs of 100 Mm^3 Abingdon reservoir with 300 Ml/d Phase 1 STT

This shows that the STT Phase 1 option NPV is cheaper than the equivalent Abingdon Reservoir, if OPEX is costed at a realistic flow pattern. The modelling done by GARD, although it needs to be updated as previously discussed when the new Pywr model results are available, indicates a usage well below the 24 – 29% usage at full flow derived from the STT Gate 2 tables [136]

Therefore, it appears that the 300 Ml/d STT Phase 1 option, supported by Minworth and Netheridge would be about 10% less costly than Abingdon Reservoir 100Mm^3 if Opex were to be costed realistically. However, even this is not a fair comparison, because the 300 Ml/d capacity connector is over-sized if the support is limited to Minworth and Netheridge. As indicated above, GARD modelling suggests that the 209 Ml/d deployable output could still be achieved if the connector were fed an additional source from the Vyrnwy direct release.

[131] https://Minworth_gate_two_submission_111122_-_Redacted.pdf
[132] SESRO Gate 2 cost report, page 28
[133] STT Gate 2 cost report Appendix A
[134] Minworth Gate 2 report, Annex K1
[135] STT Gate 2Annex K1, page 2
[136] STT Gate 2 documents – Annex A3-1 Detailed Cost Report, table 7-3.

The CAPEX costs in the GARD comparison for the 3 components of STT Phase 1 are all as per the Gate 2 cost reports (no advantage taken for simultaneous upgrade of Minworth for STT and GUC[137]). The timing of construction of the STT has been adjusted so that its operation starts in 2039-40, matching the start of operation of Abingdon Reservoir, assuming a 2 years fill-time after the end of construction.

As indicated above the STT Gate 2 report actually includes figures for utilisation of the supported options at 22.3-22.6% for both '*historical*' (1920-2010) and '*Stochastic*' (series generated based on 1950-1997 dataset) modelling' of the WRSE system[138]. In the GARD model, the STT operating costs are modelled as for the average utilisations for the STT operating in conjunction with the London reservoirs to deliver a deployable output increase of 194 Ml/d. The operating costs are thus far less than for the maximum utilisations assumed in the Gate 2 and WRMP (£18.33million per annum vs £43.7million), with consequent reduction in the total NPV for the STT in its Phase 1 configuration.

GARD were informed[139] that the diameter of the pipe[s] chosen for the interconnector will require water to be pumped downhill from the summit as well as uphill to the summit. We are informed that this pumping prevents the recovery of the gravitational potential energy provided to raise the water, for example, using turbines or Archimedes screws, at times of peak flow. We further understand that when the flow is only the sweetening flow recovery of this gravitational potential energy is possible, and that the electricity generated can be used to reduce the Opex. The inability to recover energy at higher flows materially inflates the operating costs of STT. We believe this is unnecessary. We believe that this needs to be evaluated more thoroughly.

We also believe the variable unit operating costs for STT to be excessive. We cannot find a quoted cost of electricity in the documents. The STT cost report summary, page iv, has this statement:

We note that the current high costs for power have not been incorporated in the variable calculations and rates will be reviewed at Gate 3 across all options

.

Therefore, it is possible that there might be some increase in the OPEX costs at Gate 3 which would affect the STT option more than Abingdon reservoir. However, we note that the recent higher price of electricity has been driven entirely by increase in the price of gas caused by the war in Ukraine and that as the price of gas has already returned to more normal levels we consequently expect any long-term impact on the price of electricity to be small. Furthermore, the planned de-carbonisation of electricity which the water companies are required to assume in their plans, will eliminate gas-derived electricity entirely and we therefore expect that the power costs for Gate 3 will not be significantly higher than

[137] This saving is expected to be about £47million.
[138] Ibid [62] table 8.1
[139] Thames Water drop-in meeting (Gareth Thomas) statement, Abingdon, 20th January.

currently assumed. We therefore believe that the STT option could still be less costly than Abingdon.

6.2 Carbon footprint assessments of Abingdon Reservoir and STT

6.2.1 Introduction

We have already considered the carbon footprint of the Abingdon Reservoir in Section 4.4 and established the following:

- The Abingdon Reservoir has the largest Capital (or 'Embedded') carbon footprint of any of the Strategic Resource Options.
- The Operational carbon footprint of the Reservoir is much lower in comparison.
- Offsetting of some of the Operational carbon footprint is achieved (and credited in the RAPID Gate 2 documents) by electricity generation using turbines as the water is released back to the River Thames.
- There are attempts to claim possibilities from reduction in the Capital carbon budget by technological developments with a completely unrealistic timescale (section 4.4.2). The only possible conclusion regarding these is that they would only become significant in the period after 2040 (ie. after the planned construction phase)
- There are aspirations to achieve carbon sequestration on the post-construction site, but, even if these are realised, their effect (as expressed in monetised form) on the Whole Life Carbon (WLC) of the Reservoir (See table 20) is negligible, varying from (section 4.4.3) about 2.0% for the 150 Mm^3 Reservoir to about 4.8% for the 75 Mm^3 version.
- The carbon footprint of the Abingdon Water Treatment Works and the Greenhouse Gas Emission from the Reservoir water surface, have both been omitted from the carbon budget for the Reservoir. The latter could be significant, as studies show it could be up to 150% of the carbon from pumping.

With these caveats, we now make a comparison of the carbon footprints of the Abingdon 100 Mm^3 Reservoir and the STT Phase 1 as defined in section 6.1.

6.2.2 Capex or Capital carbon

The Capital carbon for the STT Phase 1 comes from:

- The 300 Ml/d Aqueduct (pipeline) from Deerhurst to the Thames and the accompanying treatment;
- The 115 Ml/d upgrade to the Minworth STW;
- The Netheridge STW upgrade.

The carbon strategy and overview for the pipeline and treatment is given in a detailed RAPID Gate 2 report.[140] From this comes figure 4-1 (shown below as our Figure 35)

Figure 4-1 Capital Carbon for Deerhurst to Culham Interconnector (by pipeline capacity).

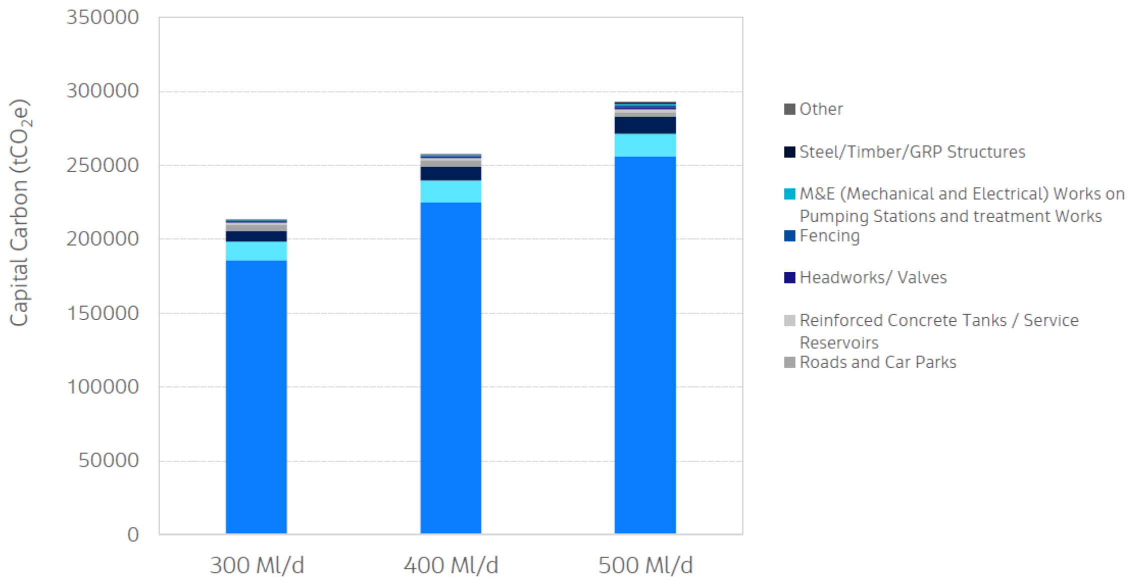

Figure 35 - Capital carbon for STT interconnector pipeline options

This shows that materials associated with the pipeline form about 87% of the capital carbon budget. As with the case for the Reservoir, discussed in Section 4.4, WRSE attempt in their draft Regional Plan Annex 2[141] to motivate a path forward for capital carbon reduction, eg. from section 11.13:

> *" … [an example of] this approach is for pipelines. For many large pipelines conveying vast quantities of drinking water around the region, 70% of the capital carbon emissions are attributed to producing the pipeline material itself. In the middle case (a moderate level of ambition), estimates by the ACWG indicate that 7% of carbon could be reduced in the manufacture of ductile iron pipes in the next 15 years, increasing to 39% in 15 to 35 years. Physically this would mean manufacturers of iron deploying stove flue or top gas recycling in most blast furnace-basic oxygen furnace sites, which is a transition the water companies can help promote by requiring contractors to use lower carbon materials thereby generating demand for these new materials"*

The report excludes alternative pipeline materials to iron and steel, whilst although they offer significant embodied carbon reductions and are, in some cases, widely available, they are '*not suitable for large diameter pipeworks*' involved in SROs

These figures for iron/steel are optimistic in the medium to long term, as it not only requires

[140] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/water-transfer-from-the-river-severn-to-the-river-thames/gate-2-reports/STT-G2-S3-360-Carbon-Strategy-Report.pdf
[141] https://www.wrse.org.uk/media/lanejwxx/wrse-draft-regional-plan-technical-annex-2-nov-2022.pdf

some research to be completed (not all iron grades are developed yet), but also testing and qualification programs (including long-term testing) and roll-out of factory refurbishment over a massive industrial plant complex (much of which is overseas[142] and on which UK Water companies have little leverage). Studies in other fields such as Nuclear power[143] have cited that it takes around 15 years to take an iron/steel variant from existence to the presence of *some* manufacturing capability. If the authors of the ACWG report cannot identify an actual *qualified* alloy available *now*, then it is highly unlikely to be available to contribute before a project start date of 2038-40. This emphasises not only the urgency to develop the materials, but also to revisit parts of SRO projects requiring long pipelines, and re-examine (eg. in the case of the Cotswold Canal version of the Severn-Thames transfer) solutions which limit the need for long-distance pipes.

The Capital carbon cost for the 300 Ml/d Interconnector (including treatment) is 243,191 $tCO_2eq.$, this is about 60% of the Abingdon 100 figure. We consider the substantial mitigation of this figure in the next decade is, as with the Abingdon Reservoir, rather low.

To this must be added the Minworth and Netheridge WwTW figures. For Minworth WwTW, the '*unmitigated*' capital carbon budget is given as[144] 130,048 tCO_2eq. There are various aspirations in the Minworth report, to mitigate this by around 40%, half of which is attributed to low carbon materials. The likelihood of achieving these low carbon materials in the next 5-10 years (the timeframe for Minworth, which is anyway being upgraded to serve the Grand Union Canal transfer) is, in our view, rather low, notwithstanding that the low carbon routemap for concrete[145] is at least in existence, which cannot be said for steel and low-emission heavy construction vehicles.

The capital carbon footprint for the preferred Netheridge WwTW option at Gate 2 has a value '*unmitigated*' of[146] 36,425 tCO_2eq. This gives a total capital carbon estimate for STT Phase 1 as 409,664 tCO_2eq.

Bearing in mind the accuracy of the estimates at this stage, one is drawn to the conclusion that the Abingdon 100Mm³ Reservoir and the STT Phase 1 have the same capital carbon footprint (although the STT carbon would be a lot less with the Cotswold canal option).

6.2.3 Opex or operational carbon

The Operational (Opex) Carbon burden is of course a concern for projects which require substantial pumping or pressurising action. These are often used to discriminate against

[142] Including in countries whose governments are not fully-committed to the COP26 agreement.

[143] See for example, D Stork et al., *Materials R&D for a timely DEMO: Key findings and recommendations of the EU Roadmap Materials Assessment Group*, Fusion Engineering and Design 89(7-8) (2013) 1586-1594. http://dx.doi.org/10.1016/j.fusengdes.2013.11.007 and references cited therein.

[144] Minworth SRO Gate 2 main document, table 6-3.

[145] https://www.ice.org.uk/media/q12jkljj/low-carbon-concrete-routemap.pdf

[146] https://www.severntrent.com/content/dam/sros-gate-2-documents/sts/STS-Gate-two-submission-(Final)-Redacted.pdf, table 6-1.

projects which are outside the reservoir category, although the Demand Management side (eg. Leakage Reduction and Water Efficiency measures) also has an even lower Opex burden and it never seems to be counted in its favour anywhere in the assessments.

We have already noted the caveats around the operational carbon footprint of the Reservoir. The carbon footprint of the Abingdon water treatment works and the Greenhouse Gas Emission from the Reservoir water surface, have both been omitted from the carbon budget for the Reservoir. The latter could be significant, as studies show it could be up to 150% of the carbon from pumping.

There are many issues regarding evaluation of Opex carbon for the transfer system, but we cite some below. We will return to these in more detail in GARD's submissions to the RAPID Gate 2 consultation responses.

1. As noted in section 6.1 (see table 14), the Opex costs quoted in the WRMP and RAPID Gate 2 documents seem to assume that the pumped transfer schemes are operating at full flow for a substantial fraction of the planning period. This increases the Opex carbon cost of transfers, and recycling schemes, relative to reservoirs. As can be seen in the RAPID Gate 2 documents, the STT SROs are expected to be operated for some 24 - 30% of the time at high flow (the lower figure for the 300 sized transfer). An example is given in table 4-1 of the Severn Trent sources Gate 2 document.[147] In GARD's modelling to date, the usage is much lower (14% at flow, split 9% supported/ 5% unsupported, ie. without Minworth and Netheridge operation above sweetening flow). This modelling will be updated when GARD has finally received the new Pywr model datasets for the Stochastic Drought series.

[147] https://www.severntrent.com/content/dam/sros-gate-2-documents/sts/STS-Gate-two-submission-(Final)-Redacted.pdf table 4 - 1

Table 4.1: Summary of utilisation over historic and stochastic time series of River Severn flow

Aspect	October 2020 historical (1920–2010)	April 2021 stochastic (climate drivers from 1950–97)
Overall utilisation throughout the complete time series – unsupported transfer	6.20%	7.80%
Overall utilisation throughout the complete time series – all types of support	22.30%	22.60%
Period of support in key droughts[4]	Top 5 historical	1 in 500-year droughts (as highlighted by WRSE)
	244 days (1944)	230 days (realisation 66, 1976)
	234 days (1921-22)	232 days (realisation 152, 1976)
	226 days (1976)	194 days (realisation 209, 1992)
	214 days (1990-91)	209 days (realisation 302, 1976)
	197 days (1945)	189 days (realisation 348, 1992)

Table 27 - Utilisation of 500 Ml/d STT option

2. Uneven detail exists in the evaluation of potential of energy recovery from the 'downhill' part of the inflow/ outflow of the various schemes. Although energy recovery is assumed in all schemes, the constraints (for instance the statement that energy recovery for the STT pipeline is 'less efficient' at high flow) have not been optimised. Whilst, as we show below, this does not have a major effect on Opex carbon, it does affect Opex costs of electricity use.

3. Operational use of chemicals is assumed to remain a substantial part of the Opex carbon budget, due mainly to the assumption that the decarbonising of this sector will take a long time (and the Power grid, the other main source of carbon, has a decarbonising trajectory). However, the same analysis needs to be applied to this source of Opex as has been applied to cement and pipeline iron/steel (See section 6.1). Whatever the limitations of those analyses, at least they are attempts. There is no attempt to assess carbon mitigation in the chemicals carbon operational budget in the WRSE draft Plan (section 11.20 of Technical Annex 2), and the STT carbon report assumes that the chemicals' carbon footprint remains the same until post-2050. This is a major failing, and it is hence impossible to compare Opex and Capex carbon strategies in the Plan (which starts with an un-mitigated chemical-Opex carbon equal to 25% of the whole unmitigated plan Opex value).

4. In contrast, the decarbonisation trajectory for the Grid electricity is considered in the STT pipeline report, showing a decrease out to 2050 and beyond. This is shown in Figure 36, taken from the STT Carbon report[148]:

[148] STT-G2-S3-360-Carbon-Strategy-Report.pdf, table 4-5.

Figure 4-5 Operational carbon hotspots for all three design sub-options at the proposed sweetening flow

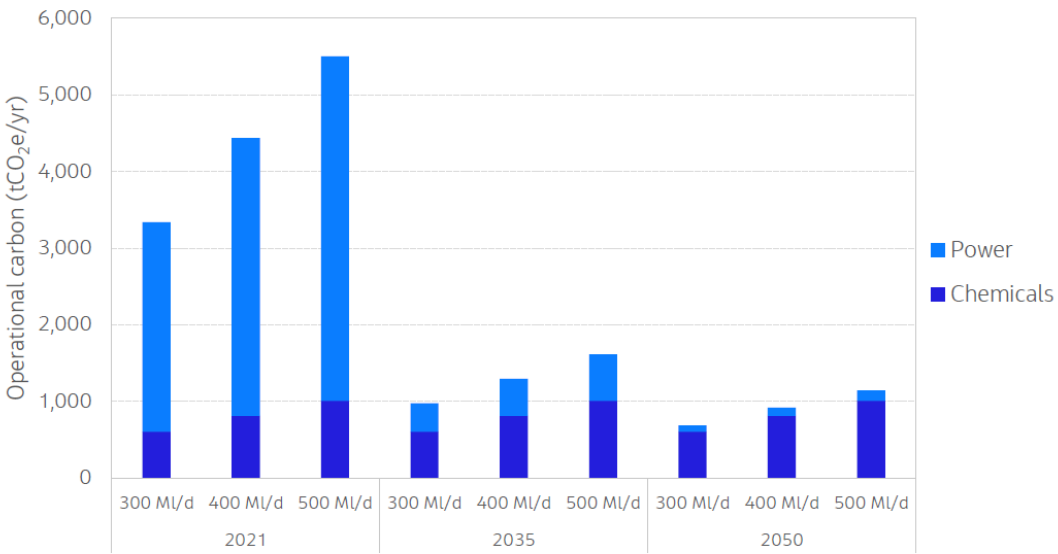

Figure 36 - Operational carbon budgets for STT Deerhurst interconnector options

5. However, proper account of decarbonisation of the grid does not seem to have been taken into account in the Minworth assessment, as there is the statement in the Minworth SRO document[149]:

   "Operational mitigation is recognition that STW will achieve its ambition of generating 100% of power from renewable sources by 2030 (representing a reduction of 66,619 tCO2e over 71 years) and optimisation of the outline control philosophy. There is also potential for a further reduction of 156 tCO2e annually, using a hydropower scheme at the River Avon discharge, not included in this assessment."

6. Thus the grid carbon burden is in a different stage even in the RAPID Gate 2 documents, and the exact operational carbon assessment cannot be made at this stage. Once again, GARD will attempt this when our STT usage is confirmed. It has to be said, however that this is not exactly transparent. In some senses, this should not need to be a criticism to be being made at this point. Ofwat has ruled that in both its '*High Technology*' and '*Low Technology*' common-reference scenarios, against which the companies are supposed to assess their plans, they are to assume 100% decarbonised electricity production by 2035[150] (which also affects the carbon footprint of all production of materials). In any case, the Opex electricity generation is seen to be a vanishingly small issue for all SRO schemes which come into operation post-2035 (this is STT and GUC Phase 2 in GARD's basic plan).

[149] Minworth SRO Gate 2 report, page 21 footnote 6.
[150] https://www.ofwat.gov.uk/wp-content/uploads/2021/11/PR24-and-beyond-Long-term-delivery-strategies-and-common-reference-scenarios.pdf pp33-34.

7. Further, non-technological development alternative options that avoid the need for additional treatment processes at Netheridge, are being pursued following discussions with the EA, which would reduce the whole-life carbon against even the preferred 'unmitigated' Gate 2 option[151].

Conclusions on Opex carbon comparisons

At this stage, without the detailed STT usage modelling, we will not make a detailed calculation of exact operational carbon budgets. This will be done for GARD's submission to RAPID, *provided we have received the Pywr stochastic dataset.*

As interim conclusions, we note that:

- the GARD usage from modelling of the previous dataset, shows that the STT 300 Phase 1 would be used 9% of the time at full flow, and 5% of the time at unsupported flow (compared to the 22% at full flow and 6-7% unsupported flow for the STT 500 option with the Gate 2 modelling). This alone drops the operational carbon budget to about 38% of the figures in the RAPID Gate 2 documentation.

- There is not uniform usage of the decarbonised grid assumption across the whole STT system (applying this properly to Minworth would knock another 10% off the reduced footprint, ie. from 38 to 34%)

- There remain treatment options at Netheridge, under discussion with the EA, which could reduce this residual amount even further by up to another 15 – 20 % (from 34 – to 28 %).

- The additional operational carbon emissions from the Abingdon WTW (needed for the pipeline supplies from the Reservoir) and the greenhouse gas emissions from the Reservoir surface, need to be evaluated for the Abingdon Reservoir whole-life carbon estimate.

Finally here, we should say that, the way in which the STT system is 'partitioned ' with different subsystems being allocated to different teams and into resulting different RAPID Gate 2 documents (at least 4 sets are required reading) makes it very difficult and opaque to assess the system as a whole and, in particular to compare different phase compositions. The STT is an eminently modular and adaptable system, but its assessment against a monolithic solution such as a Reservoir is made unnecessarily difficult.

[151] https://www.severntrent.com/content/dam/sros-gate-2-documents/sts/STS-Gate-two-submission-(Final)-Redacted.pdf para 6.30

6.3 Environmental comparisons of STT and Abingdon Reservoir

As we have seen in section 4.3, the assessments of Natural Capital (NCA), of Biodiversity Net Gain (BNG) and of the SEA are all essentially desk-based, with no significant fieldwork, nor are they based on any detailed design proposal, which would seem to be a prerequisite. We have commented at our astonishment that this is the case for the Reservoir after 25 years into the proposal. There has been ample opportunity to develop the real-world data needed to allow stakeholders to properly analyse the proposal and conceptual design. The STT proposal is at least, in terms of a serious study with modern environmental standards to assess, a much younger proposal. It is however, similarly overwhelmingly desk-based. This leads to the SEA, NCA and the BNG analysis being all in terms of 'metrics' which, whilst useful as a first scoping out of the issues, should long ago have been superseded by more detailed approach. We remain concerned that, with the proposal as currently presented, Ministers may be 'bounced' into making a determination without the data they need to make a balanced decision.

There is a further issue affecting the STT, which we alluded to in the previous section, that of fragmentation of the analysis. The system is split into 4 separate sets of reports, and even if one is interested in analysing a restricted option, such as the GARD Phase 1 proposal, there are still 3 sets of reports to assess: 'STT'[152], 'Minworth WwTW'[153] and the 'Severn Trent strategic sources'.[154] This split actually makes it extremely difficult for Stakeholders to analyse as a system. The split goes a long way to ruining the improved transparency which the RAPID process has undoubtedly brought. It also leads to the conclusion that the teams themselves can only be impeded by this split. With this split it is not an exaggeration to say that comparisons *between different* Strategic Resource Options (SROs) are almost impossible.

The fragmentation even makes it difficult for relatively objective and quantifiable metrics such as NPV or carbon footprint to be compared. We have already observed the inconsistencies in the operational and capital carbon budgets for the STT subsystems in section 6.2. When more intangible metrics, such as Natural Capital and Biodiversity are involved, the task becomes almost impossible.

Furthermore, we have already commented in section 4.3 on the inconsistencies between the Thames Water dWRMP and the RAPID Gate 2 documentation, when issues of Natural Capital and Biodiversity Net Gain are considered. GARD has been informed by team members at the 'drop-in' sessions that the Gate 2 documents are much more up to date. ***We therefore have***

[152] https://www.thameswater.co.uk/media-library/home/about-us/regulation/regional-water-resources/water-transfer-from-the-river-severn-to-the-river-thames/gate-2-reports/STT-G2-S1-001-STT-Detailed-Feasibility-and-Concept-Design.pdf
[153] https://www.severntrent.com/content/dam/sros-gate-2-documents/minworth/Minworth-Gate-two-submission-111122-Redacted.pdf
[154] https://www.severntrent.com/content/dam/sros-gate-2-documents/sts/STS-Gate-two-submission-(Final)-Redacted.pdf

decided to make the STT Phase 1 and Abingdon 100 Mm^3 comparisons in our response to the RAPID Gate 2 draft decisions, which are due out on 30th March.[155]

For now we note themes which are likely to be relevant to the comparison, and which we have already noticed as endemic in the WRSE, dWRMP and even Gate 2 documents:

1. There is an aspect of 'special pleading' in NCA and BNG in the case of reservoirs, as it seems that the *very act of creation of a reservoir itself* has positive value. This comes from the positive value assigned to what is called the '*Recreation and amenity value*' metric for and NCA on a particular proposal. Yet we have shown in section 4.3 that this metric value is not related in any simple way to reservoir size, and the large Abingdon Reservoirs seem to be remarkably bad value in this aspect (though still positively rated).
   The implication of a result like this is that the NCA Recreation and Amenity value of Abingdon 100 is nowhere near as good as a much smaller classic reservoir, and would, on its own, be regarded as a rather poor value for money. The more relevant implication is that WRSE, Thames and Affinity Water are painfully aware of this, but continue to push out the NCA value of Abingdon 100 as a real plus.

   Similar special pleading is employed for reservoirs in the case of BNG. It is important to realise that this does *not* refer to the possible creation of habitats *around* the reservoir, which are simply analysed by a simple sum of (habitat type created by area) minus (habitat type lost by area). This refers to the actual BNG of the water area itself.

2. Inadequate attention is paid to the *length of time* for which the construction period disturbs the area. The length of time matters to the probability with which the fauna will re-establish itself post-construction, This again biases against a transfer, with it shorter disturbance time and progressive remediation possibilities, when compared to a monolithic long-duration reservoir project.

3. There is inadequate weight given to the timescale for post-construction remediation to take effect, for example the replanted trees will take over a decade to have significant carbon sequestration possibilities, and to become a species-rich habitat. The reservoir waters will be significant methane emitters for 10-20 years after they have been created.

4. There is inadequate weight given to the '*scale length*' over which the construction phase habitat destruction takes place. This is important because of the radius over which insects, small birds and mammals will be displaced, by the construction

[155] https://www.ofwat.gov.uk/regulated-companies/rapid/the-rapid-gated-process/timetable-for-the-rapid-gated-process/

activity, and the size of this scale length relative to the radius of activity of (even flying) small fauna, which will impede their re-establishment.

5. Finally, there is insufficient weight given to the necessity of '*corridors'* reasonable quality untouched environment as connecting networks between the more *'special* ' habitats such as SSSI. The countryside will cease to exist if it becomes a set of '*island*' special habitats, interspersed with man-made deserts, Huge land-take projects like the Abingdon Reservoir encourage a tendency towards this.

7. Adaptable strategic resource options for early implementation

7.1 The Thames to Affinity transfer

GARD proposes that 50 Ml/d of the Thames to Affinity transfer should be brought forward to the early 2030s, connecting Affinity Water to Thames Water's London supply system. Combined with early implementation of 'Connect 2050' (re-naming it 'Connect 2030') and the GUC transfer, the Thames to Affinity transfer would allow all the planned upper Colne and Lea chalk stream reductions to be in place by the early 2030s. This would be much better than having to wait until 2040 (or even later) for Abingdon reservoir to be built and filled, as proposed by Thames Water

The Concept Design Report for the Thames valley component of the T2AT describes the source of water for the transfer as follows[156]:

> *"The source of water for the LTR option is the River Thames. The natural flow in the river will need to be supported, especially during drought years, by the South East Strategic Reservoir (SESRO) SRO and possibly the Severn Thames Transfer (STT) SRO. SESRO is a pre-requisite for the LTR option because without SESRO the LTR option would leave Thames Water with a reduced volume of strategic storage."*

In GARD's opinion, the source of water or the Thames to Affinity transfer should be a direct connection to Thames Water's London supply system, via an existing reservoir, probably the Queen Mary reservoir. The 50 Ml/d transfer to Affinity would become an additional 50 Ml/d demand on London's supply system. The existing reservoir system can provide support to the natural River Thames flows when needed in a drought, as it does for all other demands on the London supply system. By the time the T2AT transfer comes into operation in the early 2030s, the demand on London's supplies will have been reduced by about 100 Ml/d due to Thames Water's planned leakage and PCC reductions[157], and there will be additional 67 Ml/d of deployable output from the planned Teddington DRA scheme. There will be no need for any water from Abingdon reservoir or the Severn to Thames transfer.

GARD does not accept the above argument that *"SESRO is a pre-requisite for the LTR option because without SESRO the LTR option would leave Thames Water with a reduced volume of strategic storage."* The 50 Ml/d demand from Affinity Water on the London supply system would be no different to any other London demand. If the London supply system deployable output can cover the demand, as it can with planned demand savings, leakage reduction and Teddington DRA scheme, there is no need for additional London storage.

Even accepting Thames Water's low allowance for recovery of deployable output from reduced chalk stream abstractions, the 50 Ml/d Thames to Affinity transfer doesn't need to

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[156] T2AT Concept Design Report, Lower Thames Reservoir Version, paragraph 1.11

[157] Data from Thames Water WRMP tables, London Final Plan supply demand balance

wait for either Abingdon reservoir or the Severn to Thames transfer. With a 50 Ml/d transfer to Affinity and no support from Abingdon reservoir or STT, Figure 28 shows that there would still be a substantial surplus in London's supply demand balance in the early 2030s. This assumes GARD's population growth figures and the medium climate change scenario (starting at zero climate change loss in 2020). However, if the first phase of the Severn to Thames transfer is brought forward to the early 2030, as proposed by GARD, this would provide insurance against population growth or climate change being more than expected.

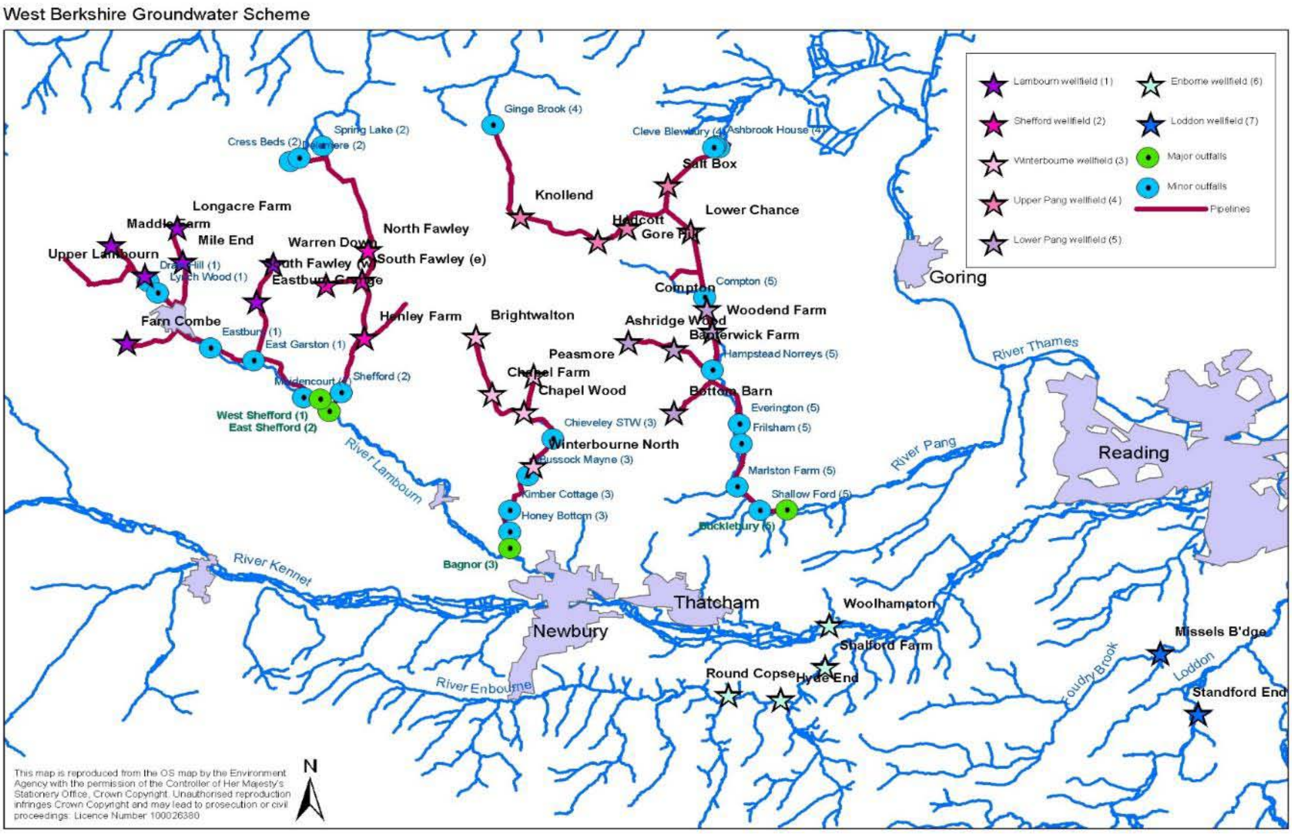
7.2 WBGWS-type scheme for the Chilterns

GARD recognises that there is uncertainty in the amount of flow recovery from chalk stream abstraction reductions that can be converted into additional deployable output from downstream reservoirs. However, this uncertainty can be managed, and with a possible net increase in deployable output from downstream reservoirs, if the chalk aquifer is used for drought support schemes similar to the existing West Berkshire Groundwater Scheme.

The West Berkshire Groundwater Scheme (WBGWS) was constructed in the 1970s to augment London's water supplies during severe droughts – its planned use is about once in 25 years. The scheme abstracts water from boreholes in the chalk aquifer in the upper Lambourn, Pang, Enbourne and Loddon valleys, discharging water into those rivers from where it flows down into the River Thames for later abstraction to fill London's reservoirs. It contributes about 90 Ml/d to London's deployable output.

The WBGWS concept could be used in the chalk streams of the upper Colne, Lea and Ouse valleys, operating in conjunction with the proposed abstraction reductions. When triggered in droughts, boreholes in the chalk tributaries would augment flows in the River Thames or Ouse for abstraction into the lower Thames reservoirs or Grafham Water. Boreholes in the Lea tributaries would supplement filling of the Lea valley reservoirs.

The layout and components of the existing WBGWS are shown in Figure 30:



Map copied from Environment Agency presentation to Action for the River Kennet in January 2020

Figure 37 - Layout of the West Berkshire Groundwater Scheme

In general, the scheme abstracts groundwater in the upper parts of the chalk valleys, where there is little if any perennial river flow, and transfers water via pipelines to discharge into the lower parts of the valleys where there is perennial river flow even in severe droughts. This avoids discharging the water into a dry river bed where it would quickly sink back to the water table. There are some intermediate discharge points to augment drought flows further up the valleys, simulating a natural flow accretion profile.

In a drought, the scheme is allowed to be used for a maximum of 8 months. The maximum daily release in each donor catchment corresponds to roughly 20-30% of average catchment recharge. The total release from the donor catchments gradually reduces from 126 Ml/d to 67 Ml/d, as the drought progresses. The scheme is triggered in periods of extremely low flows in the River Thames, when the London reservoir storage falls below a control line.

Thames Water's WARMS2 modelling of the London supply system for their 2019 Water Resource Management Plan showed that, in the past 100 years, the WBGWS would only have been used significantly in the droughts of 1921/22, 1933/34, 1943/44 and 1975/76. The scheme would also have been triggered briefly in 1949.

The recent Chalk Streams First report shows how the chalk tributaries of the Colne and Lea could be used in a WBGWS-type scheme, providing an insurance against flow recovery being less than expected[158]. Drought support releases from the Colne tributaries could be used for filling the existing lower Thames reservoirs and support from the Lea tributaries would feed into the Lea valley reservoirs. An indication of the potential scale of adopting the WBGWS concept across all the Lea and Colne tributaries is shown in Table 4. The suggested maximum releases for each of the tributaries are in the region of 20-30% of average recharge, as is the case for the Lambourn, Enbourne, Pang and Loddon:

	Colne chalk streams				
	Misbourne	**Chess**	**Gade/ Bulbourne**	**Ver**	**Totals for Colne**
Catchment area km^2	95 km2	105 km2	184 km2	132 km2	516 km2
Av. annual recharge	74 Ml/d	82 Ml/d	144 Ml/d	103 Ml/d	403 Ml/d
Continuous PWS abstraction					
Abstraction in 2019-21	15.8 Ml/d	15.1 Ml/d	36.2 Ml/d	25.8 Ml/d	92.9 Ml/d
Abstraction as % recharge	21.2%	18.4%	25.2%	25.0%	23.0%
CSF proposed abstraction	6.2 Ml/d	4.1 Ml/d	11.9 Ml/d	7.7 Ml/d	29.9 Ml/d
Reduction to achieve A10%R	9.6 Ml/d	11.0 Ml/d	24.3 Ml/d	18.1 Ml/d	**63.0 Ml/d**
WBGWS-type support					
Suggested maximum release	20 Ml/d	20 Ml/d	40 Ml/d	25 Ml/d	**105 Ml/d**

	Lea Chalk streams					
	Upper Lea (to Water Hall GS)	**Mimram**	**Beane**	**Rib & Quin**	**Stort**	**Totals for Lea**
Catchment area km2	150 km2	136 km2	175 km2	152 km2	280 km2	893 km2
Av. annual recharge	87 Ml/d	79 Ml/d	102 Ml/d	88 Ml/d	163 Ml/d	518 Ml/d
Continuous PWS abstraction						
Abstraction in 2019-21	48.4 Ml/d	10.4 Ml/d	24.9 Ml/d	22.8 Ml/d	25.0 Ml/d	131.5 Ml/d
Abstraction as % recharge	55.6%	13.1%	24.5%	25.9%	15.4%	25.4%
CSF proposed abstraction	7.2 Ml/d	6.1 Ml/d	9.8 Ml/d	7.3 Ml/d	11.5 Ml/d	43.2 Ml/d
Reduction to achieve A10%R	41.2 Ml/d	4.3 Ml/d	15.2 Ml/d	15.5 Ml/d	13.5 Ml/d	**89.6 Ml/d**
WBGWS-type support						
Suggested maximum release	25 Ml/d	20 Ml/d	25 Ml/d	20 Ml/d	40 Ml/d	**130 Ml/d**

Table 28 - Potential for WBGWS concept in the Colne and Lea catchments

Reduction of abstraction to achieve acceptable flows across all of the Colne and Lea tributaries would require about 63 Ml/d of replacement supply, potentially from Thames Water's lower Thames reservoirs. The impact on London's supplies could be offset by up to 105 Ml/d of drought support releases from the upper Colne chalk. The equivalent figures for the Lea catchment could be 90 Ml/d of replacement sources and up to 130 Ml/d of drought support releases from the upper Lea chalk.

GARD model simulation of the abstraction reductions and WBGWS-type support releases shown in Table 16 suggests that they could give a net gain to London deployable output of in

[158] Dealing with the impacts of groundwater abstraction on the chalk streams of the Colne and Lea valleys, Chalk Streams First, January 2023 https://chalkstreams.org/flow-recovery-following-abstraction-reduction/

the region of 55-60 Ml/d after allowing for 87 Ml/d of flow recovery from the total 153 Ml/d of abstraction reductions, as shown on Table 16.

The CSF report's conclusions from this assessment of the potential for use of the WBGWS concept in the Chilterns chalk streams were:

1. If the concept was adopted in all the upper Colne and Lea chalk streams, abstraction could be reduced by 150 Ml/d as proposed by EA, with replacement supplies as from London reservoirs and a net gain to London's supplies of possibly 55-60 Ml/d.

2. The drought support would only be needed about once in 25 years. Flows in the chalk streams in drought years would be increased by the WBGWS-type releases and would be slightly less in the following year (but still much more than with abstraction at recent levels).

3. Although the net gain in London supplies requires much more investigation, the introduction of the WBGWS concept would remove much of the doubt that currently exists over the amount of flow recovery from abstraction reductions.

4. In principle, the conjunctive use of the chalk aquifer and the reservoirs downstream appears a much better way of using the chalk water resource, with far less impact on chalk streams than continuous pumping of water supplies directly from the chalk.

5. The concept should now be investigated as a matter of urgency, with the aim of implementing one or more pilot schemes in AMP8 and full implementation in AMP9.

A similar proposal for using the WBGWS concept at a pilot scale has been put forward for the River Ivel catchment. This would entail much reduced existing abstraction for day-to-day supplies, replacement supplies brought in from Grafham reservoir, enhanced Ivel flows into the River Ouse used to augment Grafham reservoir refilling and use of the existing Ivel groundwater storage as a drought source in a similar fashion to the WBGWS. A pre-feasibility study of this proposal is currently being undertaken jointly by Affinity Water and Anglian Water, with a report due in summer 2023.

The Ivel investigation can point the way for investigation of the WBGWS concept at a larger scale in the Chilterns chalk streams. If the concept is found to be viable, it removes most of the uncertainty surrounding river flow recovery and maintaining supplies if recovery is found to be less than expected. This would allow the proposed upper Colne, Lea and Ouse abstraction reductions to proceed quickly with more confidence, being in place by 2034, without any need for a major new source like Abingdon reservoir or the Severn to Thames transfer.

7.3 The Grand Union Canal transfer

In our opinion, the Grand Union Canal (GUC) transfer scheme should have been considered a strategic resource option for Thames Water. Although we are aware that the GUC transfer is primarily an Affinity Water scheme, Thames Water will benefit from "new water" coming into the lower Thames and Lea via enhanced chalkstream flows and STW effluent. The larger versions of the GUC transfer also have the potential for Affinity Water to transfer surplus water to Thames Water.

GARD's analysis in our response to the consultation on WRSE's regional plan has shown that there is no theoretical need for any major new water supplies in areas that might be supplied from Abingdon reservoir[159]. However, we recognise that this depends on achievement of planned leakage and PCC reductions, and that some climate change scenarios move the analysed surplus (in normal, non-extreme drought years) to a lower value. As stated in Section 3.6, we also acknowledge that early re-naturalisation of flows in the Colne and Lea chalk streams could require additional water sources if leakage and PCC reductions come into effect later than planned, and that some new resources should be implemented as risk mitigation. These schemes should comprise a portfolio that can be delivered at an early date securing 1 in 500 year drought resilience and priority environmental improvement.

Therefore, GARD welcomes the plan for Affinity Water to complete at least Phase 1 of the GUC transfer by 2031. This would bring "new water" into the chalk catchments which ultimately feed Thames Water's London's reservoirs. The "new water" coming into the Thames catchment via the GUC transfer emanates from Minworth STW effluent and is therefore totally resilient against severe drought, unlike Abingdon reservoir. We also note that most of the effluent treated at Minworth comes from the Birmingham area which gets much of its supplies from the Elan valley in Wales. The GUC transfer is, therefore, a truly inter-regional transfer scheme as well as being a form of effluent reuse.

Although our analysis shows that a 50 Ml/d GUC transfer would be more than enough for Affinity Water's needs and re-naturalising chalk stream flows, there would be additional security of supplies for both Affinity and Thames Water, if the GUC carrying capacity can be increased to 100 Ml/d at relatively little additional capital cost, via the 'Phase 2' of the scheme, as implemented in WRSE's plan by 2040. Our view is that this phase should be brought forward for completion by 2035. Operating costs would only be on an as needed basis.

We note that paragraph 10.256 of Thames Water's main WRMP says the following:

> *"It is possible to bring forward 1:500 resilience to 2035 with a marginal impact on cost by building a larger Grand Union Canal transfer and trading between Affinity and Thames Water. However, the Grand Union Canal scheme, Teddington DRA and existing storage*

[159] GARD response to WRSE's regional plan, Section 3.3

are already mutually supporting each other in case of problems in their development, so to upsize that risk may not be advisable in the near-term".

This paragraph says that there is a risk that the larger GUC transfer and the Teddington DRA scheme could be delayed beyond their planned start in the early 2030s, putting more demands on the existing London reservoirs. This is true, but the alternative of waiting for Abingdon reservoir to be complete and filled by 2040 will delay raising the resilience standard to 1:500 years by 5 years and puts a certain extra demand on the existing London reservoirs. It also carries the risk of Abingdon reservoir being delayed beyond 2040 unless it bucks the trend of delayed completion of major construction projects.

Early completion of both phases of the GUC transfer would also allow more and earlier reduction of some of Thames Water's abstractions in the lower Lea valley, which probably have a low priority, but would be feasible if the second phase of the GUC generates extra headroom for Affinity Water. The earlier reduction of Thames Water's abstractions in the lower Lea would also allow the Deephams re-use scheme to be brought forward, as described in Section 7.4.

7.4 The Teddington DRA scheme and Deephams reuse schemes

GARD welcomes the planned Teddington DRA scheme delivering 67 Ml/d of deployable output for London. Although our analysis in Section 3.6 and Figure 28 shows that this would not be needed after about 2040 if the Government's leakage and PCC targets are met, the early construction of this scheme would ensure water availability from London's supplies to be transferred to Affinity Water, allowing early re-naturalisation of Colne and Lea chalk stream flows. The spare headroom after 2040 shown on Figure 28 could be used to bring forward some of Thames Water's lower priority abstraction reductions in the lower Lea, which would open the door for earlier implementation of the Deepham's reuse scheme (see below).

We note that, in our response to Thames Water's draft WRMP19 in November 2018, we criticised at length the abandonment of the Teddington DRA scheme and the environmental evidence on which that was based (largely temperature effects)[160]. We are, therefore, pleased to see that the scheme has now been reconsidered and put forward again, albeit in a much smaller form than we consider its ultimate potential to be. If more water was genuinely needed for London, we believe that a much larger version of the Teddington DRA should be reconsidered, making better use of the c. 400 Ml/d output of Mogden STW.

GARD recommends that the 67 Ml/d capacity Teddington DRA scheme now proposed should be planned as the first stage of a potentially larger scheme.

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[160] https://www.abingdonreservoir.org.uk/downloads/GARD%20%20response%20to%202nd%20Consultation%20on%20TW%20draft%20WRMP%20Rev%2029.11.18.pdf pages 65 to 79

The 45 Ml/d Deephams reuse scheme was included for early implementation in Thames Water's WRMP 19, but has now been pushed back to after 2060 or the following reason[161]:

> *"Discussions with the EA focused on the work to identify and update the options assessments including the rationale for rejection of options; potential groundwater options, catchment, drought, inter-regional transfers and resilience options; the update to the Feasibility Report and agreement on the status of Deephams recycling which was agreed to be incompatible with the environmental ambition flow targets that the Environment Agency is seeking for the Lower River Lee (the result being the Deephams option's inclusion on the Constrained List after 2060, but exclusion up to this point)"*

This states that the timing of implementation of the Deephams re-use scheme is linked to the timing of reductions in Thames Water's abstractions on the lower Lea. GARD's reassessment of Thames Water's supply demand balance plotted in Figure 28, shows that there would be spare headroom to bring forward reductions in TW's lower Lea abstractions to 2040, especially if the second phase of the GUC transfer is implemented early, as we propose in Section 7.3. Therefore, the Deephams reuse scheme could be brought forward to 2040 if needed.

Thames Water's quoted AIC costs for the Deephams reuse and Abingdon reservoir schemes are respectively 96p/m^3 and 111p/m^3. The Deephams reuse scheme is, therefore, substantially less costly than Abingdon reservoir. GARD proposes that it should be included with the Teddington DRA and GUC phase 2 schemes in the portfolio of modest sized measures that can be implemented quickly if and when the need arises. This would be a genuinely adaptable approach to meeting the uncertain future deficits, in contrast to the inflexibility of building a single-phase large reservoir at Abingdon with high cost and irreversible environmental impact.

We also note that early implementation of the Deephams reuse scheme could facilitate the abstraction reductions in the River Darent by connecting parts of the Darent supply area into the London supply system.

7.5 Thames estuary desalination options

Thames Water's plan appears not to have seriously considered new desalination schemes and they were not part of the Gate 1 or 2 investigations. GARD was heavily critical of the exclusion of desalination options from the SRO investigations in our response to the consultation on Gate 1 reports[162]. However, we were told that desalination schemes would still be considered in Thames Water's WRMP, even if not part of the Gate 1 and 2 investigations.

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161 TW WRMP main report paragraph 7.27, first bullet
162 GARD combined response to Gate 1 reports and Ofwat decision, page 12 https://www.abingdonreservoir.org.uk/downloads/GARD%20Final%20combined%20Response%20to%20Gate%201%2018.11.21.pdf

Although we can see that there is no need for the large desalination schemes previously considered by Thames Water – up to 300 Ml/d at Beckton or Crossness – there could be a need for a smaller desalination scheme to replace the large abstraction reductions needed for the River Darent, possibly up to 100 Ml/d of reduction. In the desalination feasibility study carried out for Thames Water's WRMP19, Option 3a was a 75 Ml/d desalination plant located at Crossness STW with a supply to a nearby service reservoir at Northumberland Heath, which is at Bexley in the Darent catchment. Clearly, this scheme was being considered in WRMP 19 as a replacement source for the Darent abstraction reductions.

The desalination feasibility report in 2019 confirmed the feasibility of the 75 Ml/d Crossness scheme describing it as[163]:

> *"Option 3a (Crossness – Erith Southern Grazing Marshes): A new 75 Ml/d desalination plant located to the south of Crossness STW to transfer desalinated water to Northumberland Heath for direct supply to Riverside WRZ."*

Despite the reassurance that GARD was given that desalination options would be properly considered in Thames Water's WRMP24, the only reference we can find to this is a brief 21-page titled 'Desalination feasibility report addendum' dated November 2022. This report rejects Option 3a as follows[164]:

Option 3a (Crossness – Erith Southern Grazing Marshes) *No code as didn't reach Constrained List*	Crossness Desalination (Unblended) - 65 Ml/d - Option 3A *TWU_LON_HI-DES_RE1_ALL_crossdesalunblend-65*	No change since WRMP19	Passed Stage 3 but rejected at Fine Screening. Capacity also revised to 65Ml/d at Fine Screening.	Rejection reasoning reviewed and confirmed. Option remains rejected at WRMP24.

The only explanation offered for the rejection is[165]:

> *"At WRMP19 Option 3a (Crossness – Erith Southern Grazing Marshes) was rejected at Fine Screening. The rejection reasoning has been reviewed at WRMP24 and has been found to remain valid. Option 3a has therefore been rejected at validation and has not been included on the Feasible List of options for WRMP24."*

We have not found any further information for the rejection. However, we note that Southern Water's preferred plan for their WRMP24 includes 9 small desalination plants totalling 120 Ml/d, including three in the Thames estuary. These desalination schemes are understood to be largely to allow abstraction reductions in sensitive catchments.

In view of the severity of over-abstraction in the Darent, in GARD's opinion a modest sized desalination scheme should be properly investigated for rapid implementation to relieve the over-abstraction in the Darent.

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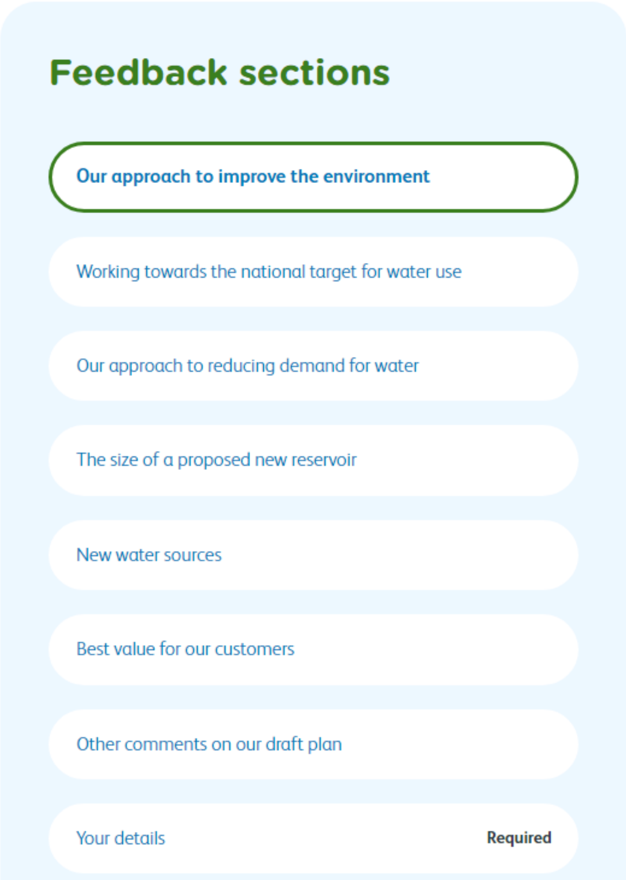
163 WRMP19 Desalination feasibility report, page 58, Mott MacDonald, February 2018
164 Desalination feasibility report addendum, page 5 https://thames-wrmp.co.uk/assets/images/documents/supplementary-reports/Feasibility-Report-Addendum-Desalination.pdf
165 Ibid, paragraph 51

Appendix A – Responses to Consultation questions

GARD has completed responses to the Feedback questions as below



1. Our approach to the environment

Whereas GARD applauds the desire to protect rivers, especially chalk streams, we think that the abstraction reductions in Thames Water's plan are much too high. The same applies to all the other water companies in WRSE's regional plan. The abstraction reductions should be prioritised to focus on rapid solutions to urgent cases, avoiding excessive costs and environmental impacts of replacement sources for unjustified abstraction reductions. We give more detail in Section 2.3 in our response.

2. Working towards the national target for water use

Thames Water fails to meet the Government target of 110 litres/head per day, especially in London. We note that United Utilities' similarly urban strategic zone, including Manchester and Liverpool, does plan to meet the target. Thames Water should do the same, including near universal smart metering. Just meeting the 110 litre/head per day target 'provides' 90% of the output of the proposed 100 Mm3 Reservoir. More detail in Section 3.2 of our response.

3. Our approach to reducing the demand for water

As well as smart metering referred to above, Thames Water should meet the Government target to reduce leakage by 50% by 2050 in all zones, not just London. Outside London, the planned leakage reductions are much less than 50% and the planned leakage in litres/property/day is far higher than other water companies in the South East. Just meeting the 50% reduction target in zones outside London, 'provides' another 40% of the output of the proposed 100 Mm3 Reservoir. More detail in Section 3.3 of our response.

4. The size of the proposed reservoir

Our analysis of Thames Water's supply demand balance shows that Abingdon reservoir is not needed – see Section 3.6 of our response. If an ill-judged decision was made to proceed with the reservoir, we can see no justification for it being the larger 150 Mm^3 version. More details in Section 4.1 of our response.

5. New water sources

Although our analysis of the supply demand balance shows that no major new sources are needed, even with reasonably cautious estimates of population growth, climate change and abstraction reductions, we propose that a modest first phase of the Severn to Thames transfer should go ahead an insurance against a future deficit being much worse than expected. See Section 3.6 of our response.

The STT scheme would comprise a 300 Ml/d aqueduct and support from Netheridge and Minworth WwTWs – see Section 5 of our response. We also propose early implementation of the Teddington DRA scheme, the Thames to Affinity transfer and the Grand Union Canal transfer – See Section 7 of our response. The Thames to Southern transfer is not needed and plans for it should be abandoned – see Section 3.5 of our response.

6. Best value for our customers

We think the plan offers poor value for customers and the environment. It delays urgently needed abstraction reductions by forcing them to wait for Abingdon reservoir. It puts forward the plan for an unneeded and environmentally damaging reservoir that will benefit no one except Thames Water's shareholders – See Section 4.6 of our response.

7. Other comments on our draft plan

This questionnaire fails to ask opinions on the magnitude of the supply deficits that Thames Water says justifies the construction of Abingdon reservoir. We think that the deficits are grossly over-forecast due to excessive allowances for population growth, abstraction reductions and climate change. More details in Sections 2.1, 2.2 and 2.3 of our response.

Thames Water's WRMP is not fit for purpose. It should be re-written with realistic deficit forecasts and sensible plans for modest schemes to be built as the need arises. The chalk streams with a genuine and urgent need for flow re-naturalisation should be dealt with in the next 10 years, without having to wait for Abingdon reservoir.

Appendix B – DEFRA Reservoir flood assessment – Simplified Method

Applied to the proposed Abingdon Reservoir

Items enclosed within black borders are directly taken from the relevant DEFRA publications[166], which were produced by DEFRA's water engineering consultants HR Wallingford Ltd. All flood spreading and flow equations used in this appendix were developed by HR Wallingford Ltd.

DEFRA's Guidance Report defines the following Risk Category table:

Table : Typical reservoir risk classification types

Risk Category	Typical reservoir types
High	• Reservoirs in dense urban areas • Reservoirs with high dams (>5m) or large volumes of water (>100,000m^3) • Reservoirs perched on hillsides above properties
To be determined	• Any reservoir where it is not immediately obvious that it could pose a danger to people and property if the dam were to fail suddenly **Use this guide to help you better understand the risk posed by your reservoir**
Not high	• Reservoirs in remote or rural areas • Reservoirs with low dams (<2m) or small volumes of water (<10,000m^3) • Reservoirs surrounded by flat land far away from any properties

The proposed Abingdon Reservoir, with a dam height of ~20m and a water volume of at least 67Mm^3, falls immediately into the **High Risk** category, without further consideration. DEFRA also note, in the same document that:

It was decided that the size of reservoir covered by this project would be reservoirs not exceeding 100,000m^3, and dam height not exceeding 10m, on the basis that:

- ·This is a typical range of size of new small reservoirs;
- ·Larger dams are likely to have greater engineering input into their siting and design, such that this rapid screening would be of less value.

In the absence of any published 'greater engineering input into … siting and design' regarding safety, the best GARD can do is to use DEFRA's Simplified Method to make an assessment of the risks and impacts of the reservoir ourselves. This Appendix investigates, at successive levels, what High Risk equates to in terms of impact on local communities, as estimated by DEFRA's Simplified Method. DEFRA define 3 High Risk tests[167]:

Test 1 uses an approach defined by the Health and Safety Executive (HSE) as the risk to an individual person, and is based on research undertaken on the depth and velocity of flows that would cause structural damage to houses (Binnie 1991). Tests 2 looks at the extent of the flooding, and Test 3 looks at the combined risk to the society or community downstream.

166 H.R.Wallingford L.t.d. 'Small reservoirs simplified risk assessment methodology: Guidance Report. '(2014) and 'Research Report '(2013), For DEFRA and the Environment Agency.

167 Binnie & Partners, (1991) *Estimation of flood damage following potential dam failure: guidelines*. 1989 Report for DOE. FR/D 0003. Foundation for Water Research, Marlow.

We note that there is also a 'High Risk Additional Test' which evaluates the impact on critical infrastructure and the environment, which we shall also briefly address.

DEFRA require the risk assessment to assume 'catastrophic failure' in order to quantify a breach in the 'dam wall' and the resulting rate of water flow through it; after a number of breach simulations by computer they conclude:

> Runs undertaken using a range of erodibility considered applicable to the UK shows that certain reservoir combinations, and in particular small non-impounding reservoirs built of high plasticity clay, are unlikely to erode at a rate that would lead to a catastrophic failure.
>
> However, as this project relates to government regulation of dam safety it has been agreed with Defra that the Guide would provide peak breach flows resulting from catastrophic failure for all dam sizes. This is in effect acknowledgment that at any individual dam there may be site specific failure modes that could lead to rapid failure (for example, physical damage by digger, aircraft impact etc.), and that to demonstrate beyond reasonable doubt that none could lead to catastrophic failure at a specific dam it would be necessary to carry out a full failure modes analysis for all credible failure modes. For the purposes of this project, catastrophic is defined as a time base for the breach hydrograph similar to that for a breach hydrograph defined using Froehlich (1995).

Which leads to the following definition of the peak flow rate Q_p released from the reservoir[168]:

> **Example of the Environment Agency RIM method for calculating the potential release of water from a reservoir**
>
> The reservoir flood risk maps are created from numerical modelling of potential flood flows. Prediction of the catastrophic release of water from the reservoir is made by assuming reservoir conditions and applying a simple formula for predicting how large the rate of release of water might get.
>
> The Environment Agency assumes that at the point of failure, water levels in the reservoir will be above the dam crest level by 0.5m. The height of the dam plus 0.5m is then used in the following equation, along with the estimated volume of water stored when the water level is at crest level plus 0.5m:
>
> $$Q_p = 0.607 V_w^{0.295} H_w^{1.24}$$
>
> Where:
>
> Q_p Peak flow rate released from the reservoir
>
> V_w Volume of water stored above ground level at the time of failure
>
> H_w Height of the water level above ground level at the time of failure
>
> This equation (Froehlich, 1995) is based upon analysis of historic dam failures. It provides an approximate estimation of potential flow rate, but does not take into account site specific dam and topographic features. It therefore provides an initial estimate for consideration and emergency planning, rather than an exact prediction.

For the Abingdon Reservoir in flood V_w ~ 94M m^3 and the flooding 'dam crest level' is ~20.5m.[169] With those values, the above equation for the estimated peak flow rate gives

$$Q_p = 0.607 \times 224.9 \times 42.32 = 5778 \text{ m}^3/\text{sec}$$

[168] Froehlich, D.C., (1995) *Peak outflow from breached embankment dam*. ASCE Journal of Water Resources Planning and Management 121(1), 90-97.

[169] Assuming a 'borrow pit' volume of 33M m^3 below ground level, leaves ~94M m^3 up to flooding crest level.

We note that this is an <u>average</u> value for Q_p and, for a specific community, the base height at the reservoir crest closest to that community may differ from the average, leading to a different H_w, V_w and Q_p; this important detail is addressed later, below.

B1: <u>High Risk Test 1</u>

Test for determining high risk		Comments
Test 1 - Force of inundation	If the velocity of the flow of water escaping from the reservoir, multiplied by the depth of water at an individual house is high enough to cause structural damage to the property, the reservoir is high risk. This is taken to be greater than $3m^2/s$.	This is not necessarily the first house downstream of the reservoir. The velocity of the flow of water can increase if the valley narrows or steepens further downstream.

In a detailed analysis it would be the depth and velocity of water at the individual house (or other occupied space) that would be used in assessing risk. However, for this simplified screening method detailed ground levels and thus variation of flood level across the flow path are not available, so instead the maximum depth and average velocity across the flow path are used for Test 1.

DEFRA use a simplified flow model, where the water spreads over a horizontal angle of 45 degrees (Ω = 0.79 radians) in front of the breach, so at distance r from the breach the flow front has flooded width W = Ω r = 0.79r. The average depth-velocity (DV) across the flooded width is Q_p/W, but the local depth varies between zero at the left and right extremes of that flooded width, reaching a maximum in the centre of the flow front, directly opposite the breach. That maximum is taken as $1.5Q_p/W$ in DEFRA's simplified method (shaded paragraph above).

DEFRA's *flow equations* for computing the velocity v(r) and the depth d(r) at distance r from the breach are;

$$d = \left(\frac{13}{3}\frac{n^2 Qp^2}{\Omega^2}\right)^{3/13} r^{-3/13}$$

$$v = \sqrt{\frac{3}{13}} d^{7/6} n^{-1} r^{-1/2}$$

and include the (Manning's) Friction coefficient 'n', which is tabulated below. Note that the above 2 equations multiply to give (after some algebra) d x v =

$DV = Q_p /(\Omega r) = Q_p / W$ (the *spreading equation*)

so the above factor 1.5 <u>must be applied to this DV</u> for Test 1.
Note also that 'n' cancels in the multiplication of d by v, so friction does not change the resulting DV; increasing friction reduces v and therefore increases d, so that DV at fixed r remains constant and

unaffected by friction, but new communities at slightly higher altitudes may become vulnerable as a consequence of that change.

Type of surface of surrounding land	Friction coefficient, n
Bare soil (agricultural land)	0.020 – 0.040
Short grass (tended playing fields)	0.025 – 0.035
Long grass (wild meadows)	0.030 – 0.050
Woodland (forest)	0.080 – 0.120
Concrete and tarmac (urban areas)	0.012 – 0.017

Since the areas between the Abingdon Reservoir and nearby towns/villages are mainly open fields, with a few roads but little woodland/forest, We take a value of n intermediate between the minimum, 0.02 for bare soil and the maximum, 0.04 for agricultural land and long grass or meadows: n = 0.03 .

The critical High Risk depth-velocity is DV=3 m^2/sec, (e.g. 3m deep water moving at 1m/sec). With no flood warning it leads to a fatality rate of 3% and a building destruction rate of 20%; DV=7 m^2/sec (e.g. 3.5m deep water at 2m/sec) leads to 16% fatalities and 100% building destruction. At DV=20 m^2/sec the fatality rate is 100%. These DEFRA figures are based on many studies of actual dam and reservoir failures, and fatalities, at those observed DV rates (see High Risk Test 3, below).

Assuming a flat environment, 1.5xDV=3 can be converted into a critical distance Rc, within which all communities are at High Risk for Test 1, given the above Qp=5778 m3/sec and averaging over the perimeter of the reservoir. The result is Rc = 3.7km from the breach. (This simple average will be replaced by a location specific Rc when the risks for specific communities are analysed in section B5).

Communities within that range include Steventon (population 2268)[170], Drayton (2987) and East Hanney (1070) and, with >20% chance of buildings being destroyed the Reservoir fails High Risk Test 1 and we need go no further according to DEFRA. However, since there seems to be no 'greater engineering input' available to carry the study further, we will continue to the next level of DEFRA tests.

B2: High Risk Test 2

Test 2 - Extent of Inundation	If more than 200 people (~83 houses) or 20 businesses would be flooded by the escaped water from the reservoir, the reservoir is high risk.	Within the flood outline from the reservoir count the number of properties and businesses within the flooded area in order to estimate the number of people that could be affected. (See Note 1.)

Note that this test considers the whole community affected by the flood from the breach, not just those facing the centre peak of the flood. Thus the average depth across the flood front is used, and the factor 1.5 multiplying depth in the previous test is dropped. This test concerns which communities the flood water reaches, without specific focus on damage to property of injury to individuals.

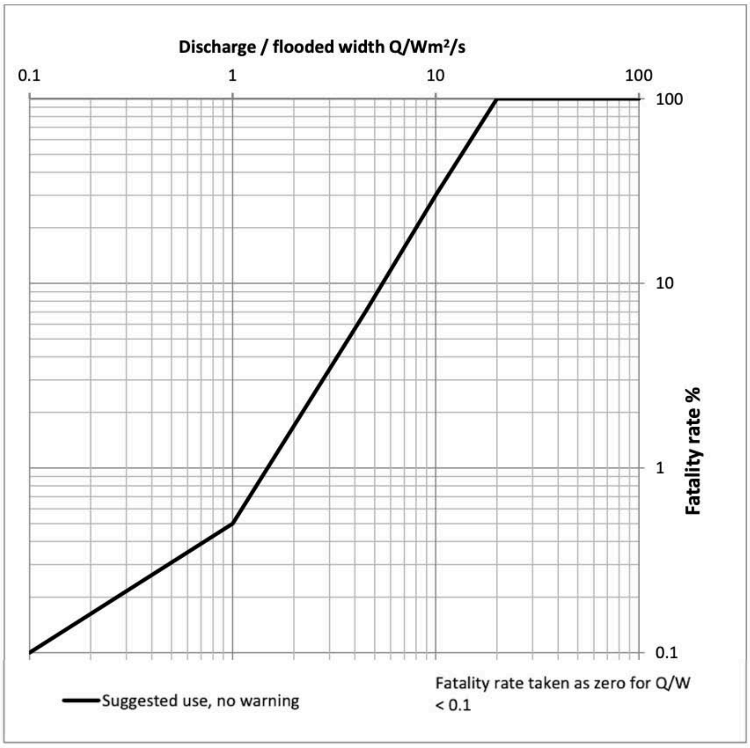
[170] Population figures, taken from official sources, may not be the most recent so are approximate.

There are several communities that would be flooded, apart from those above at identified High Risk, which include Marcham (population 2470), Milton (1396), Abingdon (34569), Culham (453), Sutton Courtenay (2952) and Appleford (250), which again and unsurprisingly confirms the Reservoir as High Risk.

B3: <u>High Risk Test 3</u>

Test 3 - Likely Loss of Life	If the combined risk to life (the 'Likely Loss of Life' or LLOL) within the flood is greater than 1.0 fatality, the reservoir is high risk.

Figure is taken from the Interim Guide (ICE, 2004) with the suggested line being for no warning and being a best fit to observed fatalities in flash floods and dam failures provided in the US Bureau of Reclamation Report no DSO -99-06.



Fatality rates for Q/W (no warning)

Using the above figure and the computed Q/W for any location within the DV=3 High Risk zone enclosing the Reservoir, it is possible to estimate the LLOL for every affected community. Suffice to say that, with a number of nearby villages in that zone (see High Risk Test 1) with a fatality rate > 3%, the average LLOL from a single breach is significantly greater than 1 so the Reservoir fails High Risk Test 3. Specific cases will be considered in section B5.

B4: <u>High Risk Additional Test(s)</u>

Additional Test(s)	There may be other unusual factors that can lead to a high risk designation such as the potential damage to critical infrastructure or the environment. The Environment Agency will consider all such factors on a case by case basis.	This could for example include destruction of a busy road or railway line with a moving population, or the destruction of a chemical plant leading to the release of a hazardous substance.

The proposed Abingdon Reservoir will be surrounded by major roads (A338, A34, A415, A417) and the London-Bristol railway line, all potential 'moving populations' within the DV>3 High Risk zone, and the Reservoir itself would constitute <u>critical water resource Infrastructure</u> if we believe TW/WRSE's justification for its construction. Thus the Reservoir also fails the High Risk Additional Test(s).

B5: <u>Specific Cases of High Risk</u>

The DEFRA analysis outlined in B1 above uses DEFRA's *spreading equation* to compute DV and explains how 1.5xDV>3 is the zone of High Risk to individuals and buildings. We define DmaxV = 1.5xDV in what follows. DV reduces in proportion to 1/r as the flood moves away from the breach. We invert that equation to obtain the distance (call it Rc) within which DmaxV is greater than 3 m^2/sec. The result is

$$Rc = Q_p / (2\ \Omega)$$

We compute Q_p for any point around the mapped crest of the Reservoir and project outwards from a model breach at that point by the above distance Rc. The result is the dotted black boundary shown in the following Figure B1.

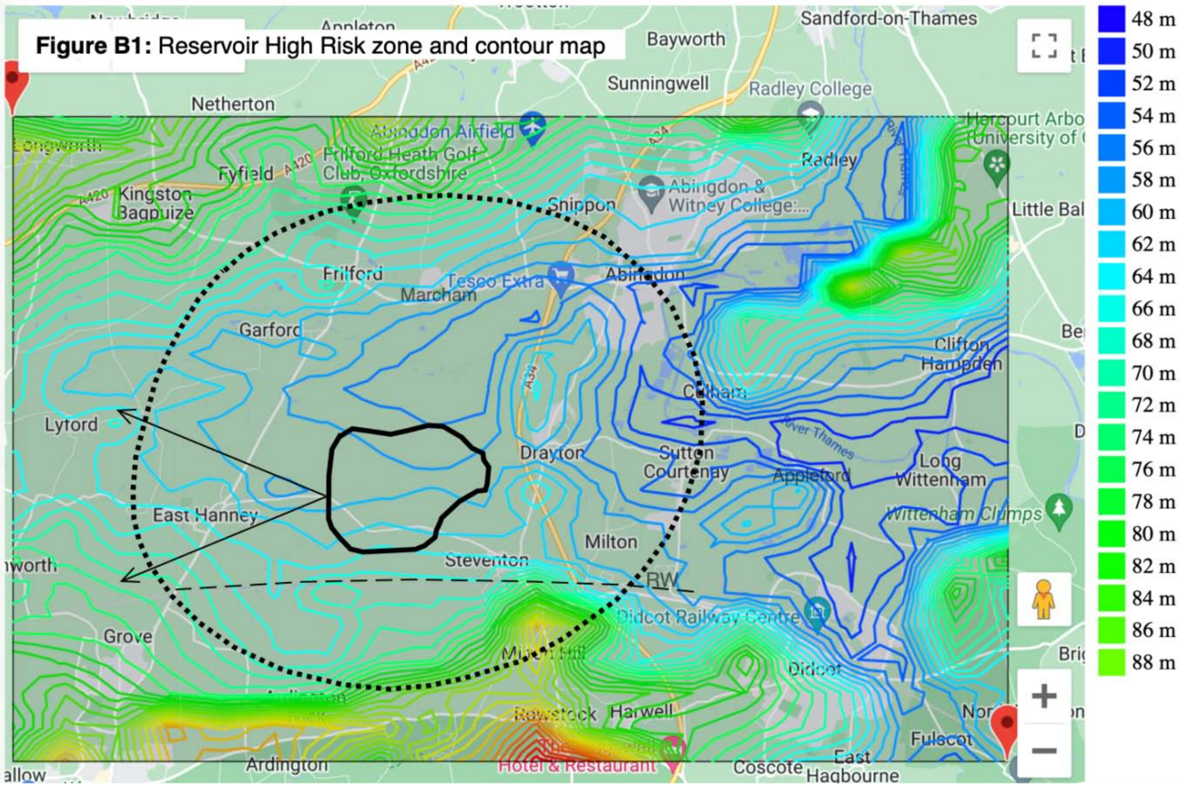


Figure B1: Reservoir High Risk zone and contour map

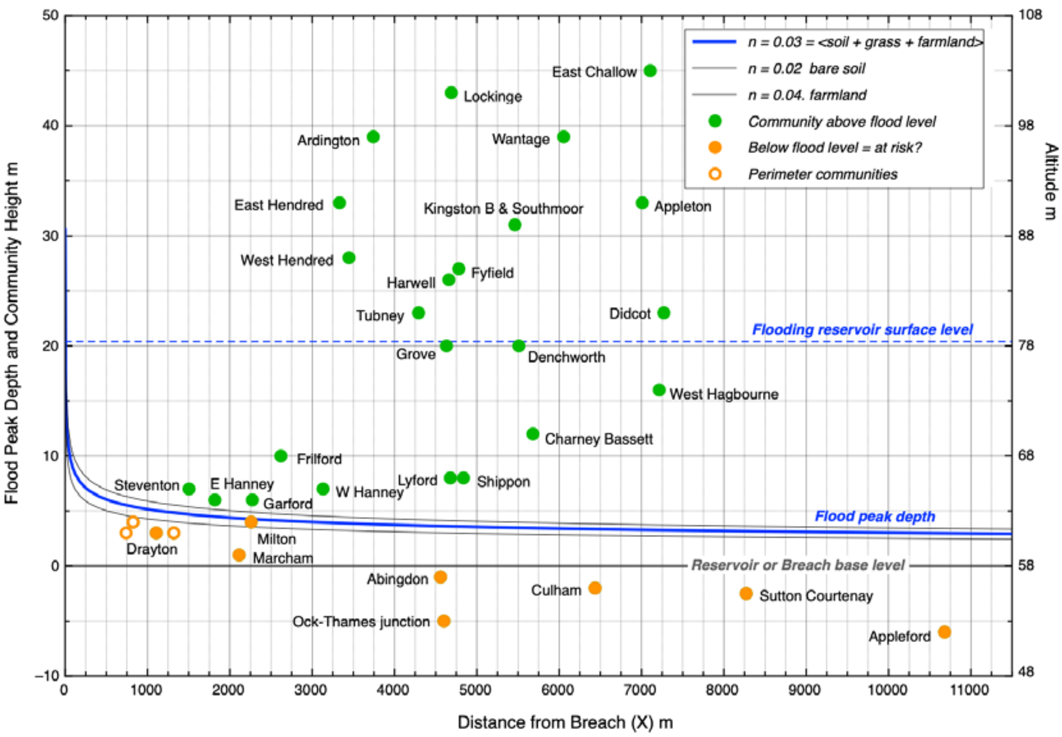
Every location within that boundary is potentially at High Risk with DmaxV >3 m^2/sec. The figure also includes the Reservoir's crest (solid black boundary[171]) superimposed on a contour map of the region (altitude contour colour coding on the R). The flow zone from a breach opposite a single community (e.g. East Hanney) is also shown; the model flood water moves in the direction of and between the two arrows, with opening angle Ω = 45 degrees.

Communities outside the High Risk zone and at higher altitude than the Reservoir may be safe. Altitudes above 78m, the altitude of the water surface in the flooding Reservoir, are certainly safe. Those above 68m are also safe according to DEFRA's simplified model as explained below. Communities outside that zone but at lower altitude than the reservoir (lower than 58m, dark blue contours) may still be in danger (South Abingdon and downstream Thames villages) and ***their risks must be properly addressed by Thames Water, because the Thames valley topography is too complex for the DEFRA Simplified Method we apply here***.

We now consider a vertical projection of the problem in order to further isolate and identify those communities that are most at risk, by excluding those whose altitude is above the flood's surface.

The following Figure B2 shows an overview of all communities possibly affected directly by a breach of the Reservoir. It uses the above DEFRA analysis to display (solid blue line, LH scale) the peak depth (i.e. average x 1.5) of the floodwater as a function of distance (X) from the breach in the reservoir wall. The central point of each community is shown at its distance (X) to the closest point below the Reservoir crest, with its height above the nominal base level of the Reservoir on the LH scale and its altitude above mean sea level on the RH scale:

Figure B2: Flood Peak Depth & Community Height vs Distance from Breach



[171] Thames Water and Affinity Water. South East Strategic Reservoir Option (SESRO) Supporting Document A-1: Concept Design Report (2022); *Appendix A.3 Indicative layout plan - 100 Mm^3 capacity reservoir; Drawing Title: Site Overview 100Mm^3 Option.*

The displayed depth is computed for the average breach with the flood progressing over flat terrain and takes no account of possible obstructions to flow, such as major roads or local topography. It is intended to be indicative only, allowing us to eliminate those communities not at High Risk, in order to focus on those most at risk. With those qualifications, communities above the peak flood level, which are Indicated by a green marker, are unlikely to be flooded at High Risk; communities below the peak flood level, indicated by an orange marker, are likely to be directly affected by the flood and might be at High Risk.

To err on the side of caution, after also studying possible variation in depth due to friction (the thin black lines) and the fact that a community typically spans a range in distance and altitude, we identify those communities above 68m altitude as out of danger, and concentrate on those below and including Frilford.

Of those communities we choose the three which are closest to the Reservoir crest, with flat open fields and no obstruction to the flood between breach and community, for which DEFRA's Simplified Method is most appropriate. Each of them is on the perimeter of one of the named communities on the above plot and they are represented (but unnamed) there by the open orange circles: 'West' Steventon, 'East' East Hanney and 'South' Drayton.

For each community the distance and base altitude of the closest possible breach point are determined[172], these are used to define community specific values of H_w, V_w and Q_p , and the resulting flood is transported at that base altitude to the target community, using the DEFRA procedure above. The effective flood depth D'max at the community is then defined by subtracting the height of that community from the peak depth of the flood water and this is used to compute an effective D'maxV for estimation of risk and impact.

The results are shown in the Table B1 below:

Table B1: Flood model results for perimeter communities.

Location	X m	Altitude m	Br Altitude m	Hw m	Vw Mm3	Qp m3/s	W m	DV m2/s	D m	V m/s	Dmax	D'max	D'maxV	D'(V=0)	Alt-Altbr	%Fatal
E.East Hanney	1319	61.0	59.0	19.4	89.9	5325.7	1055.3	5.05	3.11	1.62	4.66	2.66	4.32	2.79	2.00	6.3
W.Steventon	825	62.0	61.0	17.4	80.6	4506.5	665.4	6.77	3.21	2.11	4.81	3.81	8.05	4.04	1.00	20.2
S.Drayton	740	61.0	60.0	18.4	85.2	4910.2	599.6	8.19	3.42	2.39	5.13	4.13	9.89	4.42	1.00	29.4

These perimeter communities each consist of dozens of houses, every community having a population of order 60, so that the likely loss of life in a single breach (unwarned) would be about 11. For an unexpected catastrophic breach the time to first impact of the flood-wave at those 3 communities would be very short,

East Hanney 8 minutes ; W.Steventon 4 minutes ; S.Drayton. 3 minutes

So unless the warning anticipated the breach there would be little time for residents to save themselves.

[172] Distances measured by https://www.google.co.uk/maps/ , Altitudes using https://routecalculator.co.uk/elevation

Other 'orange' communities on the above plot are also likely to be at risk, but calculation of flood impact for them is more challenging, due to topographic features e.g. the flood must cross the river Ock to reach Marcham. Man made obstructions, such as the A34 will also shield some communities, but at the expense of others (including those in vehicles on the A34), as the obstruction diverts or slows (deepens) the flood. However, the shielding will be temporary, since the water will eventually find its way, following natural watercourses, into the Thames.

Catastrophic breach of the Reservoir's N embankment would release at least 94M m^3 of water at about 6k m^3/second in the direction of Marcham and Abingdon. When that flow enters the Thames at the Ock-Thames junction, it might exceed the average flow at Abingdon by a factor of over 200, with potentially disastrous consequences for residents around St Helen's Wharf and Caldecott. Even as far as Appleford-on-Thames the effects of a breach will certainly be felt, gravity assisting the water down the 7.7m fall in 10.7km along the Thames valley, flooding St Peter's and St Paul's Church, which is only 200m from the Thames and ~1m above it. DEFRA's procedures are too simplified to accurately predict D and V down a complex valley, at that distance.

The problems outlined in the last paragraph and this appendix can only be, and should already have been addressed fully by Thames Water in consultation with qualified reservoir engineers. It is their responsibility to define the extent of risk and provide appropriate mitigating design features and procedures. We see no sign of that happening.

Appendix C – The Regulatory Regime as a Driver of Capital Schemes

1. Criticisms of the Process and the Financial Regulatory Regime

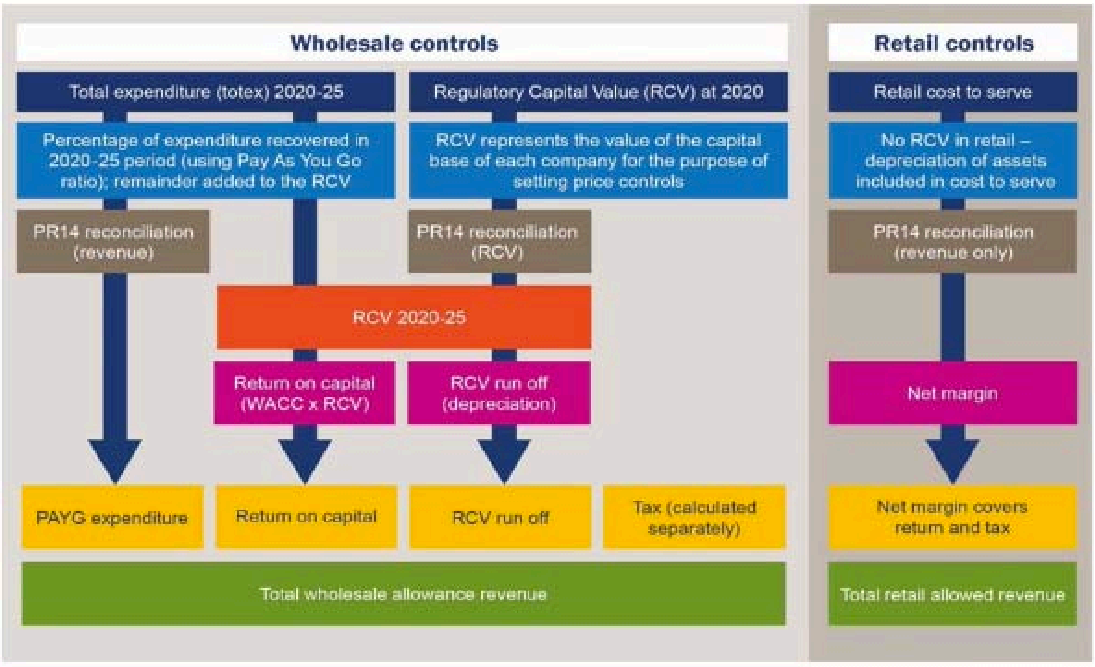
A. Introduction: Water Company finances and water industry regulation in relation to the proposed Abingdon reservoir.

Below is a coherent and damning description of Water Company finances, the regulatory regime and regulatory incentives since privatisation in 1989 that helps explain why Thames Water has been proposing to build a reservoir in Abingdon since 1995 and why, together now with its fellow water companies, Thames Water continues to keep proposing it.

There is a great deal of useful authoritative and publicly available information on Water Company financing and water industry regulation on which this is based. The issues are complex as this document illustrates but the underlying story is simple. The Competition and Markets Authority investigated and reported on the market and specifically the price control mechanism at the request of four water companies that appealed Ofwat's PR19 price control determinations. Its Reports and Determinations are of particular use in understanding the regulatory regime and the role of OFWAT is setting price controls. Figure 2-2 of the Competition and Markets Authority's '*Final Report*', reproduced below, sets out diagrammatically the major components that determine the total revenue that Water Companies are allowed to charge their customers.

2.105 This is illustrated in Figure 2-2.

Figure 2-2: Determination of overall revenues from the building blocks



Source: Ofwat

This information is relevant to all the current processes: WRSE Regional Plan, Water Company dWRMPs, and the RAPID Gated process.

GARD has created a spreadsheet, described below, which computes the very large financial returns that would accrue to Water Company shareholders if the reservoir were to be built. We compare this to the absence of any similar return from spending additional money improving operations - including specifically additional operating expense to reduce leakage and per capita consumption earlier and more rapidly. It is clear that the regulatory regime creates extremely large incentives for Water Companies to favour large capital projects like the reservoir, to the detriment of improving operations. Initial results which demonstrate this are discussed in section II below.

Summary

1. There is a fundamental and extremely perverse incentive in the Water Industry regulatory regime that encourages investment in "big concrete" projects as the solution to any and all problems. This is widely acknowledged and has been stated by many authoritative experts including Sir Ian Byatt, former Director General of Ofwat, and Professor Sir Dieter Helm of Oxford University and UK Government adviser on regulation.

2. In simple terms and as shown in Figure 2.2 above, all expenditure by a Water Company that can be classified as being of a capital nature, including for example, building a reservoir and including the cost of developing proposals for a such capital asset, gets added to the water company's Regulatory Capital Value (RCV) and the company has a statutory right to make a real return on that RCV in all future years.

3. These perverse incentives in the regulatory environment specifically favour very long-life assets such as a reservoir in contrast to alternative methods of securing water for the southeast. The alternatives to the reservoir include the Severn Thames Transfer, desalination and increased effort in reducing water wastage by leakage reduction in the distribution pipework system. All these alternatives involve lower capital expenditure and shorter life assets , but consequently, these alternatives look less attractive from the perspective of Water Company shareholders.

4. If the reservoir were to go ahead, Water Company shareholders would still be earning their guaranteed return on the reservoir in 250 years' time. The asset lifetimes used for regulatory return calculations (and for accounting depreciation) significantly favour reservoirs (250-year life) over tunnels, pipelines and other water network assets (80 – 100 year lives).

Almost all Water Companies have highly geared balance sheets with very high levels of borrowings, which constrains financial flexibility and in order to reduce gearing favours the expenditure on assets which increase their RCV, eg. currently net debt to regulatory capital value (RCV) for Thames Water is at above 80%. These high levels of borrowings which have all been incurred since privatisation have largely been used to fund payments to previous shareholders. As a consequence of their corporate structures coupled with high levels of borrowings, most Water Companies have paid no or very low levels of corporation tax, for many years.

B. The perverse financial incentives in the Water Industry Regulatory Regime

Since the setting up of Ofwat in the 1989, the concept of the Regulated Capital Value (RCV) and Regulatory Asset Base (RAB) has been used as a key element in determining the charges that water companies can levy on their customers. As described above, in simple terms, expenditure that can be classified as being of a capital nature (eg a reservoir - and including the cost of developing proposals for a reservoir) is added to the water company's RCV and the company is allowed to charge customers a guaranteed inflation-proof return on that RCV in all future years.

This is succinctly expressed by Professor Sir Dieter Helm of Oxford University, writing in Sept 2021[173]:
"*the companies had an incentive to find hard physical capital solutions (concrete) rather than seek out natural capital options and find common interest outcomes that took account of the wider catchment costs and benefits. The way the capital base was determined (and the RABs) formed part of the attraction of the concrete route to investors*".

"*It is not exaggerating to say that this is a scandal of financial engineering, aided by OFWAT*."

And in October 2022:

"Failure to overhaul the regulatory regime won't make the companies behave any better, because it will not change the incentives they face."[174]

Sir Ian Byatt who was the head of the UK water regulator Ofwat after the industry was privatised in 1989, was equally forceful when quoted in the Financial Times in 2017 [175]:

"[Sir Ian says] ***THE SYSTEM REWARDS COMPANIES FOR SPENDING MONEY ON CAPITAL***

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[173] http://www.dieterhelm.co.uk/natural-capital/water/floods-water-company-regulation-and-catchments-time-for-a-fundamental-rethink-2/

[174] http://www.dieterhelm.co.uk/natural-capital/water/water-a- new-start/

[175] The Financial Times "The Big Read Thames Water PLC Thames Water: the murky structure of a utility company. As raw sewage poured into London's rivers, the water supplier awarded huge dividends to Thames Water's Investors" Gill Plimmer and Javier Espinoza May 4, 2017. https://www.ft.com/content/5413ebf8-24f1-11e7-8691-d5f7e0cd0a16

INVESTMENTS WHETHER OR NOT IT IS IN THE INTEREST OF CUSTOMERS. *This often comes AT THE EXPENSE OF MORE MUNDANE OPERATIONAL TASKS, such as* ***PREVENTING SEWAGE FROM SEEPING INTO THE WATER, STOPPING LEAKS ON ITS 10,000 MILES OF PIPES AND INSTALLING WATER METERS – one of the most effective means of preventing water waste****."*

*"If they had remained [..*public limited companies..*] they would have retained a corporate governance code. But* ***WHAT PRODUCES DIVIDENDS NOW IS GETTING THE CAPITAL BASE UP****."*

This regulatory environment further creates additional incentives in favour of the reservoir in comparison to alternative methods of securing water for the southeast which involve higher operating expenditure (specifically the Water Transfers but also Desalination and Demand Management measures like Leakage Reduction). The alternatives do not look anywhere near as attractive from the perspective of Water Company shareholders, having lower CAPEX, shorter depreciation periods, and a higher proportion of operating expenses

Advantages of an Abingdon-sized Reservoir to Water Companies

Water Company representatives have stated on several occasions that the Abingdon (SESRO) Reservoir was preferred because it was a simple straightforward scheme when compared with Severn Thames Transfer (STT) which would be more difficult to implement and more complex to operate.

From these statements, GARD believe that the reservoir is preferred by the Water Companies, over the STT for the reasons set out below, none of which relate to it being the lowest cost or best value solution, but just to it being easy to understand and implement**:**

- The reservoir requires less co-ordination with third parties – the majority of the construction works are on a single self-contained site, all within the Thames Water region.
- The reservoir results in a self-contained easily identifiable asset – the reservoir will be a completely new asset capable of clear delineation**.**
- **The raw water source** is entirely within Thames Water's sole control – there is no need for raw water from another company, nor for price negotiations on the cost of such water.
- The reservoir will have a long service life, with steady cash flow. In contrast, any charging mechanism for the STT would have a fixed and variable element, with in some years less water required than others. This would make any income from the asset less predictable and make the project harder to borrow against.
- The reservoir would create a larger and longer lasting addition to the Water Companies Regulated Asset Bases – thereby creating a larger return for their

shareholders.

- The export of a majority of the deployable output of the reservoir to provide the needs of Affinity Water and Southern Water provides a guaranteed income stream.

- Because of all the above, SESRO would be a more 'Bankable' scheme against which finance could be raised relatively straightforwardly.

C. General Criticisms of Regulatory Regime.

WRSE and RAPID processes. We have serious concerns over the way these processes are run, including:

1. Complexity of the process. GARD believe that the processes of WRMPs, Regional plans and RAPID plans which are nominally under the control of OFWAT and the Environment Agency have in effect been captured not just by the Water Companies but in addition by the armies of consultants advising the water companies. The water companies and the consultants have made the whole process including in particular project evaluations so complex that no one who has not spent a very long time immersed in the process stands much chance of understanding it. In common with other aspects of water company regulation, these processes get more complicated each time they are iterated. We have serious doubts whether the water companies or their consultants themselves can see the wood from the trees. The ability of computers to churn out endless output just serves to hide the wood from the trees – one example is the 1566 pages of WRSE's Investment Model report[176]. Who can have looked through all of this report, let alone all the many other examples? We seriously doubt that the Water Company Board members who must give their "assurance statement" do so.

2. Complexity as a cover. This complexity acts as a cover for the water companies to promote their favoured schemes (those who pay the piper call the tune). This response from GARD identifies many errors and other failings that we have identified in the process in the time and with the limited resource available. We believe that many more errors are contained in the proposals, but that shortage of time and resource prevent them being identified.

3. We believe that the Capex figures for the SESRO reservoir are likely materially underestimated. We note with alarm that the cost estimate for the Thames Tideway Tunnel at an equivalent stage (£2 billion) doubled once the Tideway Tunnel project was approved by the government and detailed work was undertaken. It increased from £2 billion to between £3.7 billion and £4.3 billion in September 2010. This doubling was attributed to: *"the original cost estimate for the tunnel [being] revised*

[176] https://www.wrse.org.uk/media/yiplrr4w/wrse-investment-model-draft-regional-plan-results.pdf

following extensive studies, said head of London Tideway Tunnels Phil Stride". The original £2bn figure was reached in 2006 by a desktop study worked on by "a handful of people", he said, but more detailed research, ground investigations and site surveys have led to the revised figure. "It's much more detailed. We've had hundreds of people working on it, which comes at a cost in itself," said a Thames Water spokesman. Stride said the original study was limited by the amount that could be spent on it given that the project had not been approved by the government at that time. "The accuracy of any estimate is dependent on the time and effort that goes into it,"[177]

In the light of this, we note the alarming parallels that:

a) the SESRO project has not yet been approved by the government, and

b) Thames Water are yet to conduct "ground investigations" on the SESRO site as notified by their Engagement Manager on February 7th 2023. *"As part of the development work on the proposed reservoir we need to carry out some survey work to gather technical data about the ground conditions and existing environment to inform engineering design and assessment of potential environmental impacts. We're writing to local landowners to request access to their land to carry out the surveys."*[178]

Any increase in the cost estimate for SESRO, let alone a doubling, would further damage the case for it being included in the best value plan.

4. Our specific concerns over Environmental Assessment and Population projections are well-covered in our main report.

2. Financial Model

GARD created a financial model using cost and other data contained in the RAPID Gate 2 document for SESRO and the Thames Water dWRMP. The model also used data from the CMA determination on the elements of WACC. GARD have used this model to calculate the cashflows arising from over the 250-year life of the reservoir, 2022 to 2285. Specifically, GARD used this model to calculate the following:

1. The increase in Shareholder Value that would immediately arise and benefit the Shareholders in the three Water Companies who would jointly own the reservoir if it were to be given the go ahead (Thames Water, Affinity Water and Southern Water).

Our calculations show that the immediate increase in Shareholder Value created by any decision to approve the reservoir would be £846 million. This arises from the return on the increase in Regulated Capital Value (RCV) resulting from the £1,788 million Capital

[177] New Civil Engineer "Thames Tunnel sewer costs rise up to £2bn" 16th September 2010
[178] Email from Rachel Groves "Notification of local survey work - for your information" to Garford Parish Meeting dated 7th February 2023

Expenditure on the reservoir. All these numbers are fixed in 2022 currency.

2. GARD separately calculated the increase in Shareholder Value that would arise if the same amount of money identified as the initial construction cost of the reservoir, £1,878 million, were instead to be spent on increased operating expenses over the same period, to reduce leakage and to reduce demand. We believe that the answer is zero.

There is therefore a **staggering £846 million incentive** within the Regulatory Regime to build the reservoir rather than to accelerate the reduction of leakage rates and water consumption.

3. The additional cost that Water Company customers would pay for the reservoir. The numbers are absolutely staggering: £4,829 million over the 80-year WRSE planning horizon and £13,673 million over the 250-year life of the reservoir. Again, all these numbers are fixed in 2022 currency.

4. In contrast, the additional cost that Water Company customers would pay for an additional £1,878 million of operating expenditure to reduce leakage and to reduce demand, is only £1,878 million. The reservoir would therefore cost customers an additional £3,041 million over the 80-year planning horizon of the WRSE process.

5. GARD have used £1,878 million here to illustrate the differing financial consequences to customers of the same value of expenditure on different things. Furthermore, figures 11-3, 11-4, 11-5 and 11-6 in Thames Water's dWRMP together with tables 5-1 and 5-2 in WRSE's "Draft Regional Plan Technical Annex 2 (Nov2022)" show that accelerating Thames Water's plans to reduce leakage and reduce per capita consumption would provide a reduction in demand equal to or greater than the deployable output of the 100 Ml/d SESRO. This is quite apart from the improvement in resilience from reducing demand. The benefits of regulators setting more aggressive demand reduction targets are illustrated in this quote from the EU: *"Whilst water loss management is often pictured as the implementation of technological solutions to a hidden problem, this is really only part of THE REAL SOLUTION, which is all ABOUT MANAGING UTILITY PEOPLE TO PERFORM. It is about empowering them with the responsibility, training, practical tools and proven techniques, MOTIVATING THEM TO PERFORM, and inspiring them to believe that they can make a difference."*[179]

6. It needs to be stated that the building of the reservoir is on all measures worse than the alternative examined here of reducing leakage and consumption: it is specifically more expensive for customers, has a materially worse carbon footprint, is in the wider context more environmentally damaging and by bringing in no new water supplies to the South

[179] EU Reference document Good Practices on Leakage Management WFD CIS WG PoM 2015 https://op.europa.eu/en/publication-detail/-/publication/3ff6a13c-d08a-11e5-a4b5-01aa75ed71a1/language-en

East is not drought resilient.