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Thames to Southern Transfer (T2ST) SRO

Water Quality Assessment

Thames Water

28th June 2021

Revision 4

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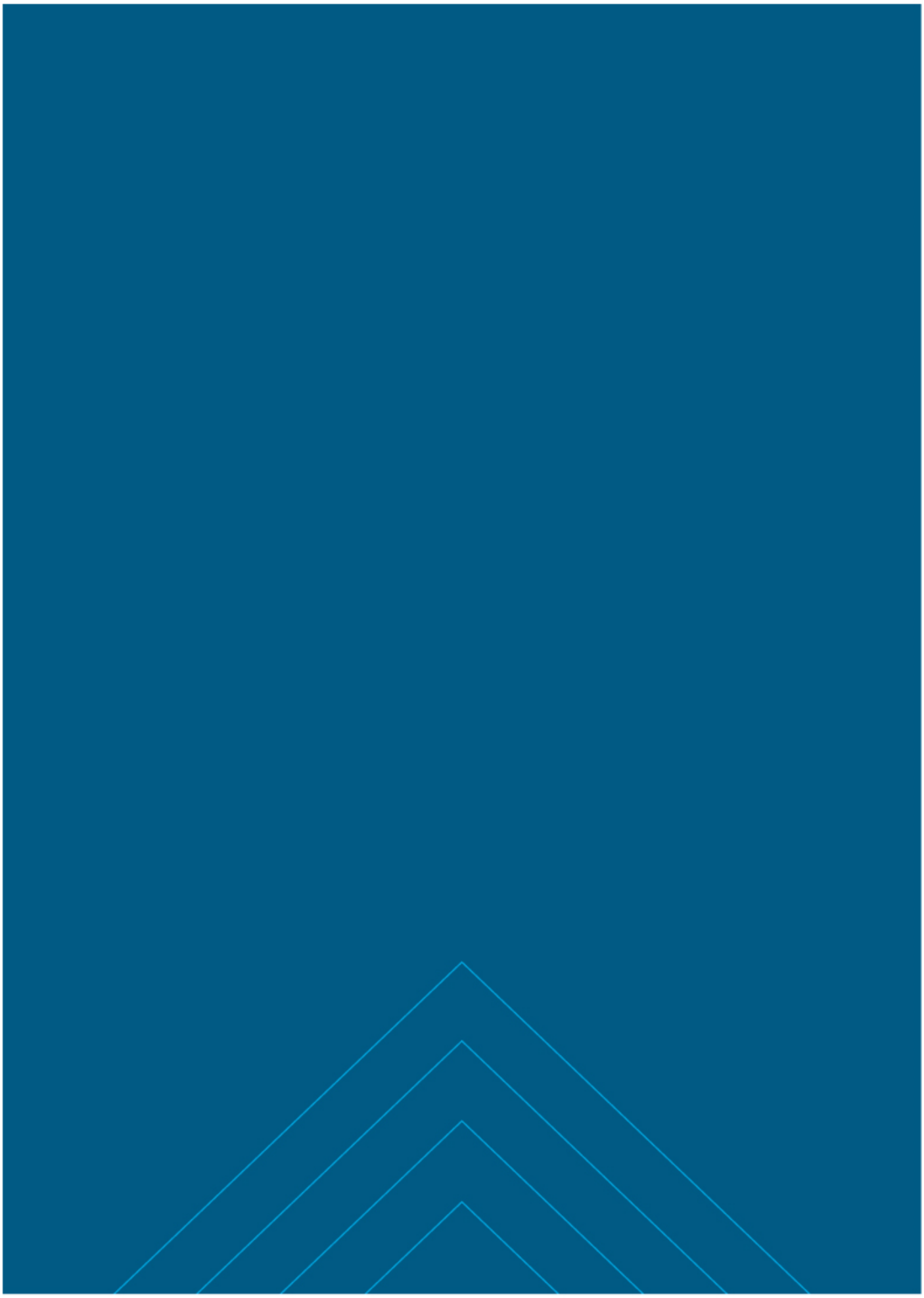

Executive Summary

This report summarises the water quality assessment that has been undertaken as part of the Thames to Southern Transfer (T2ST) Strategic Resource Option (SRO) RAPID Gate 1 conceptual design stage. The approach for this water quality assessment follows the All Company Working Group (ACWG) methodology to ensure a consistent process of reviewing the strategic water quality risks. This methodology has been created in accordance with the Drinking Water Inspectorate (DWI) planning requirements, to follow global best practice in Drinking Water Safety Planning in alignment with the UK Regulatory framework and emerging water quality considerations. This Water Quality Risk Assessment (WQRA) forms the third stage of the five steps of the ACWG Methodology, with WQRA spreadsheets produced and reviewed through a workshop with stakeholders from Thames Water and Southern Water. These spreadsheets follow a 'source-to-tap' approach for water safety planning through abstraction, treatment and distribution to customers for the T2ST SRO, identifying the key 'limiting hazards' and control measures to reduce these risks.

This report summarises the output of the Gate 1 WQRA and outlines control measures (in particular, water treatment) to manage these risks for each of the water source options available in the T2ST SRO.

Six SRO options were carried forward from the Thames to Southern Transfer SRO Options Appraisal report as the basis of the conceptual design options, which are fully described in the T2ST Concept Design Report. These six options represent alternatives for the location of abstraction, either near Culham or upstream of Reading [redacted] and the location of water treatment – either treatment close to the River Thames (point of abstraction) and potable water transfer to the receiving Southern Water zones, or raw water conveyance to the receiving Southern Water sites and treatment in the receiving supply zones.

The SRO options may each be supplied by several different water sources, each with differing water quality risk profiles. These include raw water from the new Abingdon Reservoir (SESRO SRO) and a future Severn to Thames Transfer (STT) SRO.

Therefore, to undertake a source-to-tap water safety risk assessment, five different water source scenarios have been defined in this document:

A. Abstraction from the proposed South East Strategic Reservoir Option (SESRO) – sourced from the River Thames at Culham at high flow;
B. Abstraction from the River Thames upstream of Reading [redacted] – supported by SESRO water released upstream (originally sourced from River Thames);
C. Abstraction from the River Thames upstream of Reading [redacted] or Culham – includes flows sourced from River Severn (STT) with pipeline conveyance;
D. Abstraction from the River Thames upstream of Reading [redacted] or Culham – includes flows sourced from the River Severn (STT) with canal conveyance;
E. Abstraction from the River Thames upstream of Reading [redacted] or Culham – includes flows sourced from River Severn transfer (STT) released upstream with planned support from WwTW effluent (conveyance by either pipeline or canal)

A matrix is provided in Section 3 identifying which source scenarios may be applicable to which SRO options.

The key drinking water quality risks ('limiting hazards') associated with each source scenario A-E were identified through a workshop with Thames Water and Southern Water, in accordance with the ACWG methodology, and are summarised in Section 4.

Sources of data used to develop these limiting hazards included the outputs received from SESRO and STT SRO water quality risk assessments, existing River Thames Drinking Water Safety Plans (DWSPs) and DWSPs for the Southern Water receiving areas. Due to the maturity of the scheme, through this process a number of data gaps have been identified for further investigation in subsequent stages of SRO design. These are summarised in Section 6.

Control measures to reduce these limiting hazards to an acceptable level were identified, including appropriate treatment processes, which are summarised in Section 5.

Risk scores for all limiting hazards in each water source scenario from source to tap are presented in the accompanying WQRA spreadsheets. These scores were reviewed and agreed as part of the ACWG workshop

with Thames Water and Southern Water. These collaborative ACWG workshops were held 13th and 15th April 2021.

It is noted that due to limited time available for this stage, these water source scenarios represent a consolidation of many possible permutations and combinations, which necessitated a number of high level judgements as discussed below.

It has been agreed by Southern Water that new Water Treatment Works (WTWs) will be required in all SRO options due to the scale of additional output required. Opportunities for re-use or expansion of the existing WTWs at Otterbourne, Testwood, Andover and Kingsclere may be explored during Gate 2. This decision is reflected in the Concept Design Report.

The existing Testwood WTW is currently fed by Testwood lakes, which have previously been proposed for additional storage of T2ST water. As it is likely that introduction of T2ST water to these lakes would change the water quality risk profile supplied to the existing Testwood WTW (and therefore may require additional investment to manage these risks through treatment) as well as potentially introduce new ecological risks to the local environment, at this stage it has been agreed that T2ST water would bypass Testwood lakes and be supplied to an independent new WTW.

Connection points from T2ST scheme to the South East Water (SEW) Basingstoke supply zone (Northgate) and to the Thames Water Kennet Valley supply zone may also be provided, however these are non-SRO options and therefore water quality assessment of these are outside the scope of this SRO and are not discussed in this document.

A proposed water treatment process for each water source scenario A to E has been identified in Section 5. The source water scenarios result in differing risks and limiting hazards, which drive different selections of treatment processes in order to mitigate the expected risks associated with each water source.

The highest risk water source is water source scenario E, which involves planned indirect support from treated wastewater effluent. Water source E includes support from WwTW effluent, which may give rise to increased microbiological and bromate formation risks as well as increased risks of endocrine disrupting compounds from pharmaceutical and personal care products.

Water sources C and D are slightly more favourable than water source E due to reduced microbiological and bromate formation risks associated with Minworth WwTW effluent. Water sources A and B offer the lowest risks in terms of drinking water quality.

In all options and water source scenarios, treated water from new surface water sources will be introduced to new regions, including the currently groundwater-fed areas of Andover and Kingsclere. Changes in water source can affect aesthetic risks such as taste and odour, as well as corrosivity. These risks will require closer investigation during subsequent phases of work – potential control measures include pro-active consumer engagement, however there may also be a requirement for additional chemical conditioning prior to entering supply. Further work to establish the need for, and nature of, such conditioning will be required in future phases.

It is noted that a cost comparison of each water source scenario has not been undertaken at this stage. A key difference in the SRO options is whether the treatment is located close to the point of abstraction (as in options 1 and 4) or close to the receiving zones (as in options 2,3 5,6).

Raw water transfer over long distances carries a number of additional risks which must be factored into the water safety planning approach, for example reduction in dissolved oxygen concentrations due to long storage time in the raw water system, siltation, and biological growth. These risks are largely absent in potable water transfer as treatment has already been applied to remove solids and a chlorine residual is maintained to ensure wholesome water is provided at the customer tap. Well-established means of controlling and monitoring these risks exist for potable water networks. From a water quality and environmental perspective, potable water transfer is therefore considered preferable to raw water transfer.

1. Introduction

The Thames to Southern Transfer (T2ST) option has been identified as a Strategic Regional Water Resource Option (SRO) in the PR19 Final Determination, with funding allocated between Thames Water (TW) and Southern Water (SRN). The SROs need to progress through a formal gate process of review and approval, with Gate 1 in July 2021. This report details the findings for the T2ST drinking water quality assessment, which informs the concept design stage for Gate 1.

2. T2ST SRO Options

The constrained options for T2ST are described in the Options Appraisal Report. Six options have been selected to be taken forward as constrained options into the concept design stage, as summarised in Table 1 - Constrained Options for Concept Design.

Note: in all options, connection points to the South East Water (SEW) Basingstoke supply zone (Northgate) and to the Thames Water Kennet Valley supply zone may also be provided, however these are non-SRO options and therefore water quality assessment of these are outside the scope of this SRO.

Table 1 - Constrained Options for Concept Design

Option Ref:	Option Name	Option Description
Option 1	Potable water transfer from Culham to Otterbourne. (50, 80 and 120Ml/d)	Water abstracted from the River Thames at Culham near Abingdon, then treated at a new WTW located near Culham, then potable water conveyed to SRN Otterbourne WTW where it will be blended with existing Otterbourne WTW treated water. This option also includes potable water offtakes to the SRN Andover and Kingsclere water resource zones.
Option 2	Raw water transfer from Culham to Otterbourne. (50, 80 and 120Ml/d)	Water abstracted from the River Thames at Culham near Abingdon, then raw water conveyance to Otterbourne, Andover and Kingsclere areas for treatment.
Option 3	Raw water transfer from the River Thames at Reading to Otterbourne. (50, 80 and 120Ml/d)	Water abstracted from the River Thames upstream of Reading [redacted], then raw water conveyance to Otterbourne, Andover and Kingsclere for treatment.
Option 4	Potable water transfer from the River Thames at Reading to Otterbourne. (50, 80 and 120Ml/d)	Water abstracted from the River Thames upstream of Reading [redacted], then treated at a new WTW local to [redacted], then potable water conveyance to SRN Otterbourne WTW where it will be blended with existing Otterbourne treated water. This option also includes potable water offtakes to the SRN Andover and Kingsclere water resource zones.
Option 5	Raw water transfer from Culham to Testwood	Water abstracted from the River Thames at Culham near Abingdon, then raw water conveyance to Testwood, Andover and Kingsclere for treatment.
Option 6	Raw water transfer from the River Thames at Reading to Testwood	Water abstracted from the River Thames upstream of Reading [redacted] then raw water conveyance to Testwood, Andover and Kingsclere for treatment.

The following pages display the six options in Block Flow Diagram (BFD) form, showing spurs to all receiving supply zones. The diagrams also show the locations of the new proposed WTW for each option, which water source scenarios are viable for each option, and with a key indicating which treatment process is applicable. Section 3.1 gives further information regarding the water source scenarios.

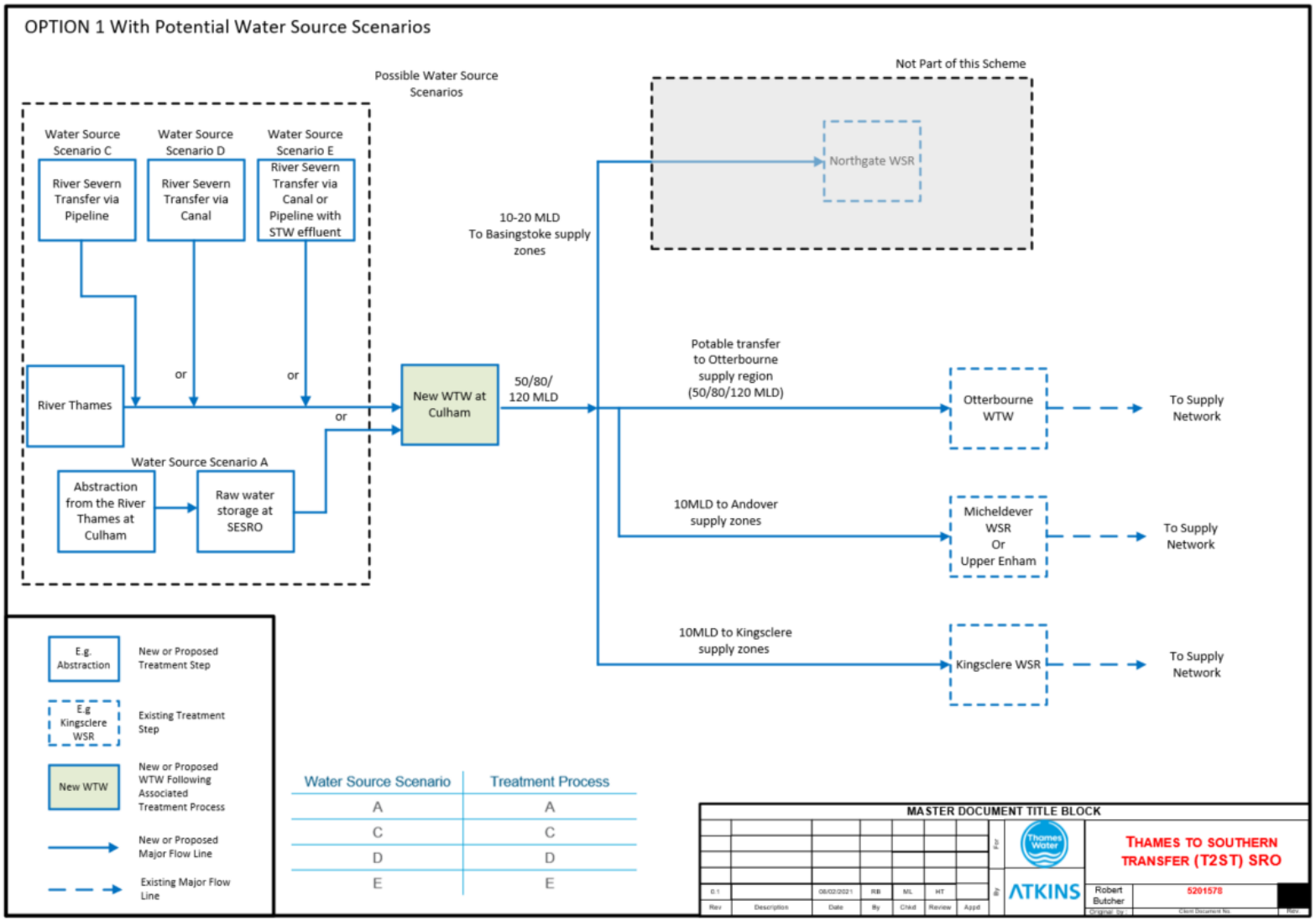

Figure 1 - Option 1 BFD

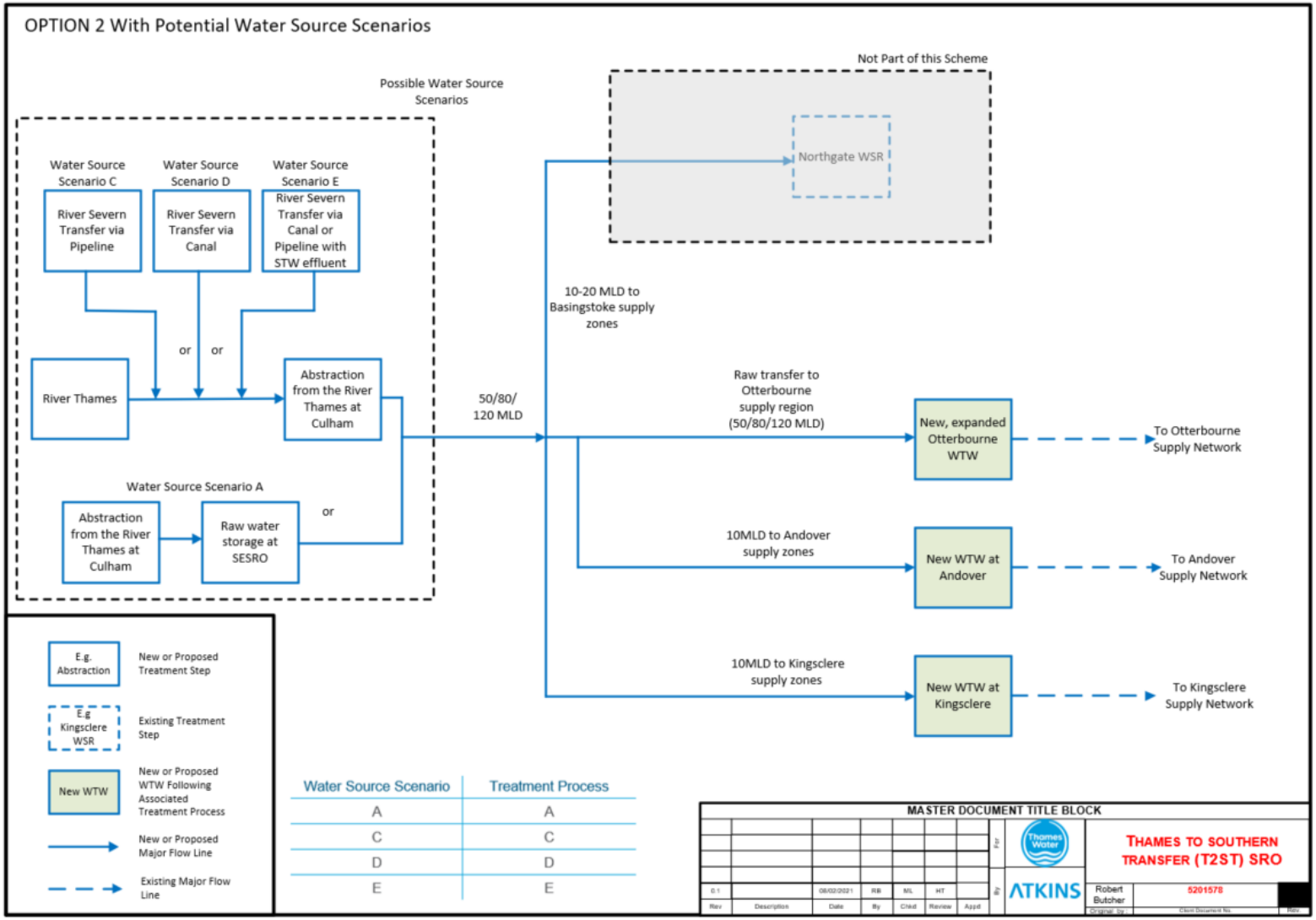

Figure 2 - Option 2 BFD

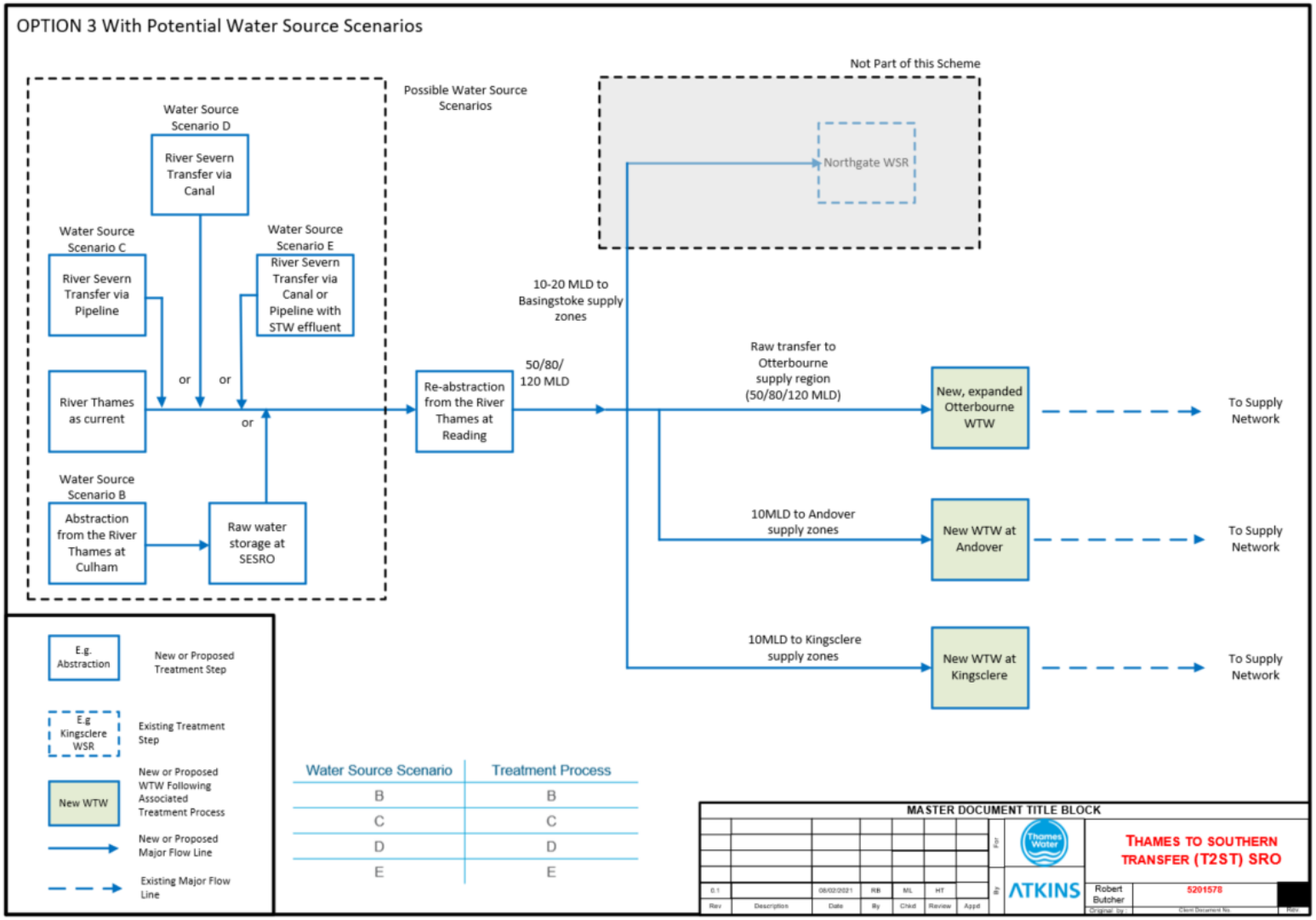

Figure 3 - Option 3 BFD

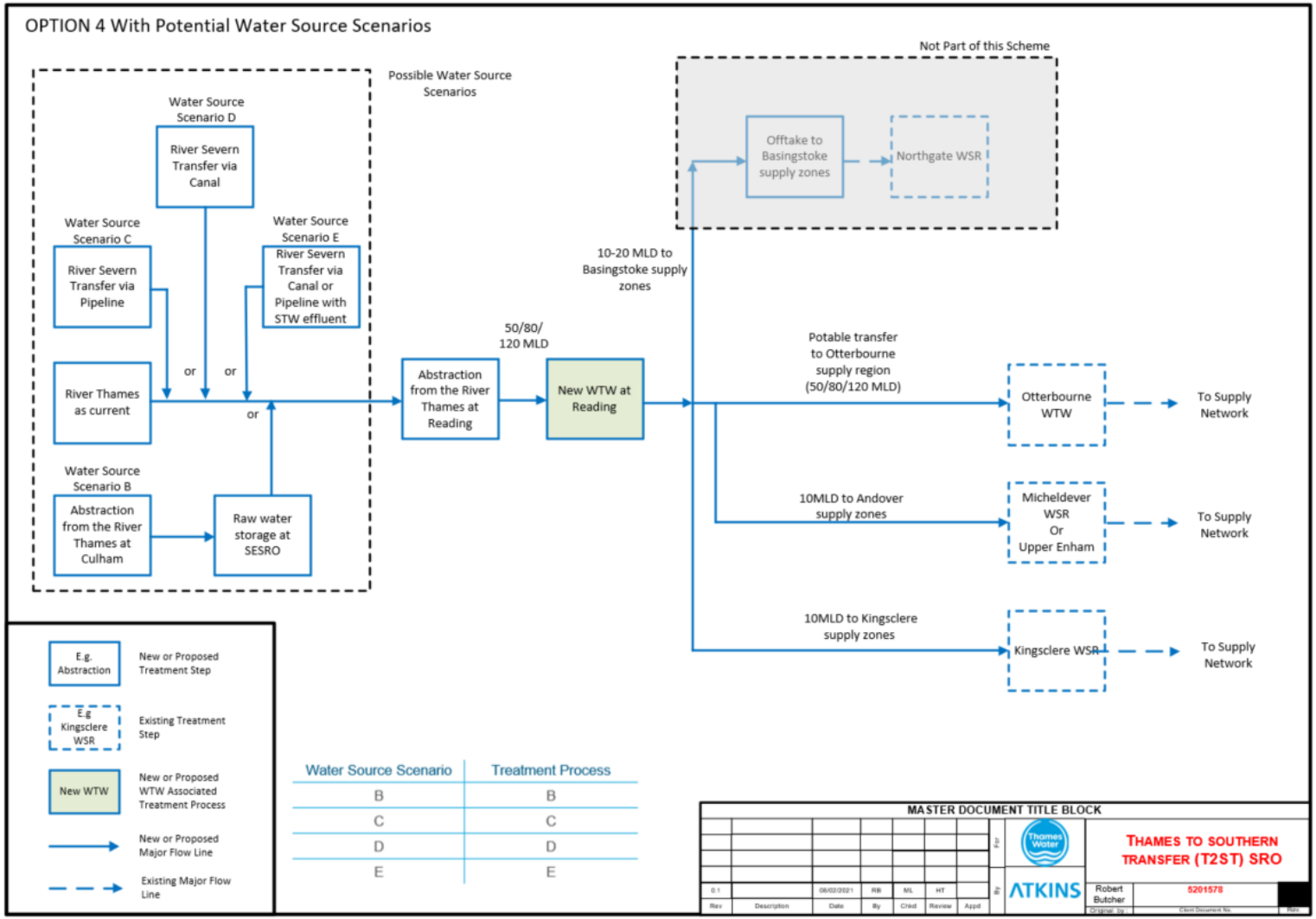

Figure 4 - Option 4 BFD

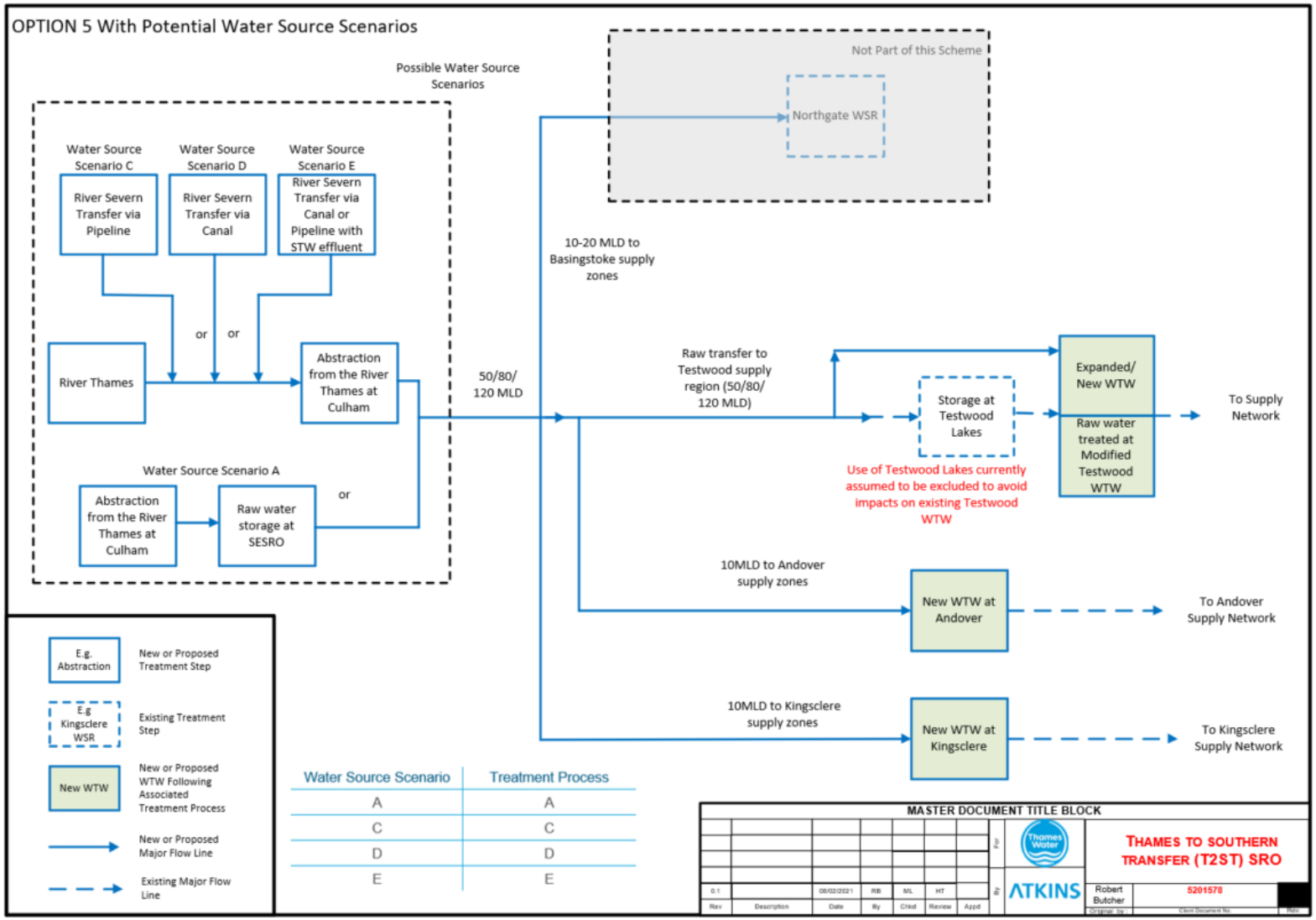

Figure 5 - Option 5 BFD

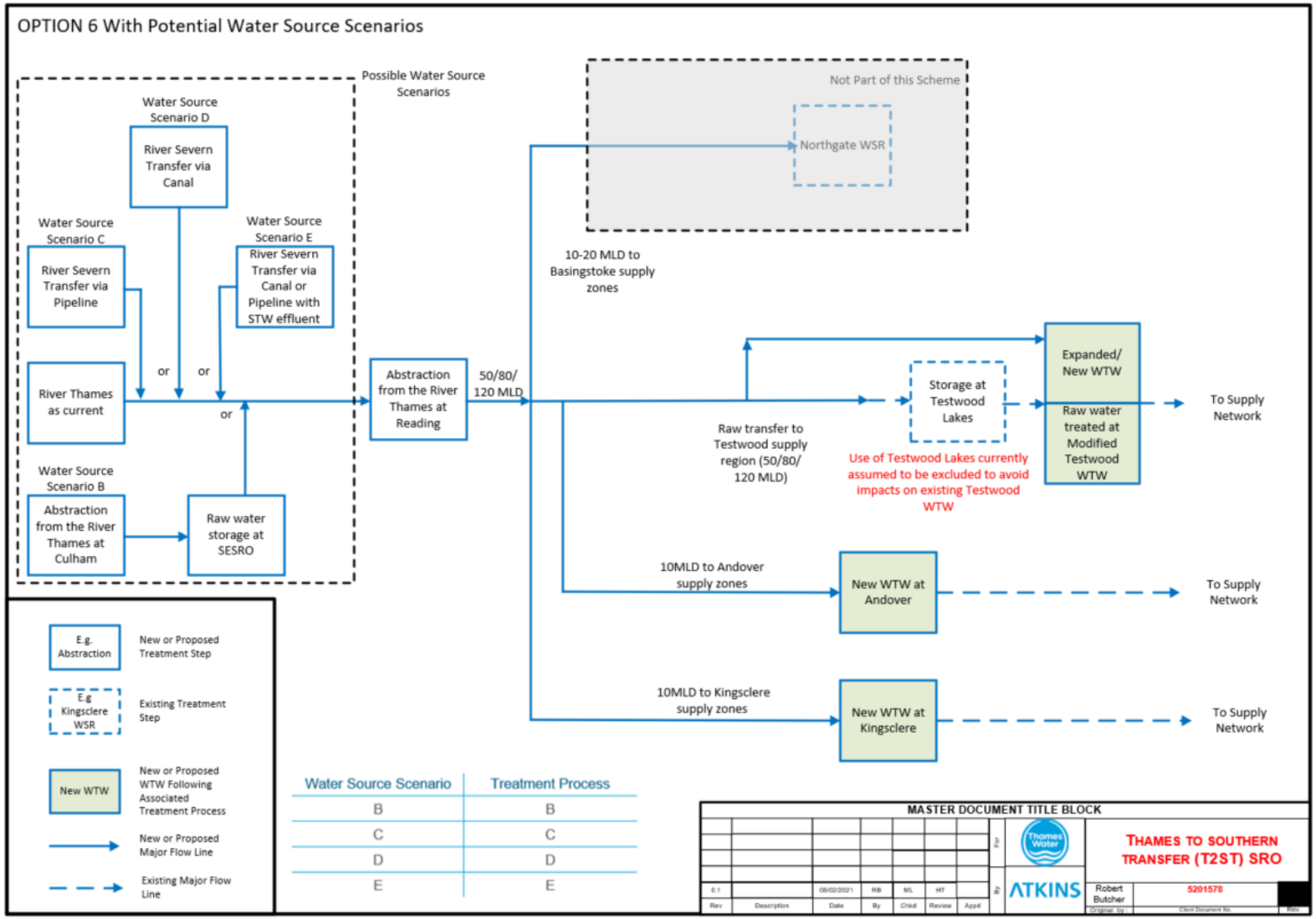

Figure 6 - Option 6

3. Basis of Water Quality Assessment

3.1. Identified Water Sources

In accordance with Drinking Water Inspectorate (DWI) requirements, the water safety planning approach to drinking water risk management involves a 'source to tap' strategy to identify and mitigate risks.

The source of the water to support the Thames to Southern transfer is therefore key in establishing the drinking water quality risks which need to be managed and identifying a mitigation and treatment strategy.

All constrained options rely on water abstracted from the River Thames, either via storage at SESRO at Culham, (Options 1, 2 and 5) or upstream of Reading [redacted] (Options 3, 4 and 6).

However, the source of this water may vary – for example, water may be sourced from the upstream River Thames via raw water storage at SESRO, or it may be supported by transfer from the River Severn, released into the River Thames upstream of the T2ST abstraction point.

These source water options have been examined to develop five major water source scenarios as identified below, each with varying risk profiles:

A. Abstraction from the SESRO – sourced from the River Thames at Culham at high flow.

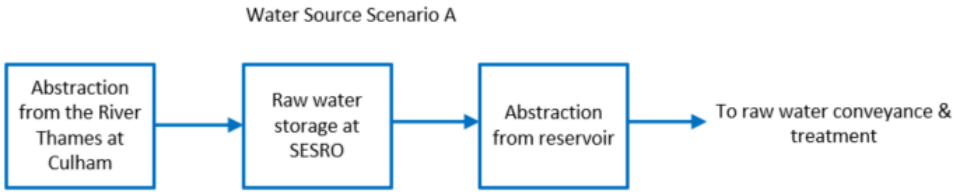

Figure 7 - Water Source Scenario A

B. Abstraction from the River Thames upstream of Reading [redacted] – sourced from SESRO water released upstream (originally sourced from River Thames).

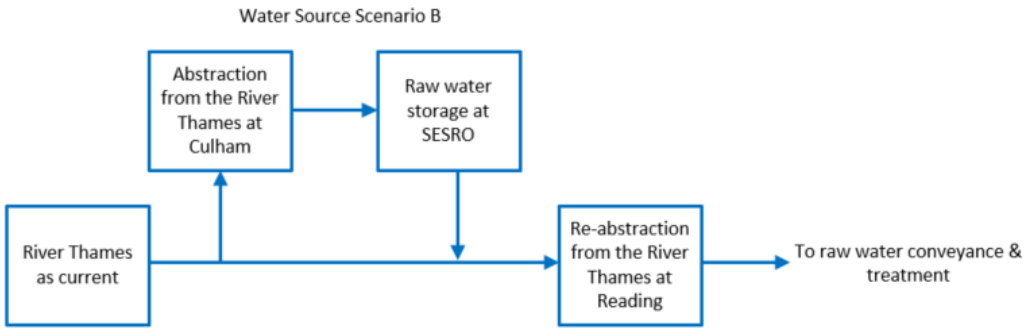

Figure 8 - Water Source Scenario B

C. Abstraction from the River Thames upstream of Reading [redacted] or Culham – includes flows sourced from River Severn, with pipeline conveyance, transfer released upstream.

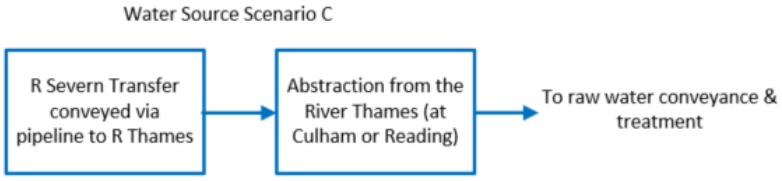

Figure 9 - Water Source Scenario C

D. Abstraction from the River Thames at upstream of Reading [redacted] or Culham – includes flows sourced from the River Severn, with canal conveyance, transfer released upstream.

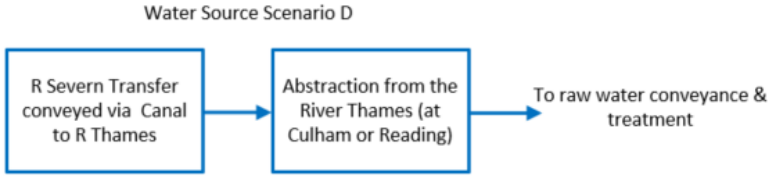

Figure 10 - Water Source Scenario D

E. Abstraction from the River Thames upstream of Reading [redacted] or Culham– includes flows sourced from River Severn transfer released upstream with support from planned support from Minworth WwTW effluent (conveyance by either pipeline or canal).

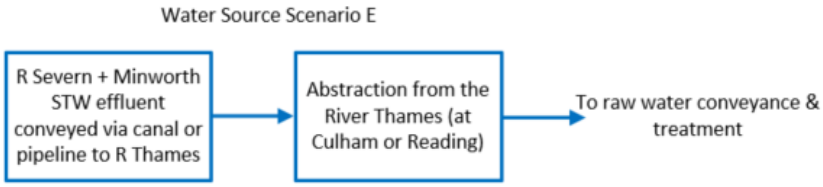

Figure 11 - Water Source Scenario E

As SRO Options 1-6 may have various water source scenarios, a matrix of the potential sources for each option is presented below in Table 2.

Table 2 - Option and Water Source Matrix

Source / Option	Definition	A (SESRO reservoir)	B (SESRO river release & re-abstraction)	C (R. Severn via pipeline & release to Thames)	D (R. Severn via canal & release to Thames)	E (R. Severn supported with WwTW effluent via canal or pipeline & release to Thames)
1	Abstract & treat at Culham, transfer potable water to Southern region	✓	-	✓	✓	✓
2	Abstract at Culham, transfer raw water to Southern region, treat at receiving sites Andover, Kingsclere & Otterbourne	✓	-	✓	✓	✓
3	Abstract upstream of Reading [redacted] transfer raw water to Southern region, treat at receiving sites Andover, Kingsclere & Otterbourne	-	✓	✓	✓	✓
4	Abstract & treat upstream of Reading [redacted] transfer potable water to Southern region	-	✓	✓	✓	✓
5	Abstract at Culham, transfer raw water to Southern region, treat at receiving sites Andover, Kingsclere & Testwood	✓	-	✓	✓	✓
6	Abstract upstream of Reading [redacted] transfer raw water to Southern region, treat at receiving sites Andover, Kingsclere & Testwood	-	✓	✓	✓	✓

SESRO Source Scenarios (A & B) The proposed location of SESRO is upstream of a proposed intake from the River Thames at Culham. For water source scenario A, which is a possible water source scenario for Options 1, 2 and 5 it is assumed for the purposes of this study that SESRO water is abstracted from the reservoir and supplied directly to treatment locally or at the receiving Southern Water sites.

SESRO is planned to contain between 75-150 Million m^3 of water capacity. Although the actual turnover period of SESRO will depend on use for T2ST and other schemes, it can be said that retention time in the reservoir will be sufficiently large to alter the water quality of the water at the outlet of the reservoir compared to the inlet of the reservoir. For example, the large retention time will allow heavy suspended solids such as insoluble metals to settle, reducing the expected average turbidity. However, reservoir storage is also associated with an increase in the risk of algal blooms and associated by-products. As such, source water scenario A (direct reservoir abstraction) will present different risks compared to scenario B (re-abstraction from the river).

The proposed operation of SESRO would include filling from the River Thames at times of high river flow, and discharge back to the River Thames when the river is at low flows to supplement other downstream SRO

schemes. As such, it is expected that SESRO would feed into and have a major impact of the water quality risks of the water abstracted upstream of Reading [redacted] for water source scenario B, which is a possible water source scenario for Options 3, 4 and 6, but the nature of the direct river abstraction is likely to modify these risks. For example, turbidity may be expected to be higher in the direct river abstraction (B) than in the reservoir abstraction (A) due to mobilisation of solids at high river flows.

The risk assessments for source scenarios A & B are informed by the Water Quality Risk Assessment (WQRA) produced by the SESRO SRO. Additionally, existing River Thames Drinking Water Safety Plans (DWSPs) have been referred to as part of this assessment - particularly that for Farmoor WTW, which is located upstream of the proposed abstraction points for both SESRO (source scenario A) and upstream of Reading [redacted] (source scenario B).

STT Source Scenarios (C, D, E)

The Severn to Thames Transfer (STT) SRO has been identified as a potential source to feed either directly into SESRO, or upstream of the SESRO intake on the River Thames. This would present additional source water quality risks to the T2ST. Within the STT SRO there are a number of sources of water currently being assessed including:

- River Severn raw water transfer via pipeline (water source scenario C) which will result in the water presented to T2ST combining the risk profile of the River Severn and the River Thames
- River Severn raw water transfer via navigable canals (water source scenario D), which may increase risks including pesticides, oil and fuel etc.
- River Severn supported by treated wastewater effluent (e.g. from Minworth Sewage Treatment Works) described as water source scenario E, which would be expected to increase microbiological risks.

Note: Direct wastewater treatment works effluent reuse (piped from WwTW outfalls) is understood to be excluded from consideration.

The risk assessments for source scenarios C, D & E are informed by the WQRA produced by the STT SRO as well as the existing River Thames DWSPs, as STT water would be released into the River Thames upstream of T2ST abstraction in all cases.

Receiving areas

The receiving zones of Testwood or Otterbourne are both currently fed by surface water (Testwood WTW from Testwood Lakes and the River Test, and Otterbourne WTW from the River Itchen) whereas Andover and Kingsclere are both groundwater sites. Regardless of the source scenario, T2ST will supply treated water from a new source into a combination of groundwater fed and surface water fed regions. Therefore it is considered acceptable to develop the water quality risk assessments based on source water scenario.

Drinking water risks for each of these source scenarios have been reviewed in Section 4 and treatment strategies have been developed for each water source scenario in Section 5.

3.2. Conceptual Drinking Water Quality Risk Assessment Assumptions

For the concept design stage, a number of assumptions have been made to allow for a clear assessment of water quality risks and treatment needs, as below.

1. It is assumed for the SRO options at Culham (Options 1, 2 and 5), water source scenario A will apply, and that there will be a direct reservoir abstraction from SESRO to a new Culham WTW or pumping station, (as opposed to a river abstraction immediately downstream of the SESRO outfall into the River Thames).
2. It is assumed that the SESRO intake on the River Thames at Culham is upstream of Abingdon STW outfall.
3. It is assumed that Farmoor WTW DWSP, as the closest abstracting WTW on the River Thames, is a representative characterisation of the risk profile of the water in the Thames close to the T2ST abstraction points, notwithstanding inputs from SESRO or STT. These DWSPs are understood to be based on several years of water quality monitoring data for existing abstraction points with likelihood scores calculated based upon this data.
4. Only supply connections to Southern water sites/customers at Andover, Kingsclere and Otterbourne or Testwood are considered in this study. There are currently three transfer flow rates in question; 50, 80

and 120 Ml/d, which are based on the total flow of water to the Southern Region and supply zones. Andover and Kingsclere supply zones are assumed to receive 10Ml/d of this each, with the remainder arriving at either Otterbourne (Options 1-4) or Testwood (Options 5 & 6).

5. Supply connections to South East Water at Basingstoke or the Thames Water supply zone to Kennet Valley are pending WRSE model outputs and are not included in this water quality risk assessment, or included in the sizing of treatment of raw or potable network assets, as they are non-SRO options and do not form part of the T2ST SRO at this stage.

6. Re-use/expansion of existing Southern Treatment Works:

   Andover & Kingsclere (groundwater sources):

   Existing WTWs exist at Andover and Kingsclere, however both treat groundwater of a significantly different risk profile to T2ST water. They are both considerably smaller than the required additional output – as a result it is not considered to be feasible to modify these WTWs to treat T2ST water, so new treatment works will be allowed for in both the Andover and Kingsclere areas.

   Otterbourne & Testwood (surface-water sources):

   SRO Options 2 and 3 involve the transfer of raw water to an expanded Otterbourne WTW, and Options 5 and 6 involve the raw water transfer to an expanded Testwood WTW.

   By introducing a new raw water supply to either of the existing works, the current risk profile for the existing works would change, which would be expected to result in a need for modification of the existing works and DWSPs.

   Given their existing treatment processes, both sites would be likely to be challenged by new and increasing risks as a direct result of the T2S transfer. While quantitative comparison of these risk profiles would need to be carried out at a later design stage, increases to taste, odour and algal by-product risks, differing pesticide risks and new soluble metal risks could be expected based on a comparison of the existing DWSPs for these sites with the expected risks from T2ST outlined above.

   At both sites, the volume of the T2ST transfer would also constitute a significant percentage increase (50-150%) on top of the existing works capacity. Therefore even if treatment processes were found to be suitable to mitigate the new or increasing T2ST risks, existing assets would need to be expanded by such a significant amount that the cost of doing so would be expected to be comparable to the cost of providing a new dedicated treatment stream.

   It has therefore been agreed with Southern Water (Concept Design Report) that Gate 1 work should proceed on the basis that T2ST water would not be introduced into the existing water treatment works at Otterbourne or Testwood, but instead assume construction of a new dedicated WTW designed to manage the T2ST specific risks.

7. It has previously been proposed that SRO Options 5 and 6 may make use of the Testwood Lakes as raw water storage.

   While offering potential raw water buffer storage, the blending of untreated water from separate sources may result in challenges to the treatability of the water for drinking water supply (for example, promotion of strains of algal blooms resulting in algal toxin production).

   Thus from a drinking water quality perspective it is preferable that the existing lakes are not used for buffer storage, as the change to the source risks in Testwood lakes may also require the existing Testwood WTW to be modified to control these risks, in addition to the new, expanded WTW to provide extra treatment capacity.

   There is also a risk of environmental impact on sensitive water bodies from introduction of new environmental risks to the lakes and potentially to the connected River Test, such as the introduction of invasive non-native species.

   This approach; that existing Testwood Lakes be bypassed by T2ST water, has been agreed as discussed in the Concept Design Report. This study excludes assessment of any impact of T2ST water on the DWSP for the existing Testwood WTW.

8. Minworth WwTW effluent is assumed to have been treated to compliance with the requirements of the Water Framework Directive prior to discharge into the River Severn upstream of the Severn to Thames transfer.

4. Drinking Water Quality Risk Assessment (WQRA)

4.1. All Company Working Group (ACWG) Methodology

To ensure a consistent approach with all SROs, the All Companies Working Group (ACWG) Water Quality Risk Assessment methodology has been adopted. The methodology has been based on existing UK and global regulation and policies. The primary source of regulations followed is from the Water Supply (Water Quality) Regulations (2016) – (S.I2016/614) as amended by the 2018 Amendment Regulations (S.I 2018/706) for England and the Water Supply (Water Quality) Regulations (Wales) (S.I 2018/647 (W.121)) for Wales including DWI Guidance on their implementation. Other regulations implemented can be found in the ACWG WQ Risk Framework Report, report ref: B19589BJ-DOC-001| 06. This guidance ensures the ACWG methodology follows the DWI water safety planning requirements. The framework concept includes 5 stages, with the water quality risk assessment being stage 3, and stage 4 & 5 producing outputs for the Gate documents.

Figure 12 - 5 Stages of the ACWG Methodology Framework

There is a 5 step process for the WQRA (stage 3 of the ACWG methodology) for each water source scenario, which is described below:

1. Agree likely limiting hazards for the SRO from the list of hazards included in the methodology. These are hazards which are likely to drive the development and/or acceptability and/or viability of the scheme. WQ Risk Assessment list contains approx. 100 hazards.
2. Conduct/review hazard and hazardous event assessment with reference to likely limiting hazards.
3. Identify control measures. Check existing mitigation through control measures required is aligned with existing project considerations.
4. Agree pre and post control risk scores.
5. Identify residual risks and data gaps to be addressed during RAPID gated process.

Collaborative review workshops with Thames Water and Southern Water to undertake the above process were held on 13th and 15th April 2021

WQRA spreadsheets for each water source scenario are provided alongside this report.

The following sections of this report follow the ACWG methodology for developing a WQ risk assessment.

4.2. Existing Water Quality Information

The output from the SESRO and STT SRO water quality risk assessments were used as a basis for the limiting hazards for the T2ST SRO prior to the T2ST WQRA workshop. At the time of receipt, the SESRO and STT WQRA outputs were marked as draft, due to the concurrent timescales of all SROs. However, it is understood that prior to the T2ST workshop on the 13th April 2021, workshops for both SESRO and STT SROs had been held to agree these risk assessments in accordance with the ACWG methodology.

The first T2ST SRO workshop was held on the 13th April 2021, with a follow up session held on 15th April 2021, both attended by stakeholders from Thames Water and Southern Water.

The T2ST workshops were attended by representatives who had been present at both the SESRO and STT workshops (Thames Water representatives) and therefore it is considered that inputs from these representatives to the T2ST process should capture the hazards identified by the full SESRO and STT ACWG methodology.

It is noted that currently there is a programme of water quality monitoring being undertaken across the SROs, however data from this monitoring programme will not be available until Gate 2.

Thames Water have provided a set of Drinking Water Safety Plans (DWSP) for a number of their sites. These DWSPs provide the best insight into the known risks within the River Thames, as they are based on knowledge of the catchment and historical data from the river at the various site abstraction points.

A review of the DWSPs for Farmoor Intake Catchment, Reservoir and WTW and as well as Datchet Intake Catchment pre- and post-control scores was undertaken to support the identification of limiting hazards (see below).

These sites were chosen due to their locations being closest to the proposed intakes on the River Thames. Farmoor Reservoir and WTW is upstream of the proposed Culham / SESRO and [redacted] (Reading) abstraction locations, whilst the Datchet intake is downstream as illustrated in Figure 13.

Figure 13 - Location of Culham intake (SESRO) upstream of Reading[redacted]

Farmoor Intake Catchment DWSP gives an indication of the water quality risks of direct abstraction from the River Thames, and so is expected to somewhat similar to water source scenario B.

The high 'red' risks include many typical surface water risks including insoluble metals, turbidity, cryptosporidium and a number of pesticides including metaldehyde. Other notable risks include Nitrite and Chromium. These are discussed further in the supporting ACWG water quality risk assessment (WQRA) spreadsheets.

Farmoor Reservoir DWSP provides a useful indication of risks which may be similar to that at SESRO (water source scenario A) due to the inclusion of a reservoir before treatment. Comparison of the intake catchment and reservoir stages in the Farmoor DWSP identifies a number of risks which are reduced by the use of a reservoir, such as insoluble metals and turbidity.

Datchet abstraction point is downstream of a number of large WwTW discharge points (including Reading sewage treatment works) and industrial discharges as the river enters more heavily populated areas – this appears to be reflected by elevated risks in the DWSP, for example, of ammonium. As these contributors to the river are themselves downstream of the proposed Reading abstraction [redacted] Datchet is therefore considered to be less representative of the risks present at either T2ST abstraction location.

The existing DWSP information for the receiving Southern water areas (Otterbourne, Testwood, Andover and Kingsclere) was also reviewed to identify new or increasing residual risks resulting from treated T2ST water being introduced to the Southern distribution network. Risks due to this change in treated water source may impact on

corrosivity, aesthetic properties, taste & odour issues in storage and distribution, and customer acceptability at the tap.

Note: As included in Section 3.2, Concept Design Assumptions, it was agreed that new WTWs are assumed for treatment of T2ST water and therefore treated T2ST water would be introduced downstream of the existing Southern WTWs (in the distribution network) only. The identification of limiting hazards from these sources of information is further discussed in the following section.

4.3. Limiting Hazards

Following the ACWG methodology, and using the sources of information identified above, limiting hazards for each of the water source scenarios for the T2ST schemes were identified.

Limiting hazards were agreed by picking the risks which were most likely to drive the development, acceptability or viability of the SRO, in accordance with the ACWG methodology.

The agreed limiting hazards for each water source scenario, along with a summary of the source information which led to this selection, are presented in Table 3. Further details including the scoring of these limiting hazards are provided in the supporting ACWG water quality risk assessment (WQRA) spreadsheets.

Table 3 - Limiting hazards for water source scenarios A-E

		Water source scenario	A	B	C	D	E
Limiting hazard	**Source of risk info**	**Comment**	*SESRO reservoir*	*SESRO via river*	*STT*	*STT via canal*	*STT with WwTW support via canal*
E. coli (bactiera limiting hazard)	SESRO DWSP + STT DWSP	Limiting hazard for bacteriological pathogens. Faecal pathogens derived from sewage, livestock, human activity, and wildlife in the catchment and is present in both the River Thames and the River Severn.	Y	Y	Y	Y	Y (highest risk noting planned WwTW support)
Cryptosporidium	SESRO DWSP + STT DWSP	Limiting hazard for chlorine tolerant pathogens. Derived from sewage, livestock, human activity, and wildlife in the catchment and is present in both the River Thames and the River Severn.	Y	Y	Y	Y	Y (highest risk noting planned WwTW support)
Iron	SESRO DWSP + STT DWSP	Limiting hazard for metals. Iron & manganese within the source rivers are most likely to be in particulate form (rather than bioavailable), however dissolved metals can be generated from reservoir sediment under low DO conditions. Legacy mining in the catchment headwaters of R.Severn is also a potential source.	Y	Y	Y	Y	Y
Manganese	SESRO DWSP + STT DWSP		Y	Y	Y	Y	Y
Bromate	Minworth WwTW effluent information	For STT WwTW support only: High bromide in Minworth WwTW effluent flagged – risk this is converted to bromate (regulated parameter) if correct treatment not selected	-	-	-	-	Y
Nitrite	R. Thames Farmoor DWSP	Noted as red risk in Farmoor DWSP	Y	Y	Y	Y	Y
Pesticides: Total	SESRO DWSP + STT DWSP	Derived from agricultural and amenity applications of pesticides in the R.Thames & R.Severn catchment	Y	Y	Y	Y	Y

		Water source scenario	A	B	C	D	E
Limiting hazard	**Source of risk info**	**Comment**	*SESRO reservoir*	*SESRO via river*	*STT*	*STT via canal*	*STT with WwTW support via canal*
Metaldehyde	SESRO DWSP + STT DWSP	Important pesticide as difficult to treat, therefore included as a limiting hazard which may influence treatment. Historically high observed environmental levels in R.Thames & R.Severn derived from agricultural and amenity applications in the catchment. Concentrations will vary seasonally. Metaldehyde is notably subject to outdoor use ban from March 2022 and this has been considered in the risk assessment.	Y	Y	Y	Y	Y
Benzo(a)pyrene	STT DWSP	Benzo(a)pyrene, a polyaromatic hydrocarbon, has been noted as present within the River Severn and is considered the limiting hazard for hydrocarbon contamination.	-	-	Y	Y	Y
Corrosivity	Southern Water receiving network assessment / workshop / STT DWSP	Treated R.Thames/Severn waters may have different corrosivity from that in existing receiving Southern network – limiting hazard covering associated risks e.g. metals compliance, aesthetic turbidity issues, discolouration	Y	Y	Y	Y	Y
Taste	SESRO DWSP	Limiting hazard for taste & odour derived from biological activity in the reservoir. Note that changes to customer perception due to change in source type are captured under Change in Source Type as the limiting hazard	Y	-	-	-	-
Change in Source Type	Southern Water receiving network assessment / workshop / STT DWSP	T2ST involves introducing treated surface waters into currently groundwater fed regions (Andover & Kingsclere). Limiting hazard for any effects of introducing treated water from a new source into an existing network (including customer acceptability e.g. complaints due to change in perception of taste & odour, hardness, etc)	Y	Y	Y	Y	Y

		Water source scenario	A	B	C	D	E
Limiting hazard	**Source of risk info**	**Comment**	*SESRO reservoir*	*SESRO via river*	*STT*	*STT via canal*	*STT with WwTW support via canal*
Pathogens - Bacteria, **Viruses**, Protozoa	STT DWSP	Limiting hazard for viruses (bacteria and protozoa risks are covered by the E.coli & Cryptosporidium limiting hazards above). Due to the population located around the Rivers Severn and Thames, pathogens are likely to be present including viruses. While viruses are expected to be present in the Thames source waters, they are not on the 'limiting hazard' list for source water scenarios A and B as they were not included in the SESRO WQRA. They are not expected to be limiting in the sense of driving additional control measures, as the virus risk is expected to be managed (based on knowledge of existing R. Thames risk profile & controls) by the control measures/disinfection strategy required for E.coli & Cryptosporidium, which are both limiting hazards for all T2ST source water scenarios. However, the STT WQRA included this parameter as a limiting hazard and thus it is included in the limiting hazard list for source scenarios C-E, which may have a different virus risk profile from that in the R. Thames (particularly in source scenario E where WwTW effluent support is included). Note that Somatic Coliphages are expected to be included in future regulation (as they are included in the revised Drinking Water Directive). It is therefore recommended that they be considered in the Gate 2 monitoring programme across all T2ST source water scenarios.	-	-	Y	Y	Y (highest risk noting planned WwTW support)
Total Organic Carbon (TOC)	SESRO DWSP / STT DWSP	Limiting hazard for disinfection byproduct precursors & potential natural colour risk due to peat influence in STT catchments. Derived from biological activity in the catchments and expected in all lowland surface waters	Y	Y	Y	Y	Y

		Water source scenario	A	B	C	D	E
Limiting hazard	**Source of risk info**	**Comment**	*SESRO reservoir*	*SESRO via river*	*STT*	*STT via canal*	*STT with WwTW support via canal*
Chromium	R. Thames Farmoor DWSP	Regulatory PCV change expected; noted as red risk in Farmoor DWSP	Y	Y	Y	Y	Y
Endocrine Disrupting Compounds	Workshop	Emerging contaminant associated with WwTW discharges in source catchment. Limited information was available on EDCs in the R.Severn and R.Thames source waters at the time of assessment – a recommendation was agreed during the workshop for further investigation for all water source scenarios to address this data gap	-	-	-	-	Y (highest risk noting planned WwTW support)
Perfluorooctanoic acid (PFOA)	Workshop	Limiting hazard for perfluorinated substances, industrial contaminants of emerging concern for which legislative limits are expected to be introduced.	Y	Y	Y	Y	Y
Turbidity	Workshop	Design parameter – expected in surface water sources	Y	Y	Y	Y	Y
Algae	SESRO DWSP + STT DWSP (canal options only)	While algae may be present in all sources, speciation of algae (particularly relevant to potential types of algal toxins) and scale of risk is likely to differ between reservoir, river and canal sources, with eutrophication presenting a particular risk of high algal loads with associated algal toxin risks in the reservoir. STT DWSP flagged canal conveyance as a particular risk factor for algae and associated issues. Associated issues including algal toxins, taste & odour issues and influence on treatment processes e.g. increases to pH, are covered by this limiting hazard.	Y (reservoir)	-	-	Y (canal)	Y (canal)

4.4. Raw Water vs Potable Water Transfer

A key difference in the SRO options is whether treatment is located close to the point of abstraction (as in options 1 and 4) or close to the receiving zones (as in SRO options 2, 3, 5, 6).

Options 1 and 4 will treat water at the source of abstraction (near to the SESRO abstraction for Option 1, and near to the River Thames abstraction upstream of Reading [redacted] for Option 4); then will transmit potable water to the Southern Water receiving supply zones.

The four remaining options (2, 3, 5, 6) will supply raw water to Andover, Kingsclere and Otterbourne or Testwood for treatment.

Raw water transfer may carry a number of additional risks which must be factored into the water safety planning approach, including:

- Reduction in dissolved oxygen concentrations due to long storage time – potentially requiring means of aeration e.g. cascades to prevent anaerobic conditions and associated risks
- Biological growth in pipes and raw water storage tanks requiring significant maintenance and potentially compromising asset life and capacity/resilience (e.g. reduction in effective pipe flow capacity due to mussel growth on pipe walls)
- Transfer or generation of biota and or microbiology which may have effects on downstream processes – e.g. chironomids (note that ecological / environmental risk assessment e.g. of invasive non-native species INNS is covered by a separate study – see Conceptual Design Report).
- Siltation in raw water mains and storage tanks

While means of treatment and control to mitigate these risks in raw water systems are available, further information (i.e. output of environmental studies) would be required to select appropriate control measures select appropriate control measures, and they are likely to incur additional capital and operational expense and result in residual risks should control measures fail.

For the raw water transfer options, provision has been made within all treatment processes for coarse and fine screening to reduce the risk of large solids causing physical damage and blockages, however further information on the risks above, particularly the biological and biota risks, would be required to select appropriate control measures.

These risks are largely absent in potable water transfer as treatment has been applied to remove solids and a chlorine residual is maintained to ensure wholesome water is provided at the customer tap. Well-established means of controlling and monitoring these risks exist for potable water networks.

From a water quality and environmental perspective, potable water transfer is therefore considered preferable to raw water transfer.

Should raw water transfer options be taken forward to the next stage, further work is recommended to explore the most appropriate control measures.

5. Treatment Requirements and Process Selection

5.1. Selected Processes

From the water quality assessment, limiting hazards for the five water source scenarios have been determined as outlined in Section 4. Following the ACWG methodology, control methods are then selected to mitigate the risks. The assumption is that if the limiting hazards are controlled, all other risks in the water source will be controlled. As the limiting hazards differ between the water source scenarios, five treatment processes have been selected through a conceptual design phase to mitigate each risks profile. The following tables explain the selected treatment processes against each of the limiting hazards.

The STT will include pre-treatment at Deerhurst/Lechlade, involving [redacted], prior to conveyance to, and discharge into the River Thames. This pre-treatment is understood to be in place to prevent deterioration of the River Thames. However, as the Deerhurst/Lechlade pre-treatment is not expected to treat the water to drinking water quality, and the water is subsequently released into a surface water (River Thames), the T2ST treatment process includes the control measures appropriate for the source risks. This includes subsequent clarification and filtration stages to ensure the water is fully prepared for downstream treatment including disinfection. This approach considered robust, and in line with best practices in water safety planning.

Minworth WwTW effluent is assumed to have been treated to compliance with the Water Framework Directive prior to discharge into the River Severn upstream of the Severn to Thames transfer.

Table 4 summarises the relationship between the water sources; which options are applicable to said water source; and which treatment process would be required at each new water treatment work within each option, to efficiently mitigate the limiting hazards.

Block Flow Diagrams are provided below in the upcoming sections, along each water source, showing all treatment processes for each water source scenario. The main differences between the treatment processes for water sources A and B in is the selection of clarifier type – DAF in Process A, and Lamella Clarifiers in Process B. DAF has been selected in Process A due to the expected higher algae loads, which are typically buoyant, and reduced silt due to pre-settlement in the reservoir. High rate lamella clarifiers have been selected for Process B, as higher concentrations of readily settleable solids are expected in the fast-flowing river.

GAC is included in all processes to control the wide range of organics such as taste and odour and pesticide risks. The empty bed contact times (EBCT) may differ between the water sources and are dependent contaminant concentration, which is to be assessed in future design stages.

[redacted]

Table 4 - Water Source, Option and Treatment Process Matrix

Water Source Scenario	Applicable Options	Treatment Process
A	1, 2, 5	A
B	3, 4, 6	B
C	1, 2, 3, 4, 5, 6	C
D	1, 2, 3, 4, 5, 6	D
E	1, 2, 3, 4, 5, 6	E

5.1.1. Treatment for Water Source Scenario A

Table 5 - Selected Treatment / Control Measure for Limiting Hazards of Source Water A

Limiting Hazard	Treatment / Control Measure Selected
Escherida Coli	[redacted]

Limiting Hazard	Treatment / Control Measure Selected
Cryptosporidium	[redacted]
Iron	[redacted]
Manganese	[redacted]
Nitrite	[redacted]
Pesticides: Total	[redacted]
Metaldehyde	[redacted]
Corrosivity	[redacted]
Taste	[redacted]
Change in Source Type	[redacted]
Total Organic Carbon	[redacted]
Chromium	[redacted]
PFOA	[redacted]
Turbidity	[redacted]
Algae	[redacted]

Figure 14 - Process A for Water Source Scenario A

5.1.2. Treatment for Water Source Scenario B

Table 6 - Selected Treatment for Limiting Hazards of Source Water B

Limiting Hazard	Treatment / Control Measure Selected
Escherida Coli	
Cryptosporidium	
Iron	
Manganese	
Nitrite	
Pesticides: Total	
Metaldehyde	
Corrosivity	
Taste	

Limiting Hazard	Treatment / Control Measure Selected
Change in Source Type	[redacted]
Total Organic Carbon	[redacted]
Chromium	[redacted]
PFOA	[redacted]
Turbidity	[redacted]
Algae	[redacted]

Figure 15 - Process B for Water Source Scenario B

5.1.3. Treatment for Water Source Scenario C

Table 7 - Selected Treatment for Limiting Hazards of Source Water C

Limiting Hazard	Treatment / Control Measure Selected
Escherichia coli	[redacted]
Cryptosporidium	[redacted]
Iron	[redacted]
Manganese	[redacted]

Limiting Hazard	Treatment / Control Measure Selected
Nitrite	[redacted]
Pesticides: Total	[redacted]
Metaldehyde	[redacted]
Benzo(a)pyrene	[redacted]
Corrosivity	[redacted]
Change in Source Type	[redacted]
Pathogens – Bacteria, Viruses, Protozoa	[redacted]
Total organic Carbon	[redacted]
Chromium	[redacted]
PFOA	[redacted]
Turbidity	[redacted]

Figure 16 - Process C for Water Source Scenario C

5.1.4. Treatment for Water Source Scenario D

Table 8 - Selected Treatment for Limiting Hazards of Source Water D

Limiting Hazard	Treatment / Control Measure Selected
Escherichia coli	
Cryptosporidium	
Iron	
Manganese	
Pesticides: Total	
Nitrite	
Metaldehyde	
Benzo(a)pyrene	
Corrosivity	
Change in Source Type	

Pathogens - Bacteria, Viruses, Protozoa	[redacted]
Total Organic Carbon	[redacted]
Chromium	[redacted]
PFOA	[redacted]
Turbidity	[redacted]
Algae	[redacted]

Figure 17 - Process D for Water Source Scenario D

5.1.5. Treatment for Water Source Scenario E

Table 9 - Selected Treatment for Limiting Hazards of Source Water E

Limiting Hazard	Treatment / Control Measure Selected
Escherichia coli	[redacted]
Cryptosporidium	[redacted]
Iron	[redacted]
Manganese	[redacted]

Limiting Hazard	Treatment / Control Measure Selected
Bromate	[redacted]
Nitrite	[redacted]
Pesticides: Total	[redacted]
Metaldehyde	[redacted]
Benzo(a)pyrene	[redacted]
Corrosivity	[redacted]
Change in Source Type	[redacted]
Pathogens - Bacteria, Viruses, Protozoa	[redacted]
Total Organic Carbon	[redacted]
Chromium	[redacted]
Endocrine Disrupting Compounds	[redacted]
PFOA	[redacted]
Turbidity	[redacted]
Algae	[redacted]

Figure 18 - Process E for Water Source Scenario E

5.2. Chemical Additions

5.3. Process Risks and Considerations

Metaldehyde has been identified as a risk in River Thames water and is expected to be present in all water source scenarios. Metaldehyde could warrant a separate treatment process to ensure removal, however it is expected to be banned for outdoor use in 2022, and should this be the case, the risk is likely to substantial reduce over the

timeframe for implementation of the T2ST SRO. Although there may be some removal via conventional GAC, this is not expected to provide full mitigation. It is recommended to be monitored over the next gated stages.

[redacted]

5.4. Waste Handling Considerations

The water treatment process yields a waste stream. The provision of a waste management route – connection to the public sewerage system, frequency of vehicle movements for removal of dewatered cake solids, disposal of out-of-specification recovered washwater – can be a significant issue in the planning of a new water treatment works site.

In order to provide a like-for-like comparison and due to the lack of detail around potential sites at this stage of assessment, it has been assumed that waste management route is the same for all sites and source water scenarios.

The assumed waste treatment aims to produce a thickened sludge for disposal to public sewer, with recovered washwater returned to the head of the works to maximise efficiency.

For the purposes of estimating annual sludge production volumes for opex costs, a thickened sludge dry solids content of 1%w/w has been assumed as recommended in the Thames Water Asset Standards document "AM-DES-WP-WP15 Washwater and Sludge Treatment" to prevent sewer blockage. It is understood Thames Water may not be the wastewater undertaker at all sites, this assumption is used to provide a standard costing basis for wastewater handling and may vary in later design stages.

6. Recommendations for Further Work

As is to be expected at this conceptual stage, several areas requiring further examination, data gathering or review have been identified through the Gate 1 WQRA to inform the development of future work scopes. These are summarised below:

- Information to inform likelihood scores for emerging contaminants – in particular Endocrine Disrupting Compounds and perfluorinated substances.
- Information to inform magnitude of expected pathogen risk from WwTW effluent supported source scenario.
- Surveillance of parameters which may change from their historic likelihood/consequence, for example due to regulatory changes – e.g. metaldehyde, chromium
- Information on the nature and magnitude of risks associated with types of biota (e.g. invasive non-native species), in particular, their impact on raw water conveyance SRO options
- Data to inform a quantitative design raw water quality envelope for treatment plant design and sizing.

  It is noted that a programme of water quality monitoring at the potential abstraction points is under development for Gate 2 and it is recommended that this is reviewed with respect to the above goals. The parameters included in the revised Drinking Water Directive together with DWI guidance notes (e.g. chlorate, PFOS and PFOA) should be considered as part of the Gate 2 monitoring programme.
- Investigation of change in source water risks:

  While the treatment processes identified in Section 5 are expected to treat water to drinking water quality standards, residual risks which can result from the introduction of treated water from new sources into existing treated water networks must be considered. The receiving zones of Testwood or Otterbourne are both currently fed by surface water (Testwood WTW from Testwood Lakes and the River Test and Otterbourne WTW from the River Itchen) whereas Andover and Kingsclere are both groundwater sites.

  The greatest residual risk to provision of acceptable drinking water quality lies with customer acceptability risks such as changes to the aesthetic qualities of water (including its colour, taste and odour); through modification of nitrate blending strategies; to changes to the corrosivity of water and impacts on the nature and concentration of corrosion by-products entering the water on route to the customer tap. The transfer of potable water over long distances also requires careful management of residual disinfectant and disinfection by-products.

  These risks are recognised as of key importance to a source-to-tap water safety planning approach and should be explored in subsequent phases of work should the scheme be taken forward. The water quality risk assessment process identified that the Andover and Kingsclere regions are likely to be impacted the most due to the change in type of water source – from a ground to surface source. Pro-active consumer engagement is a planned control measure which will be taken to reduce the impacts of this risk, however there is a risk that additional conditioning treatment is required in addition to the treatment processes outlined in Section 5. Further work is required to establish the need for (and inform the design of) such a stage.

7. Conclusions

The six No. SRO options for the T2ST SRO differ mainly by their abstraction point on the River Thames, and whether conveyance from the Thames to the receiving supply zone is with raw or treated water. Behind each of these options lies the source of water, for which water source scenarios A to E have been described for this scheme.

The source water scenarios result in differing risks and limiting hazards, which drive different selections of treatment processes in order to successfully mitigate the risks associated with each water source.

The highest risk water source is water source scenario E, which involves planned indirect support from WwTW effluent.

Water sources C and D are considered to have slightly lower risk than water source E [redacted].

Water sources A and B (supported by SESRO) offer the lowest risks in terms of water quality.

Options involving potable water transfer (Options 1 and 4) are preferred to options involving raw water transfer from a water quality perspective due to the increased risks involved with raw water transfer, such as degradation of pipelines through biofouling and siltation.

Based on the additional flows required and the water quality risk profile, new treatment works would also be expected to be required at all Southern Water receiving zones if raw water conveyance options are taken forward. Existing WTWs at Andover and Kingsclere both provide treatment to groundwater of a significantly different risk profile to T2ST water. Otterbourne and Testwood WTWs, although fed by surface water, are likely to also have different water quality risks compared to the T2ST risk profile. Thus, during the current phase of work (Gate 1) it has been taken that in all cases, new WTWs dedicated to T2ST treatment would be required to cope with the additional capacity as well as differing risks.

In all options and water source scenarios, treated water from new surface water sources will be introduced to new regions, including the currently groundwater-fed areas of Andover and Kingsclere. Changes in water source can affect aesthetic risks such as taste and odour, as well as corrosivity. These risks will require closer investigation during subsequent phases of work – potential control measures include pro-active consumer engagement, however there may also be a requirement for additional chemical conditioning prior to entering supply. Further work to establish the need for, and nature of, such conditioning would be required in future phases.

Due to the maturity of the scheme, through this process a number of areas have been identified for further investigation in subsequent stages of SRO design. These are summarised in Section 6.

Appendices

A.1. Strategic Water Quality Risk Assessments

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