GARD response to Thames Water's April 2017 Fine Screening Report

Contents

Figures

Tables

Summary

GARD continues to have major concerns over the findings of the Fine Screening Report:

1. Whilst accepting that a London deficit of 800 Ml/d by 2100 could be a reasonable basis for contingency planning, there is big uncertainty, particularly in climate change projections and the demand growth forecasts (eg immigration post-Brexit). The FSR should give more recognition of these uncertainties and more emphasis on incremental development of schemes over many decades, avoiding unnecessary schemes and providing a "no regrets" approach.
2. We do not accept the rejection of the Unsupported Severn-Thames transfer on grounds of low deployable output and high unit cost. There is a large unexplained discrepancy between historic and stochastic yields of the scheme. No evidence of costs has been supplied.
3. We do not accept the expected rejection of the Lower Lee direct abstraction scheme on grounds of low yield and high unit cost. The yield has not been properly assessed for the use of the scheme in conjunction with the rest of the London supply system.
4. Thames Water's stochastic drought analysis has shown that the Abingdon reservoir has very poor resilience to droughts of longer duration than 24 months and has failed to provide robust evidence that such droughts would be so rare as to be an acceptable risk for London's supplies.
5. There is no evidence provided to demonstrate that the water quality in Abingdon reservoir would be acceptable when the water level falls to give average depths of less than 5m, which would result from the proposed abnormally small volume of emergency storage.
6. There is no recognition of the possibility of the Abingdon reservoir becoming a "white elephant", with permanent and irreversible local impacts, if the 800 Ml/d water supply deficit fails to materialise.
7. We think that the deployable outputs of supported Severn-Thames transfer schemes have been underestimated. More attention should be given to managing the impact of regulation releases on the River Vyrnwy, and releases substantially larger than 180 Ml/d should be considered. Proper consideration should be given to GARD's April 2016 proposal for supporting the transfer with water from the Severn rail tunnel "Great Spring".
8. We consider that, in planning for the contingency of an 800 Ml/d deficit by 2100, the proposed restrictions on total reuse and desalination schemes are premature and unjustified. The concerns over excessive dependence on reverse osmosis treatment and increased estuarine salinity are unproven. With incremental development of reuse and desalination options over many decades, the acceptability of multiple schemes will become apparent over time and other option types can be chosen later if necessary.
9. The FSR fails to consider GARD's proposal for SWOX reuse schemes, despite the evidence presented by GARD that environmental impacts and derogation of downstream supplies would be minimal.
10. In the next phase of WRMP19 programme development there should be more transparency of conceptual designs and cost estimates. There should also be more transparency of Thames Water's modelling of scheme yield assessments and operational usage which provides crucial data for conceptual designs and cost estimates.

1. Introduction

This paper gives GARD's comments on Thames Water's up-dated Fine Screening Report dated April 2017. In general, we feel that the detailed comments that we made on the October 2016 Fine Screening Report[1] have been either unjustifiably rejected or ignored altogether. This response is brief of necessity, bearing in mind the short time available to make it and the ever-increasing tightness of the WRMP programme. Where possible, we have referred back to our October 2016 FSR response and other recent GARD papers, rather than repeat the same arguments in full.

2. Forecast deficits

2.1 The Deficit for London

We welcome the additional detail on the forecast deficit that has been provided in Table 2.1 of the FSR and in slide 9 shown at the 28th April stakeholder meeting[2] which is copied below:

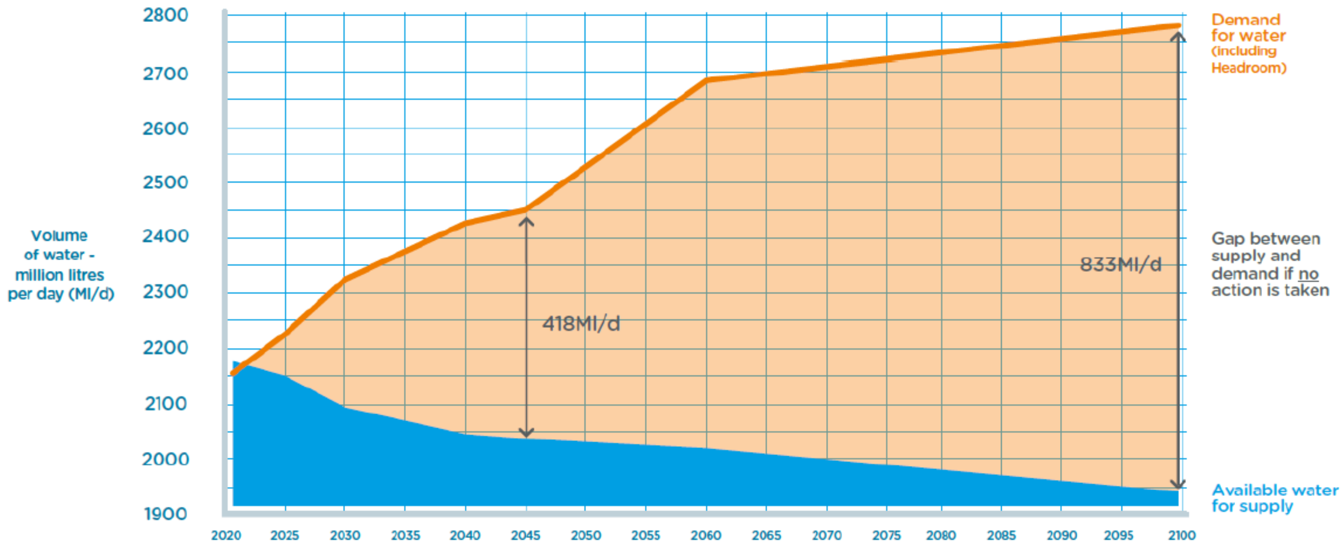

Figure 1 - TW forecast of growth in water supply deficit for London

This raises a number of questions:

1. Demand is forecast to rise by about 630 Ml/d between 2020 and 2100, an increase of 30%. This increase is net of reductions due to improved demand management and leakage control, so the underlying demand increase is substantially higher than 30%. This is a very large increase and no justification has been supplied. Slide 7 states that these demand increases have been determined by Edge Analytics and Leeds University. Please can full details of this be made available to stakeholders?

2. Demand is shown to rise sharply between 2045 and 2060. On querying this at the stakeholder meeting on 28th April, we were told that this is due to increased immigration.

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[1] GARD response to Thames Water's draft Fine Screening Report on WRMP19 Resource Options. 31st October 2016

[2] https://corporate.thameswater.co.uk/-/media/Site-Content/Thames-Water/Corporate/AboutUs/Our-strategies-and-plans/Water-resources/Document-library/Past-meetings/TSM-28-April-2017-Presentation-Final.pdf

What is the justification for this? Why should immigration suddenly increase in 2045? How can this be reliably forecast more than 25 years into the future? Does this estimate take account of the immigration controls that seem likely post-Brexit?

3. Available supply is shown to fall substantially between 2020 and 2040:

    - 75 Ml/d between now and 2030
    - 60 Ml/d between 2030 and 2040

    What is the explanation and justification for these falls in supply output?

4. Slide 8 of the stakeholder presentation showed a sustainability reduction of 125 Ml/d for the Lower Lee licence. At the meeting we were told that this is in addition to the reductions in supply shown in Figure 1 above. What is the justification for this reduction? Please can we see the Environment Agency's report on this?

5. Between 2040 and 2100, available supplies are shown to fall by a further 100 Ml/d, ie 5%. No explanation is offered, but we assume that this is to allow for the possible effects of climate change. Whilst accepting that it makes sense to make contingency plans for the possibility of reductions in supply due to climate change, we would comment that these reductions are highly uncertain.

    We unreservedly accept the premise of global warming and consequent climate change – the evidence of rising temperatures over the past 100 years appears irrefutable. However, we are not aware of any evidence that the climate changes that have already taken place have led to any increase in the frequency or severity of droughts affecting London's water supplies. In fact, the frequency and severity of droughts affecting London's supplies has reduced over the past 100 years as illustrated below:

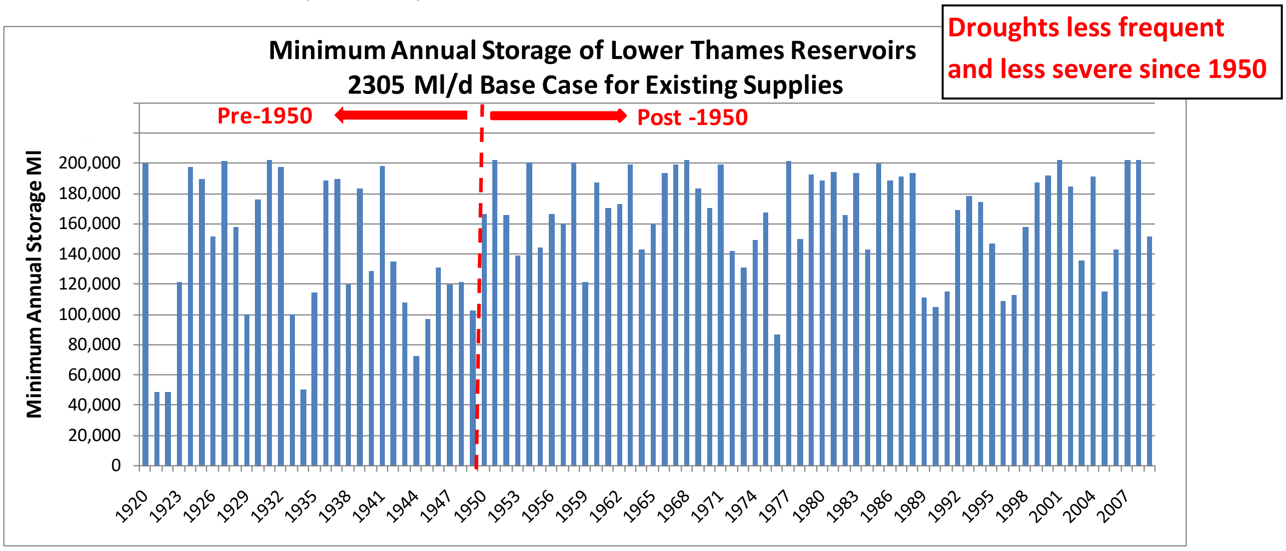


Figure 2 - Frequency and severity of droughts affecting London's water supplies

This plot shows the WARMS2 minimum annual storages from simulation of existing London's supplies at the base case maximum output of 2305 Ml/d, under the historic flows since 1920. From visual inspection of the plot, it is clear that that the effects of droughts have become less frequent and less severe since about 1950. In our opinion, this is strong evidence that London's supplies have not become more vulnerable to droughts over the past 100 years, despite the climate change that has already occurred.

We accept that this should not be used as evidence that climate change will not make London's supplies more vulnerable to droughts in the future – there are no grounds for complacency. However, it puts the likelihood of this happening into perspective – the climate change impacts are highly uncertain. Equally, in our opinion, there are big uncertainties associated with the demand growth shown in Figure 1 above.

The 800 Ml/d deficit that TW are considering for dWRMP should be viewed as a planning contingency, not a "supply demand forecast" as stated on Table 2.1 of the FSR or "baseline forecast resource deficit" as stated on the presentation slides for the April stakeholder meeting.

In our opinion, this uncertainty in the deficit forecast should be made much clearer in the Fine Screening Report. There should be more explanation of the factors driving the deficit shown in Figure 1 and more assessment of the likelihood of this deficit occurring.

Reflecting this uncertainty, there should be more emphasis on the need for flexibility in the resource development programme, to allow for future deficits being a lot less than 800 Ml/d. There should be more emphasis on avoiding unnecessary development of schemes, particularly schemes with irreversible impacts. There should be a clear 'no regrets' policy in choosing the preferred programme and this should be one of the measures for assessing individual schemes. At present, there is no measure for this in the scheme assessment methodology.

2.2 The deficit for Swindon and Oxford zone

The deficit for SWOX, taken from slide 10 from the presentation on 28th April, is as below:

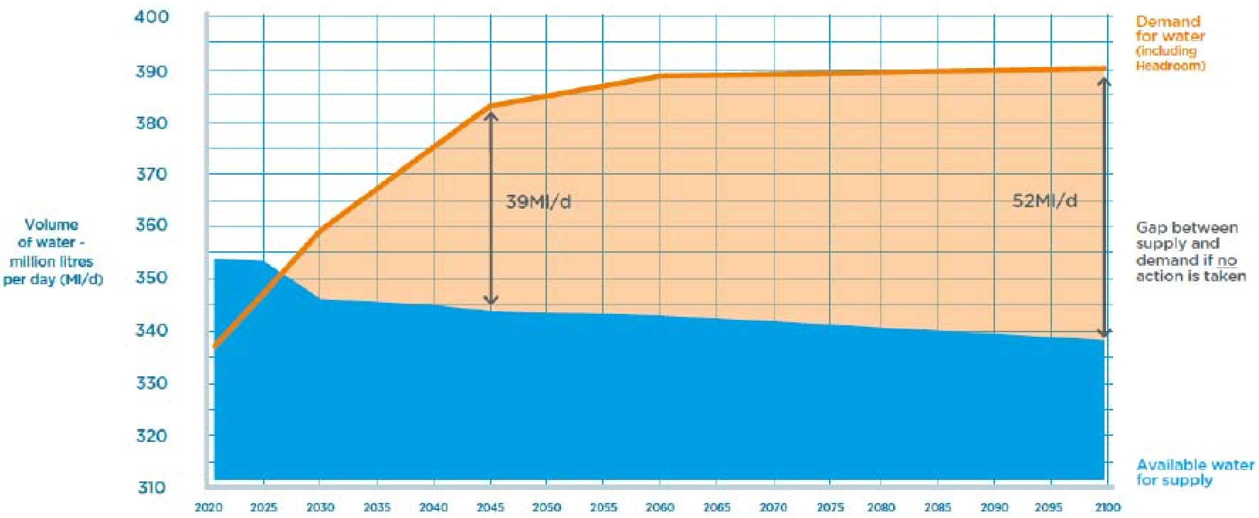


Figure 3 - TW forecast of growth in deficit for Swindon and Oxford zone

As for London, the Fine Screening Report should include an explanation and justification for the deficits, include details of the uncertainties associated with the forecast and an assessment of the likelihood of the deficit occurring. Also as for London, there should be a 'no regrets' approach to resource development and measures for the suitability of the supply options in achieving this, recognising the uncertainties in growth in demand and reduction in water available.

2.3 The deficit for Slough, Wycombe and Aylesbury zone

Table 2.1 of the Fine Screening Report shows a forecast deficit of 77 Ml/d for the SWA zone by 2100. This is illustrated on slide 10 of the presentation to stakeholders:

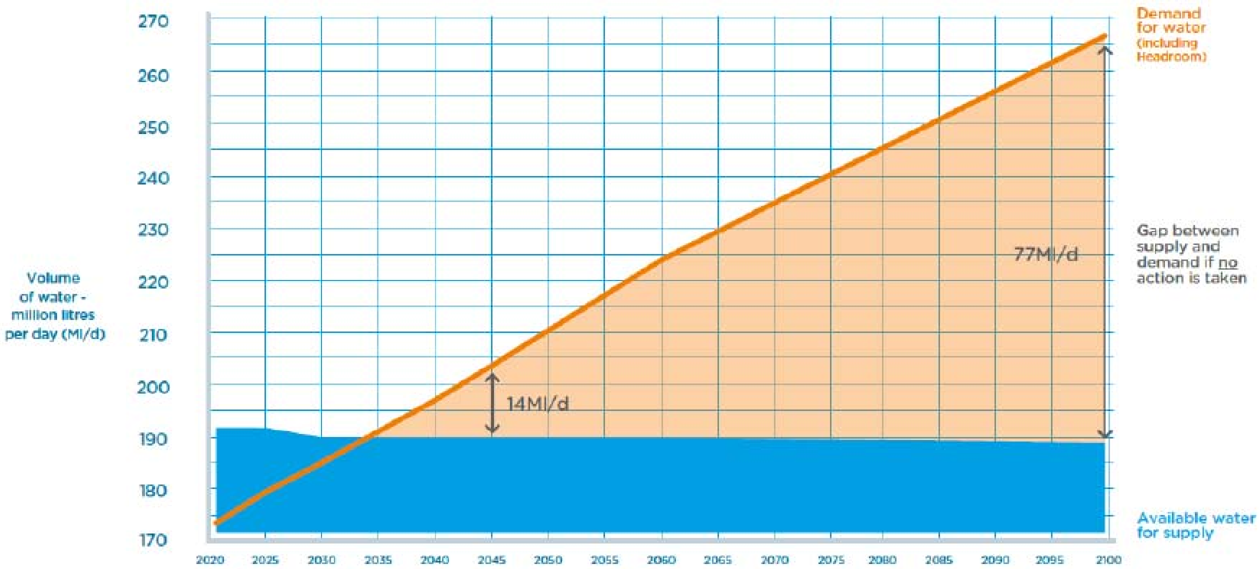


Figure 4 - TW latest forecast of growth in deficit for Slough, Wycombe and Aylesbury zone

The Fine Screening report offers no explanation or justification for the very large increase in demand in Thames Water's forecast. The forecast 77 Ml/d deficit in 2100 is orders of magnitude bigger than the 6 Ml/d deficit in 2040, as forecast in WRMP14. This has shifted the measures required from being minor adjustments to existing sources to the need for major development. The absence of highlighting of this in the Fine Screening Report is a serious lapse in transparency, which should be rectified.

As far as we can see, Section 7 of the Fine Screening Report contains no proposals for meeting a 77 Ml/d deficit. Is this to be another attempt to justify the Abingdon reservoir? The options for meeting a deficit of this magnitude should be made clear in the Fine Screening Report.

3. Demand management

No details of demand management or leakage reduction measures are given in the revised FSR. At the stakeholder meeting on 28th April we were told that there have been delays in modelling of these measures. When will detail be made available and will stakeholders be given the opportunity for early comment?

In the absence of new detail, we emphasise our previous main points:

1. Meter penetration should be increased as fast as possible to achieve levels similar to best practice by other water companies, for example Southern Water. The previously planned trials of differentiated tariff structures should be undertaken. There should be a detailed and transparent programme for meter penetration that should form part of the WRMP. The programme should include details of assumptions for meter penetration and associated benefits.

2. There should be more emphasis on leakage control and pressure management, reflecting Figure 2 of the demand management feasibility report which showed active leakage control and pressure management as having a much lower AIC cost than development of new water resources.
3. The mains replacement programme should take account of the long term need to replace pipe networks, many of which are over 100 years old. The pipes will not last indefinitely, so replacement is inevitable at some point. This should be taken into account in the economic assessment of mains replacement as a leakage reduction measure. Also, we do not think that rigorous economic analysis should be the sole basis for decisions on leakage reduction. Thames Water's customers have expressed a strong desire for more leakage reduction and common sense supports this view.

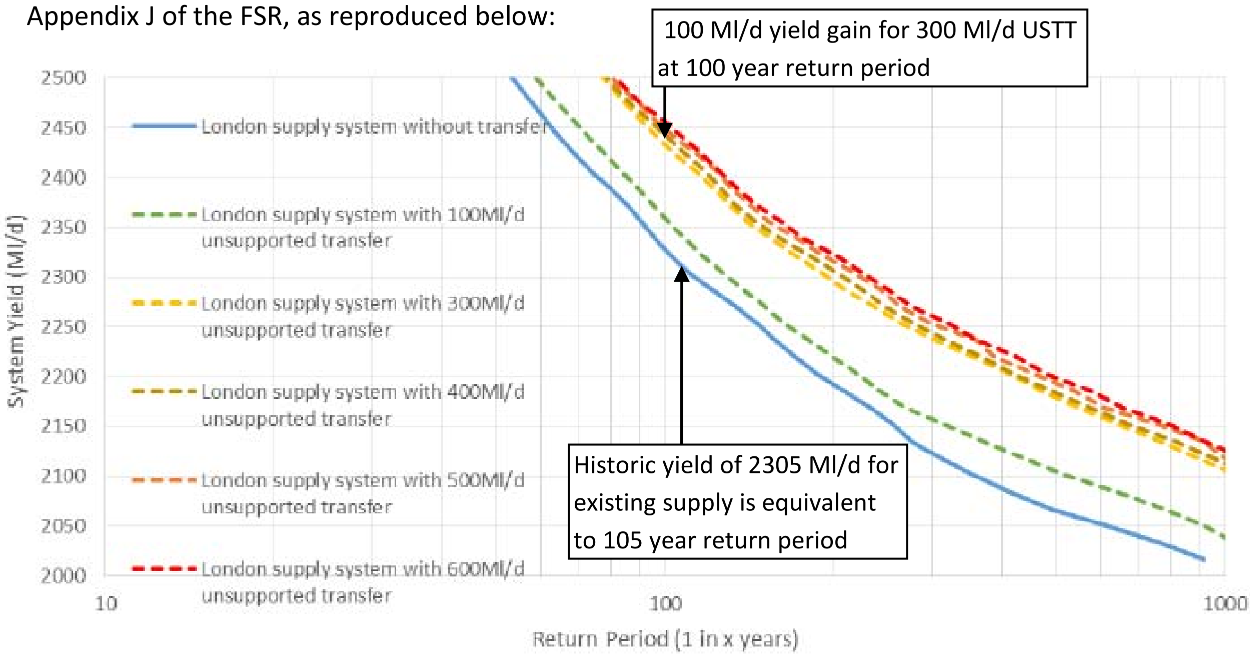
4. Options rejected by Thames Water

4.1 The Unsupported Severn-Thames transfer

We do not accept the justification for rejection of the unsupported Severn-Thames transfer as stated on page 53 of the FSR:

Rejected at validation stage of feasibility report on cost grounds given low stochastic reliable yield for unsupported transfers.

The "low stochastic reliable yield" has been based on Atkins' assessment shown on Figure 4-2 of Appendix J of the FSR, as reproduced below:



Note: We assume that the "yield" referred to by Atkins is equivalent to "deployable output" in WRMP terms.

Figure 5 - Atkins' assessment of yield of existing London supplies and USTT option

From the plot shown in Figure 5, Atkins have concluded that that the stochastic yield of the 300 Ml/d transfer is about 100 Ml/d (without allowing for climate change) throughout the 10 year to 1000 year range of drought severities. We question the validity of this finding for the following reasons:

1. We accept the assessment of existing London supplies, from which Figure 5 shows that the 2305 Ml/d base case deployable output of existing supplies has a 105 year return period. This looks to be a reasonable value, bearing in mind that the 2305 Ml/d DO is determined by the most severe drought in the 95 year historic flow records – ie the drought of 1921/22 as determined by both WARMS2 and GARD models. As a reality check, this makes sense.
2. Atkins' 100 Ml/d stochastic yield assessment does not make sense to us and appears to fail the reality check of comparison with the DO based on historic flow records. Thames Water's assessment of historic DO is 142 Ml/d (FSR pdf page 180). Our assessment of historic DO is 150 Ml/d – we do not accept TW's value of 142 Ml/d, nor do we accept that the difference is due to use of GARD's model as suggested by TW[3]. However, whether the historic DO is 150 Ml/d or 142 Ml/d, it is still much higher than Altkins' value of 100 Ml/d. We can think of only three possible explanations for this large discrepancy:
    i. Atkins stochastically generated data for Severn flows at Deerhurst are much less than the historic flow record derived by HR Wallingford and used by both Thames Water and GARD in assessment of the USTT's historic DO – this would suggest big differences in assumptions or flaws in either Atkins' or HRW's work. For example, in generating the stochastic flow data for the Severn and Thames, what were the assumptions for correlation of rainfall in the two catchments?
    ii. By chance, there has never been an occasion since 1920 when a severe Severn drought has coincided with a severe Thames drought. We reject this explanation and suggest that early recovery of Severn flows, compared to the Thames, in all the historic droughts is the consequence of big geological differences in the catchments. In particular, the high proportion of chalk in the Thames catchment always delays flow recovery by 2 or 3 months after the start of autumn rain, whenever it occurs. The Severn responds almost immediately to autumn rain – this is the prime reason for the effectiveness and resilience of the unsupported transfer.
    iii. Atkins' simulation modelling of the operation of the USTT fails to validate against the equivalent WARMS2 modelling, either because of inadequacies of Atkins' IRAS model or differences in assumed operating rules.

Whatever the reason for the large discrepancy between historic and stochastic yields, it needs to be investigated and explained with full transparency. GARD's request for more information[4] has been refused[3] after a delay of 10 weeks. We will continue to pursue this request. GARD also intends to undertake its own assessment of stochastic yield, using Atkins' stochastic flow data, and also to challenge TW's figure of 142 Ml/d for the historic DO.

Atkins suggests that due to climate change the yield would fall from 100 Ml/d to 80 Ml/d (FSR pdf page 187). In the absence of Atkins' flow data for the climate change scenarios (data requested by GARD on 14.2.17, but refused by TW email of 24.4.2017), we are not able to comment on this yield

[3] Thames Water email to GARD on "Resilience of UTR and unsupported Severn-Thames transfer options", 24.4.2017

[4] GARD email to Thames Water on "Resilience of UTR and unsupported Severn-Thames transfer options", 14.2.2017

reduction. However, we note that, if the historic DO of 150 Ml/d is reduced by 20%, it still leaves a deployable output of 120 Ml/d.

Atkins suggest a further 10-20 Ml/d fall in yield due to other Severn abstractors fully using their licensed entitlement (FSR pdf page 189). In our opinion, if the stochastic 100-year yield is equivalent to GARD's historic yield of 150 Ml/d, this would still leave over 100 Ml/d of yield after allowing for climate change and other abstractors.

We do not know what value of yield or DO has been used in the assessment of AIC costs that led to the rejection of the USTT option on cost grounds – this should have been stated in the FSR. However, based on the concerns expressed above, we fear that the yield has been under-estimated by about 40%.

No information has been provided in the FSR on the USTT cost data used to justify rejection of the transfer. This is a major lapse in transparency that should be rectified.

Overall, we feel that the USTT still should be considered as the first phase in any development of the Severn-Thames transfer. Even without any flow support and allowing for climate change, it can provide a deployable output of over 100 Ml/d, with the potential to meet deficits in SWOX and elsewhere in the Thames valley, as well as London. It can be developed without any trading agreement with other water companies (aside from provision of a small pipeline sweetening flow), using Severn flows that are naturally available. If the deficit turns out to be less than forecast, there would be minimal residual impact from construction of the transfer facilities (compared to the Abingdon reservoir). It would fit with a 'no regrets policy'.

4.2 The Cotswold canal transfer

We note that the Cotswold Canal transfer option has been rejected on grounds of comparison of costs with the pipeline transfer option. No cost information has been provided – a serious lapse in transparency. Whilst we would leave it to the Cotswold Canal Trust to challenge the detail of the costings and underlying conceptual design assumptions, we consider that the FSR or feasibility report should provide details of:

- The pumping heads, average annual pumping volumes and average annual energy use that were assumed in the assessment of pumping costs for the canal and pipeline transfer options – did the analysis take proper account of the saving in pumping costs of the canal option when compared to the pipeline option?
- How were the economic benefits of restoration of the canal evaluated and taken into account in the cost comparison?

4.3 Lower Lee direct abstraction

We note that the Lower Lee DRA option has been provisionally rejected on grounds of high AIC cost and that the associated DO is only 33-55Ml/d (FSR Table 5.7 page56). At the stakeholder meeting on 28th April, referring to slide 40, were told that Lower Lee flows drop to 50-60 Ml/d during droughts, giving a DO of only 35-50 Ml/d after allowing for the Hoddesdon transfer.

In our opinion this analysis is incorrect because the Lower Lee DRA scheme would be operated in conjunction with the Lee valley reservoirs. Therefore, the DO would depend on the <u>total volume</u> that the direct river abstraction would contribute to the Lee valley supply system over the duration of the critical drought, rather than the minimum daily flow during the drought. The total volume would be governed by the average daily transfer during the drought which would be a lot more than the minimum daily value. The DO of the scheme should be determined by using WARMS2 to simulate the operation of the DRA in conjunction with the Lee valley reservoirs and other components of the London supply system. At the stakeholder meeting, we were told that this has not been done. This should be rectified in the FSR.

5. Options taken forward for detailed assessment

5.1 The Abingdon reservoir

5.1.1 Resilience to stochastic droughts and climate change

On the limited evidence that is available in the FSR (including Appendix I, stochastic analysis of the Upper Thames Reservoir), we consider the following statement on Table B.3, page 117 of the FSR to misleading:

> *The resource benefits of large reservoir options should not be significantly diminished as a result of climate change scenarios resulting in increasingly wetter winters and drier summers.*

We do not agree that this is a substantial benefit as recorded on Table B.3. As we said in our response to the October FSR, the Abingdon reservoir has poor refill capability in dry winters, giving it low resilience to droughts extending over two winters. Therefore, resilience to wetter winters and drier summers is of limited relevance. The key climate change concern is the possibility of drier winters and droughts of longer duration than 20-24 months. This does not appear to have been considered sufficiently (if at all) in the climate change assessment.

Furthermore, we do not accept the conclusion on Table B.3, page 117 of the FSR:

> *Stochastic analysis of resilience of reservoir storage to future droughts indicates that the reduction in Deployable Output associated with future droughts is not significantly less than the Deployable Output based upon historical droughts. Therefore assessed as material benefit.*

In our opinion, the stochastic analysis in Appendix I over-emphasises the resilience of the Abingdon reservoir to droughts of similar duration to droughts in the historic record (ie less than 24 months) and underplays the significance and likelihood of droughts of longer duration. For example from Appendix I (FSR pdf page 167:

> *The yield of the UTR is expected to be robust for all droughts with a similar critical period to the major historic events. This covered the majority of the sampled drought events, so the UTR provided a yield benefit within 20% of the 287Ml/d yield calculated from the historic record for 27 out of 30 of the tested droughts.*
>
> *Some longer duration (24 to 36 month type) events were contained in the libraries, and under three of these there was insufficient winter recharge available for the UTR to offset this longer duration, so the yield of the UTR was significantly lower than the historic estimate.*

For one of these three droughts longer than 24 months, the yield would drop from 287 Ml/d to just 95 Ml/d – a catastrophic reduction (Table 3-1, Drought 1). For the other two longer duration droughts, there would be reductions in yield to 220 Ml/d and 230 Ml/d respectively (Table 3-1, Drought 5 and Table 3-3, Drought 9). These are large reductions which would increase the AIC cost of the Abingdon reservoir by about 20-25%.

The likelihood of these longer droughts occurring is assessed as roughly 1 in 1000 years using an extremely crude calculation, which, in our opinion, has little statistical credibility (Appendix I, Section 4, FSR pdf page 172). The report then uses this to conclude:

> *"The above analysis suggests that the UTR can be considered to be resilient in terms of water resources planning, down to an extremely low frequency return period."*

We do not accept this conclusion. Aside from the doubts over the reliability of the assessed likelihood of longer duration droughts, there is no statement or justification of the level of risk deemed acceptable for London's supplies. We also note that, using GARD's model to simulate the effect of the Water UK stochastic drought data that Atkins supplied to GARD, one of the droughts gave a similarly catastrophic failure to the 95 Ml/d DO drought referred to above. This drought was said to have a return period of 1 in 200 years. Is this considered an acceptable risk?

Overall, we conclude that Atkins' work has confirmed that the Abingdon reservoir would have very poor resilience to droughts in excess of 24 months duration and that their work has failed to provide convincing evidence that such an event would be so rare as to be an acceptable risk for London's supplies.

5.1.2 Reservoir water quality and minimum water depth

The 150 Mm^3 Abingdon reservoir is said to have a total storage of 165 Mm^3 and a live storage of 150 Mm^3, giving a dead storage of 15 Mm^3. The emergency storage is to be 30 days of output, equivalent to about 9 Mm^3, ie only 6% of live storage. Therefore, the combined dead storage plus emergency storage is 24 Mm^3, ie 15% of the total storage. With a total water depth of about 28m, this implies that the average water depth when storages falls to the emergency level will be only about 4m (ie 15% of 28m).

A minimum average water depth of only 4m raises big questions about water quality in the reservoir in a major drought, bearing in mind the weather conditions likely at the peak of the drought. No details of measures to control reservoir water quality have been provided in the reservoir feasibility report. The emergency storage of 6% of live storage is an unusually low amount in reservoir engineering practice – 15 to 25% of live storage would be a typical allowance for emergency storage. For example, the existing London reservoirs have a combined emergency storage of 24%.

The release of poor quality, algal-laden water into the Upper Thames during droughts is potentially a significant environmental impact, threatening deterioration in the WFD ecological status of the river. To date no information has been provided on this and the issue has not been recognised in the Table B.3 screening criteria in the FSR.

Lack of attention to reservoir water quality, appears to have been a serious omission which should be rectified in the FSR, and addressed in future environmental assessments and the conceptual design report, which should be made available to stakeholders in its draft form as soon as possible.

5.1.3 Potential for being a "white elephant"

The Abingdon reservoir will become a "white elephant" if it is constructed in anticipation of a future deficit which does not materialise. As we have pointed out in Section 2.1 of this paper, for TW's proposed 800 Ml/d planning deficit, there are big uncertainties over demand growth and climate change. The local environmental impacts of reservoir construction will be permanent and irreversible. This is a much bigger threat for the Abingdon reservoir than for the other major option types, where construction impacts will be a lot lower and less permanent. This should be taken into account in the Fine Screening assessment and the issue should be highlighted to stakeholders.

5.2 Supported Severn-Thames transfer

5.2.1 Deployable output and resilience

Details of GARD's assessment of the deployable out of supported Severn-Thames transfer options were given in Section 4 of GARD's response to the Fine Screening Report in October 2016. The analysis was based on modelling of historic river flow data since 1920. Thames Water's equivalent analysis was based on stochastically generated flow data and is described in Atkins' report appended to the latest FSR[5], with yields summarised in Table 2.1 of the Feasibility Report up-date[6]. Some of the deployable output assessments are compared below (we assume that the yield benefits assessed by Atkins are equivalent to DOs assessed by GARD):

Option	Atkins DO	GARD DO
300 Ml/d transfer supported by 180 Ml/d from Vyrnwy and 15 Ml/d from Severn Trent	200 Ml/d	209 Ml/d
400 Ml/d transfer supported by 180 Ml/d from Vyrnwy and 15 Ml/d from Severn Trent	240 Ml/d	252 Ml/d
300 Ml/d transfer supported by 180 Ml/d from Vyrnwy and 128 Ml/d from Severn Trent	240 Ml/d	247 Ml/d
400 Ml/d transfer supported by 180 Ml/d from Vyrnwy and 128 Ml/d from Severn Trent	280 Ml/d	302 Ml/d
500 Ml/d transfer supported by 180 Ml/d from Vyrnwy and 128 Ml/d from Severn Trent	303 Ml/d	345 Ml/d

Table 1 - Comparison of GARD and Atkins assessments of DO of supported STT options

The GARD assessments of the 300/400 Ml/d transfer options, using historic flow data, are all 5-10% higher than Atkins' using stochastic drought data. Although the differences are a lot less than the 40% difference in GARD and Atkins' assessments of the unsupported transfer, they are still potentially significant when it comes to option selection. For the 500 Ml/d transfer, the difference of 42 Ml/d (14%) is bigger and potentially more significant because, in GARD's opinion, the 500 Ml/d transfer is likely to be the optimum if the Severn-Thames transfer is supported by both Vyrnwy and Severn Trent. We find it surprising that, in Atkins' analysis, increasing the transfer capacity from 400 Ml/d to 500 Ml/d, only raises the deployable output by 23 Ml/d.

[5] WRMP19 Options Appraisal: Appendix document for the Lake Vyrnwy support scheme. 19 Aril 2017.
[6] WRMP19 Resource Option Development. Feasibility Report Status Update Note. Thames Water, Mott MacDonald, Cascade. 21 April 2017.

Therefore, GARD wishes to see full detail of the stochastic flow data used by Atkins and their simulation of option performance using their IRAS model.

For the combined support from Vyrnwy and Severn Trent, GARD also considered the 500 Ml/d transfer with regulation releases of up to 400 Ml/d from Vyrnwy, ie regulation releases of the same magnitude as the flood storage releases. Our analysis showed that larger regulation releases (only rarely needed) make better use of available storage in Vyrnwy reservoir and can provide a deployable output of approaching 400 Ml/d for Thames Water. We propose that the option of Vyrnwy regulation releases larger than 180 Ml/d should also be considered in Thames Water's detailed assessment of supported transfer options.

On Table 2.1 of the Feasibility Report update, the yield of all STT options have been reduced by 40 Ml/d to take nominal account of climate change and full use of licences by other abstractors. No evidence has been supplied to support this seemingly arbitrary and substantial reduction. This should be rectified in the FSR. GARD would like to see full detail of the assumptions and modelling underlying the reduction.

5.2.2 Impact of regulation releases on the River Vyrnwy

We are aware that Natural Resources Wales have expressed concerns over the impact of regulation releases on the flow regime and ecology of the River Vyrnwy. This matter was covered in some detail in GARD's December 2015 report on modelling of Vyrnwy support options[7]. The modelling looked at somewhat different options to those currently being considered by United Utilities and Thames Water, for example regulation releases of up to 400 Ml/d (as for flood relief releases), but we feel some of our findings from that work are still valid:

- With the operating rules proposed by GARD for sharing the storage with United Utilities, the reservoir would spill more during the spring and early summer than at present with the reservoir only used for direct supply to United Utilities. With the reservoir spilling, there would be a much more natural flow regime with a substantial ecological benefit at an important time of year, eg for salmon juvenile development and smolt migration.
- In dry years, when regulation releases would create unnaturally high and steady flows in the summer – this could be mitigated by incorporating more variation into the regulation releases and extending their duration.
- There would need to be more autumn releases for flood storage – again the pattern of flood storage releases could be changed to create a more natural flow regime, encouraging salmon migration as an ecological benefit for this option.

The impact of changes to the flow regime, both positive and negative, needs careful assessment in the investigation of this option, including design of mitigation measures. The operating rules for the scheme need to be designed to reduce ecological impacts and deliver potential ecological benefits, whilst also meeting the public water supply needs.

[7] Modelling the use of Vyrnwy reservoir to support the Severn to Thames transfer, pages 14-17. GARD, December 2015.

In our opinion, the process of developing the operating rules for this option should be similar to that used by the Usk and Wye Abstraction Group in developing operating rules for the Wye and Usk supply systems for Habitats Directive compliance, balancing the ecological needs for the river with public water supplies[8]. Cascade are familiar with this work, but we have seen no evidence that a similar approach is being used in developing and assessing the conceptual design of the Vyrnwy support option. This should be rectified in the conceptual designs and impact assessment for this option.

In the investigations of the Vyrnwy support option for the NRA's 1994 water resource strategy, there was a proposal to send part of the regulation release to the River Tanat via the existing tunnel aqueduct. There is also potential for the regulation releases to be delivered by pipeline to a lower point in the River Vyrnwy, avoiding some of the impacts in the reach below the dam. These potential mitigation measures should be considered as part of the conceptual design development.

5.2.3 Support through the Severn rail tunnel "Great Spring"

Table 5.3 of the FSR refers to the "South East Wales resource (including Great Spring)". This option makes use of about 60 Ml/d of water leaking into the Severn rail tunnel which is currently pumped to waste on the Welsh side of the estuary. The option is said to be on hold pending information from Welsh Water and confirmation of Natural Resources Wales and Welsh Government views. Table 5.4 says that the water will be provided by a "conveyance", which we assume means a pipeline connecting the Severn rail tunnel to the upper Thames. Table 5.5 states that the option has not been progressed because no information has been provided (presumably information requested from Welsh Water and NRW).

In a letter to Thames Water in April 2016, GARD proposed a different option for making use of the water from the Great Spring[9]. Rather than a pipeline direct from the Severn rail tunnel to the upper Thames, the water would be transferred indirectly to provide support to the Severn-Thames transfer through an arrangement comprising:

- Say, 60 Ml/d of spring water from the rail tunnel fed into Welsh Water's South-East Wales conjunctive use zone (SEWCUS).
- Supply from the Wye to SEWCUS via the Wye-Usk transfer reduced by 60 Ml/d
- Regulation from the Elan dams to support the Wye-Usk transfer reduced by 60 Ml/d
- Supply to Birmingham via the Elan aqueduct increased by 60 Ml/d in droughts (it is cut back in droughts under current licence conditions)
- Severn Trent abstractions from the Severn reduced by 60 Ml/d in droughts (not needed if Elan supply is increased), making available...
- Additional 60 Ml/d of water for Thames Water via the Severn to Thames transfer

This option may be more palatable to NRW and the Welsh Assembly than a direct supply of 60 Ml/d from the rail tunnel to Thames Water. The introduction of 60 Ml/d of Severn tunnel water into the

[8] River Usk and River Wye: Alternative licence proposals for DCWW, CRT and Severn Trent Water. Dwr Cymru Welsh Water, Canal and River Trust, Severn Trent Water, Wye and Usk Foundation with support of Natural Resources Wales and Environment Agency. December 2014.
[9] Letter from GARD to Thames Water dated 10th April 2016, headed the "Columbus" scheme, including schematic map.

South-East Wales supply system would introduce options for improved management of abstraction from the Rivers Wye and Usk, both of which are aiming for more natural flow regimes under the Habitats Directive. There would be significant ecological benefits to the Rivers Wye and Usk as well as, potentially, about 50 Ml/d of additional water for SWOX, the Thames Valley and London.

This option was proposed by GARD more than a year ago. We have received no feedback on whether the proposal is being considered. The option should be pursued as a serious source of water for supporting the Severn-Thames transfer. It is not acceptable for it to left unconsidered because of lack of response from Welsh Water or NRW.

5.3 Reuse and desalination schemes

5.3.1 Benefits of incremental development and adaptive management

In general GARD strongly supports the options being developed for effluent reuse and desalination schemes for London (including the Teddington direct river abstraction which is enabled by diversion of Mogden effluent). With relatively short lead times and construction durations (particularly compared to the Abingdon reservoir), these options provide the opportunity for incremental development as the water supply deficit grows. The construction of these schemes would have relatively little permanent environmental impact (compared to the Abingdon reservoir). If the schemes turn out to be un-needed because the forecast deficit doesn't materialise, they would simply be unused. Unlike the Abingdon reservoir, they would not be white elephants leaving an irreversible impact on the environment.

In our opinion, this aspect of the flexibility of the reuse and desalination schemes should be emphasised more in the Fine Screening Report.

The incremental development of reuse and desalination options would also reduce the risks of over-dependence on reverse osmosis technology or cumulative effects on estuary salinity. These risks are repeatedly emphasised in the FSR, for example:

> *Thames Water has confirmed that it considers that* ***the cumulative effect of exposure to these resilience risks would be unacceptable*** *if all desalination and reuse options at both Beckton and Crossness were developed using Reverse Osmosis technology (FSR page 67).*
>
> *There is a potential limiting factor on desalination capacities due to possible increased salinity levels in a given reach of the Tideway. A precautionary approach to the environmental assessment has been adopted that has resulted in a limit of 300 Ml/d of additional desalination capacity in any single reach of the River Thames, but subject to further analysis (i.e. estuarine modelling) it is expected that higher levels may be acceptable (FSR page 62).*

To an extent, the FSR already recognises the importance of incremental development, for example:

> *Thames Water proposes a precautionary but adaptive, approach to implementing planned water reuse that will also provide information on the effectiveness of measures to control risks of emerging concern...... Building upon previous and ongoing pilot trials, it is considered that there would be benefit from applying this precautionary-adaptive approach initially on a small-medium scale reuse plant so that the learning can be maximised before deploying a large scale water reuse programme (FSR page 16).*

However, this suggests that the incremental approach would only apply to an initial pilot trial, rather than the whole resource development programme over many decades. In our opinion, there should be more recognition of the benefits of an adaptive approach over the whole development programme, perhaps lasting 50 years or more, with intervals of say, 10-20 years, between each phase of development.

5.3.2 Inappropriate limits on total reuse and desalination

In our opinion, in assessing possible future development programmes for WRMP19, Thames Water should not limit total desalination to 300 Ml/d or restrict cumulative reuse and desalination options at Beckton and Crossness (FSR pages 62 and 67). At this time, it is not known for sure that reverse osmosis treatment will be subject to unmanageable resilience risks or whether there will be unacceptable impacts on estuarine salinity. These are only concerns based on limited experience of the seldom-used existing Beckton desalination plant.

With incremental development of these schemes over several decades, providing experience of their operation and an adaptive approach, there will be time between phases of development to find out whether these risks are genuine and unmanageable. Therefore, in planning the development programme to meet an uncertain deficit growing over the next 80 years, we propose that the approach should be:

- As a starting point, assume no limits on reuse and desalination
- Allow only for the possibility that experience of operating the early schemes shows that limits are needed
- Ensure that appropriate alternatives are available if it turns out that limits are necessary

This approach will allow the risks to be managed without placing unnecessary limits on these options.

5.3.3 Uncertain impacts of estuary salinity changes

In our opinion, the extent and significance of estuary salinity changes are highly uncertain. Assessments of the impacts should address the questions:

- The large and growing amounts of abstraction for London supplies over the last 150 years will have led to substantially reduced freshwater flows to the estuary, even after allowing for effluent returns – what evidence is there of any consequent salinity changes adversely affecting estuary ecology?
- With incremental development of reuse and desalination schemes over many decades, the salinity increases will be gradual, moving slowly up the estuary – will this allow the saline-sensitive plants and animals to migrate slowly upstream, leaving no residual impact?

Although these questions cannot be answered with much certainty at present, incremental development and monitoring of impacts will allow the risk of these impacts to be managed. Therefore, there is no need to impose salinity-based restrictions on these option types at present.

6. New options

6.1 Minworth STW effluent via Oxford Canal

We strongly support the option to use the Oxford canal to transfer 75 Ml/d of Minworth STW effluent into the Thames catchment, as per slide 28 of the stakeholder presentation on 28th April. However, we concerned by the contradictory statement on the slide *"The option has been rejected as Severn Trent Water has not offered the canal for transfer as river transfer considered more cost effective".*

In the event that the Severn-Thames transfer is ultimately found unacceptable (perhaps on grounds of costs or invasive species), the transfer of Minworth effluent via the Oxford canal is a separate option in its own right. It should be evaluated separately.

This option should be considered as a potential source for SWOX and the Thames valley, as well as for London. If used to meet SWOX deficits, it would form part of the SWOX reuse scheme (or Culham direct abstraction) as discussed in Section 6.2 below.

6.2 SWOX reuse and Culham direct abstraction

GARD put forward a proposal for the SWOX reuse scheme to Thames Water and the Environment Agency on 28th February 2017[10]. This included some detailed analysis of a scheme that could deliver a deployable out of 30-40 Ml/d for SWOX, and provided evidence of minimal environmental impact and potential for significant environmental benefits. It is disappointing that there is no reference to this as a potential option in the Fine Screening Report issued in late April 2017.

On slide 42 of the stakeholder presentation of 28th April, it is said that Thames Water expects to reject this option because:

- *"The SWOX reuse options require a substantially lower Hands off Flow that conflicts with the EA Catchment Abstraction Licensing Strategy [CAMS] "*
- *"The options would have a negative impact on downstream abstractors"*

We do not accept either of these reasons for rejecting the option.

In our opinion, the CAMS is a useful tool for broad brush assessment of potential for additional abstraction, but it is not appropriate for assessing a complex scheme like SWOX reuse that makes use of water added to natural river flows. The acceptability of the scheme should be assessed by proper analysis of its impact on river flows and associated ecology, not by blanket application of CAMS. GARD's paper provided details of proposed scheme operating rules and simulation modelling of the use of the scheme in conjunction with existing SWOX supplies, including Farmoor reservoir. Model output was presented to show that, with GARD's proposed operating rules, there would be very little adverse impact on river flows and potential for substantial reduction of the impacts of existing SWOX supplies. The acceptability or otherwise of the scheme should be judged on this type of analysis, not by application of CAMS.

[10] GARD proposal for consideration of sewage effluent reuse for SWOX. GARD. 28th February 2017.

The operating rules proposed by GARD have been designed to minimise impact on downstream abstractors. We have concluded that the scheme would have minimal impact on downstream abstractors, for example a loss of only 1 Ml/d in the deployable output of London's supplies.

The SWOX reuse scheme proposed by GARD is, in effect, another version of the Culham direct river abstraction scheme, but with different operating rules and much higher deployable output. The proposal makes use of water that is already abstracted for public water supplies downstream without the need for any additional treatment at Oxford and Didcot STWs (or any of the other STWs upstream of Culham). Consequently, we have not proposed any additional STW effluent treatment at these STW's, assuming that water that is acceptable further down the Thames Valley is also suitable for diversion to the Thames above Farmoor. Therefore, the SWOX reuse scheme would perhaps be better termed as the Culham direct river abstraction (similar to referring to the Teddington DRA, rather than Mogden reuse).

We also note that the deployable output of the scheme could be much enhanced by transfer of Minworth STW effluent via the Oxford canal.

7. Transparency of costs and conceptual designs

7.1 Cost transparency

On Figure 3.8 of the latest FSR, page 28, there have been substantial changes in some of the AIC costs, when compared with the October 2016 FSR:

- 150 Mm3 Abingdon reduced by over 25%
- Supported 300 Ml/d Severn to Thames transfer increased by 25%
- Thames Estuary desalination plants by 10%.

This puts these options now roughly equal on a cost (AIC per litre deployable output) basis. The FSR gives no explanation or justification of these very significant changes – a serious lack of transparency.

In our opinion, the FSR should as a minimum provide for each option a breakdown of the AIC costs shown on Figure 3.8 into capital cost, optimism bias, energy cost, other recurring costs, deployable output and total scheme output (the denominator in the AIC calculation). There should be an explanation and evidence-based justification of the changes since the October 2016 FSR.

Moving into the next stage of programme appraisal, it is clear that cost comparisons are going to be important in the selection of the preferred programme. In our opinion, for stakeholders to comment meaningfully on the evolving programme, information needs to be made available in a form that breaks down the main components of capital and recurring costs to allow stakeholders to comment on the estimates and understand cost differentials.

Whilst recognising the need for some commercial confidentiality, we also consider that for transparency of the WRMP process a mechanism is needed to allow more detailed cost information to be made available to stakeholders on request, subject to non-disclosure agreements. OFWAT have already indicated their support for such a mechanism and we hope that Thames Water can find a way to achieve it.

7.2 Conceptual designs

As the representatives of the people and businesses who would be severely affected by the Abingdon reservoir, GARD needs to see sufficient detail to satisfy ourselves and the local community that the programme of schemes to meet future water supply needs will be chosen based on adequate design to an appropriate level of detail, with realistic design assumptions and supported by appropriate design methodologies and data. In the case of the Abingdon reservoir, GARD and the local community need to see full detail of the layout of all the works which will permanently affect the area, and also temporary works during construction. Doubtless other stakeholders will wish to see similar detail for the works which will affect them.

In the attached Appendix A, we have listed the detail of the design of the various option types which we think should be made available to stakeholders through the conceptual design reports. In our opinion, this information should be made available as soon as the draft conceptual design reports are complete, allowing stakeholders to comment on designs before the cost estimates are finalised and the programme of scheme development for draft WRMP19 is appraised. The release of this information would also allow stakeholders to understand the basis of cost estimates for the options and to comment on the adequacy of these estimates.

GARD
12th May 2017

Appendix A – Details to be included in conceptual design reports

1. For the proposed Abingdon reservoir:

    - Details and justification of the operating rules assumed for the triggering of releases from the reservoir and the pumped refill of the reservoir.
    - Details and justification of the assumptions for losses in transferring water from the reservoir to London.
    - The general layout of the reservoir works. This has already been shown in the feasibility report issued to stakeholders, so Thames Water cannot argue that the conceptual design report must be kept secret because of the security risk of revealing the location of the works.
    - The locations of all construction works – borrow pits, gravel processing, access roads (within site and connections to the trunk road system), railway access, drainage, silt retention ponds, offices, stores, workshops, etc – these will be a major influence on environmental impacts and disruption to the local community during construction.
    - The locations of flood storage areas and justification of their design to demonstrate the adequacy of measures to avoid aggravation of flooding.
    - The details of the main embankment design and justification of design parameters to ensure embankment stability and allow acceptable rates of drawdown and refill.
    - Details of the foundation design, justification of the measures to reduce leakage, estimates of the amount of leakage and adequacy of drainage facilities.
    - Details of the layout of the reservoir filling and outfall facilities, including justification of the hydraulic capacity of the works and their main dimensions.
    - Details of the measures to ensure adequate water quality in the reservoir and justification of their design, including minimum water depths and allowance for dead storage.
    - Details of the landscaping, nature conservation areas, leisure facilities, footpaths, road access and public parking.
    - For the phased reservoir options (if still retained), details of all of the above at each stage.

2. For the Severn to Thames transfer options:

    - Details and justification of the assumptions for losses in transferring water from Vyrnwy reservoir or Minworth STW to support flows in the Severn and in transferring from the Severn to London.
    - Details and justification of operating rules to avoid the transfer of excessively sediment-laden or polluted water from the Severn.
    - Details and justification for the operating rules needed for the flow support releases to minimise ecological impacts and maximise benefits in the Vyrnwy/Severn river system.

- Details of the hydraulic design of the main aqueduct (pipeline or canal) to justify the capacity of the aqueduct and its hydraulic performance.
- Details of the construction of the aqueduct, including justification of choice of pipe material.
- Justification of the need for treatment works for the raw water and design details, including justification of the choice of treatment process.
- Justification of the number and capacity of pumping stations and break pressure tanks.
- Details of hydro-electric installations to re-capture energy on the downstream leg of the pipeline aqueduct (or justification of the absence of this facility).
- Details and justification of static heads, pumping heads, energy losses and efficiencies assumed in estimating pumping energy use and hydro-electric energy recovery.
- For the works to transfer Minworth STW effluent to the river Severn, equivalent details to those listed above for the Severn-Thames aqueduct.
- For the works to enable regulation releases from Vyrnwy reservoir, layout of any additional reservoir draw-off facilities and detail of works needed to mitigate impacts of releases on the ecology of the River Vyrnwy, including justification of the need for such facilities.
- For options involving support from either Severn Trent or United Utilities, a statement of need for alternative supplies required by these companies to replace loss of their own supplies in supporting the Severn-Thames transfer. If the replacement supplies are substantial, we propose that separate design details should be made available by these companies.

3. For the reuse, direct abstraction and desalination options for London, conceptual design details similar to those listed above for the Abingdon reservoir and the Severn-Thames transfer, but including:
    - Detail and justification of water treatment processes.
    - Justification of selection of tunnel or pipeline for conveyances.
    - Detail of tunnel lining and assumed construction, with justification including geological detail.
    - Detail of operating rules proposed for triggering the operation of these schemes and WARMS2 modelling of the use of the schemes in conjunction with other parts of the London supply system. This will be needed for proper assessment of the operating costs that will be a significant component of the total costs for these options.