Strategic Regional Water Resource Solutions: Annex 1.3: Interconnector Options Appraisal Summary Report

Standard Gate Two Submission for River Severn to River Thames Transfer (STT)

Date: November 2022

Severn to Thames Transfer

Interconnector options appraisal summary report

STT-G2-S3-302

November 2022

Disclaimer

This document has been written in line with the requirements of the RAPID Gate 2 Guidance and to comply with the regulatory process pursuant to Thames Water's, Severn Trent Water's and United Utilities' statutory duties. The information presented relates to material or data which is still in the course of completion. Should the solution presented in this document be taken forward, Thames Water, Severn Trent Water and United Utilities will be subject to the statutory duties pursuant to the necessary consenting processes, including environmental assessment and consultation as required. This document should be read with those duties in mind.

MOTT MACDONALD

Interconnector Options Appraisal Summary Report

Severn Thames Transfer SRO

September 2022

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Interconnector Options Appraisal Summary Report

Severn to Thames Transfer (STT)

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Contents

Tables

Figures

Executive summary

The Water Resources Long Term Planning Framework 2016 produced by Water UK highlighted the "significant and growing risk of severe drought impacts arising from climate change, population growth and environmental drivers" in England. This work was developed by the National Infrastructure Commission and reported in their publication Preparing for a drier future: England's water infrastructure needs (2018). In 2019, Ofwat published a final determination on Price Review (PR19) which gave an allowance "to progress the development of strategic regional water resource solutions, including the River Severn to River Thames transfer".

The Severn to Thames Transfer (STT) is one of several Strategic Resource Options (SROs) currently being considered under the RAPID (Regulatory Alliance for Progressing Infrastructure Development) gated process. The scheme is under consideration, as part of a portfolio of solutions, to ensure that a reliable and resilient water supply is provided to water-stressed areas and in particular the south east of England.

This SRO also takes a step towards the national transfer network that was noted in the National Infrastructure Commission report in 2018 by promoting a transfer of water from Water Resources West (WRW) region to the Water Resources South East (WRSE) region.

The Severn Thames Transfer (STT) Interconnector Options Appraisal Study was undertaken to support the STT Strategic Resource Option (SRO) Gate 2 submission to RAPID and considered options to transfer water from the River Severn to the River Thames. The overarching objective of the study was to identify a preferred interconnector option for Gate 2.

The option appraisal methodology had three stages: Longlist, Shortlist and Validation. The longlist and shortlist stages focussed on a 300 Ml/d capacity transfer for water supply, whereas the Validation stage considered a range of potential futures including larger capacity transfers and integration of the water supply scheme with restoration of the disused Cotswold Canals for boat navigation. Longlist appraisal was undertaken against qualitative environmental impact and engineering criteria. Shortlist appraisal and Validation considered costs and benefits, in a quantitative (monetised) and qualitative assessment.

The study area is primarily defined by the reaches of the River Severn that can be used for abstraction, acceptable locations for the discharge into the River Thames and the topography of the Cotswold Hills. The longlist identified a number of potentially feasible direct pipeline routes and routes that would reconstruct sections of the Cotswold Canals for open water transfer. The shortlist was selected to include a direct pipeline option that characterised options of this type for comparison against materially different options that combined pipelines with partial restoration of the Cotswold Canal corridor. The longlist and shortlist stages selected a direct pipeline from the River Severn in the vicinity of Deerhurst to the River Thames at Culham as the preferred option for a 300 Ml/d water supply transfer. The Potential Futures Validation further concluded that any benefits gained by integrating canal restoration with a water supply transfer would be outweighed by the impacts and costs. Furthermore, a direct pipeline was shown to be the only cost-effective solution for transfers larger than 300 Ml/d.

The direct pipeline solution was selected as the preferred option for Gate 2; however, it is envisaged that the STT project will progress to Gate 3, and the following next steps are proposed to support option selection:

- Further consultation with the EA and other regulators on the methodology and outcomes of the options study, followed by public consultation on the study and the various pipeline transfer routes

- Further review of the alternative direct pipeline options identified at the longlist stage including land referencing and desk top geotechnical studies to inform refinement of the pipeline route selection
- Further development of other technical aspects of the scheme design, particularly the approach to treatment and resilience to rising sea levels generated by climate change although these issues are not expected to materially affect option selection.

Back-checking will be undertaken at later gates and control points (as more information comes available) to confirm that the option selection remains robust.

1 Introduction

1.1 Introduction

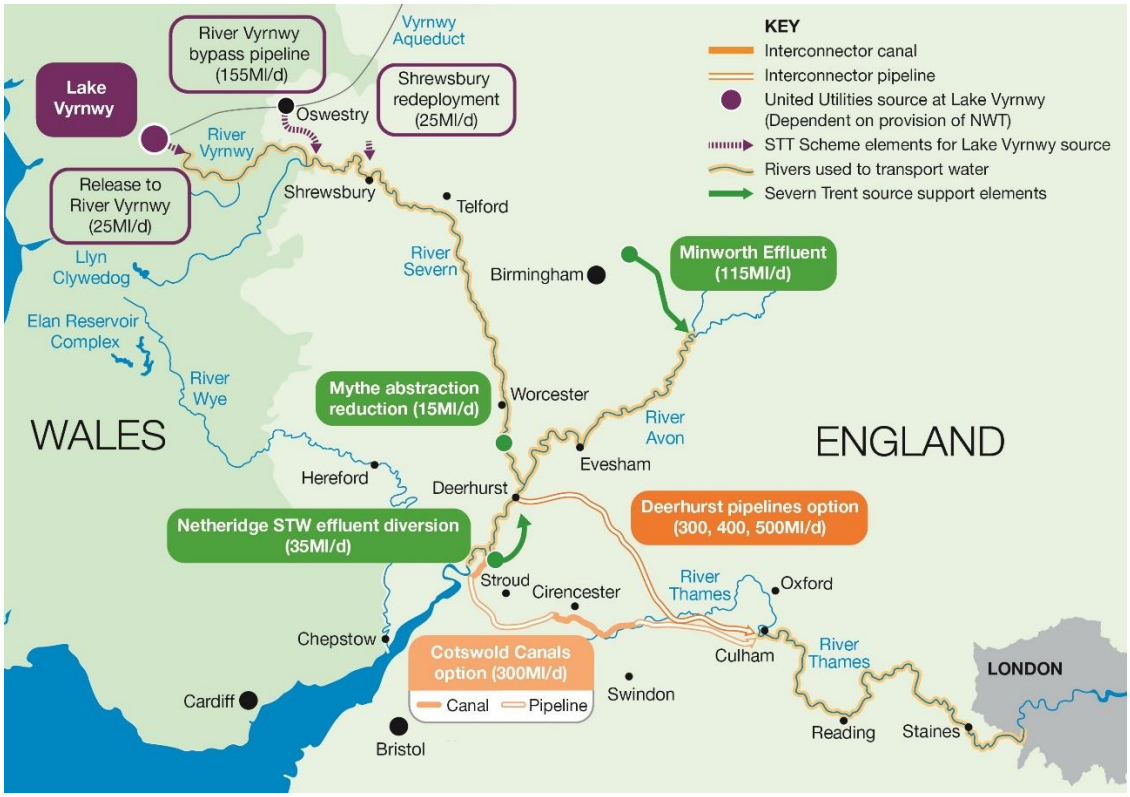
The Water Resources Long Term Planning Framework 2016 by Water UK highlighted the "significant and growing risk of severe drought impacts arising from climate change, population growth and environmental drivers" in England. This work was developed by the National Infrastructure Commission and reported in their publication Preparing for a drier future: England's water infrastructure needs (2018). In 2019, Ofwat published a final determination on Price Review (PR19) which gave an allowance "to progress the development of strategic regional water resource solutions, including the River Severn to River Thames transfer".

The Severn to Thames Transfer (STT) is one of several Strategic Resource Options (SROs) currently being considered under the RAPID (Regulatory Alliance for Progressing Infrastructure Development) gated process. The scheme is under consideration, as part of a portfolio of solutions, to ensure that a reliable and resilient water supply is provided to water-stressed areas and in particular the south east of England.

This SRO also takes a step towards the national transfer network that was noted in the National Infrastructure Commission report in 2018 by promoting a transfer of water from Water Resources West (WRW) region to the Water Resources South East (WRSE) region.

The system consists of various water resource options that could augment flow in the River Severn, thus allowing water to be abstracted and transferred through an interconnector to the River Thames for re-abstraction in the south east.

Figure 1.1: Severn Thames Transfer Schematic



Ofwat set out a regulatory process for the SRO projects with a series of formal approval gates. This options appraisal report has been produced to support Gate 2 and considers interconnector options to transfer water from the River Severn to the River Thames as part of the STT SRO. Route options have been developed and assessed through longlist, shortlist, and validation stages to determine a preferred option for the Gate 2 submission.

Interconnector options were previously considered during WRMP19 and SRO Gate 1; however, this study seeks to start from first principles and identify then appraise all potential options for an STT transfer. The overarching objective of the study is to identify a preferred STT Interconnector solution for the Gate 2 submission that would provide a resilient water supply to the south east of England. The preferred option will be technically feasible and deliver best value to water company customers.

The Gate 2 preferred option and other alternatives considered will be subject to further engagement and consultation with stakeholders during Gate 3, this may result in the provision of further information that could affect the option selection. Alternatively, there may be a future change in circumstance such as a legislative or political change that may affect the selection. Where this occurs, either in Gate 3 or future phases of the STT, a backcheck will be made on this option selection and adjustments made as appropriate to ensure the selection is current and valid at each stage.

1.2 Options Appraisal Methodology

This study is undertaken within the context of the Strategic Resource Option (SRO) programme, national, regional and company water resources planning and the potential for the project to progress to Nationally Significant Infrastructure Project (NSIP) status and Development Consent Order (DCO) examination. Therefore, a number of guidance documents are considered relevant, including:

- National Framework for Water Resources[1] including relevant guidance on SEA, HRA and WFD
- Water Resource Planning Guidelines[2] (WRPG)
- HM Treasury Green Book[3]
- Draft National Policy Statement for Water Resources infrastructure

There is also other environmental legislation that will apply as the project progresses, such as the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017. In general, the various guidance documents agree on the requirement for an approach to option selection that does not rely on least cost as the sole determinant of a preferred solution.

Following this guidance, this study seeks to identify a preferred solution that will be technically feasible and deliver best value to water company customers, where best value is considered to balance:

- Environmental and social impact
- Resilience
- Cost (including engineering risk and procurement / delivery complexity)
- Social and environmental benefits that would be delivered by the scheme

[1] Meeting our Future Water Needs: a National Framework for Water Resources, Environment Agency, 2020

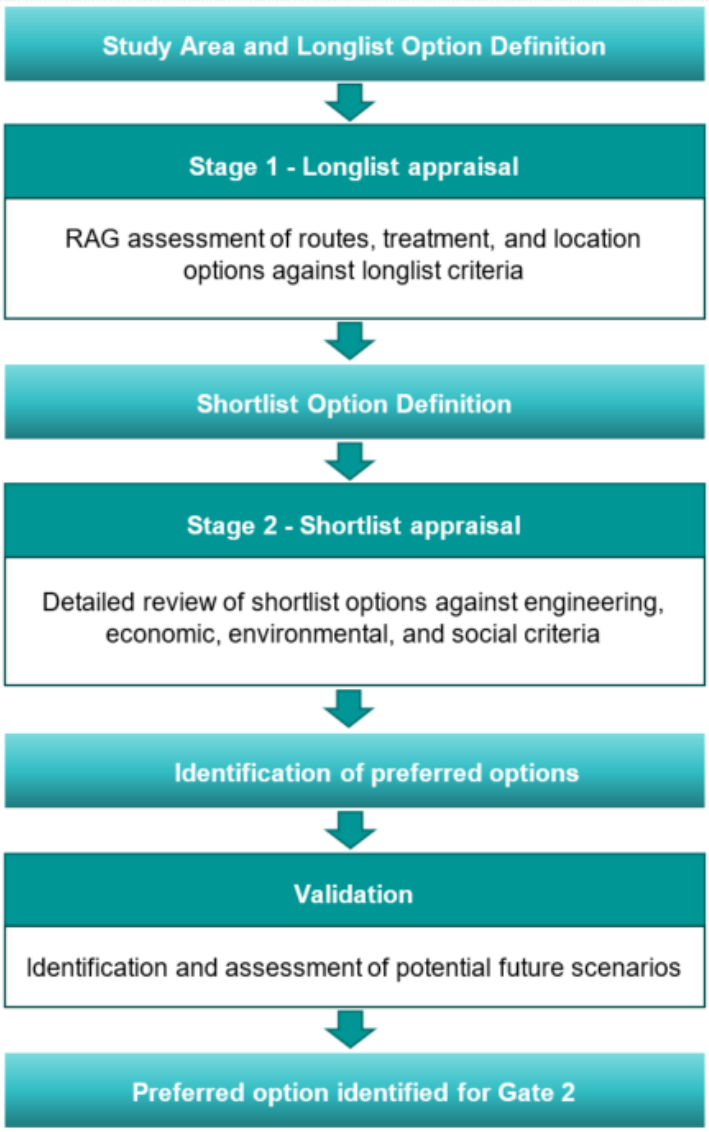
[2] Water Resources Planning Guideline, Environment Agency, updated 2 July 2021

[3] HMT 2020, The Green Book, Central government guidance on appraisal and evaluation

Appraisal methodology and criteria have been selected to align with guidance and legislation and enable appraisal of best value as defined above.

The appraisal methodology developed for this study is staged in line with HMT Green Book guidance. Assessment criteria have been selected to characterise the different costs, benefits, and other impacts of the scheme – drawing upon criteria and metrics used for regional planning and Water Resource Management Planning, where applicable. Some criteria have been monetised and others assessed qualitatively on a non-monetised basis to provide a data-based appraisal supported by expert judgement.

Figure 1.2: Options Appraisal Methodology Schematic



The option appraisal methodology has three stages.

The longlist and shortlist stages focussed on a 300 Ml/d capacity transfer for water supply, whereas the Validation stage considers a range of potential futures that include consideration of larger capacity transfers and integration of the water supply scheme with restoration of the disused Cotswold Canals for boat navigation.

The longlist and shortlist appraisals concentrated on transfers of 300 Ml/d as this is considered to be the credible maximum that could be transferred in the restored canal sections without adversely affecting boat navigation when the transfer is operational.

Longlist appraisal was undertaken against qualitative environmental impact and engineering criteria.

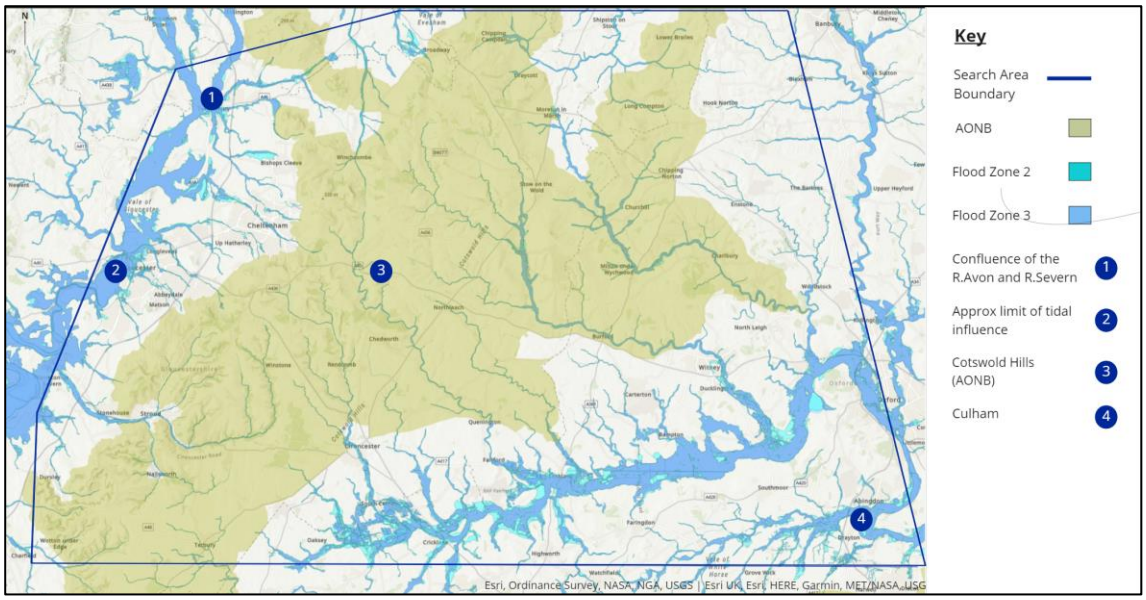
Shortlist appraisal considered both costs and benefits, in a monetised and non-monetised assessment.

The validation stage reviewed the preferred option selection to determine whether the selection would remain valid under a number of different potential future scenarios.

1.3 Defining the Study Area

The study area is primarily defined by the reaches of the River Severn that can be used for abstraction, acceptable locations for the discharge into the River Thames and the topography of the Cotswold Hills.

Figure 1.3: Plan of the Study Area



2 Longlist Definition and Appraisal

Longlist options identification and assessment was undertaken at the component level, grouped as follows:

- Intake locations
- Route options
- Treatment type and location options

All options discharge to the River Thames at Culham[4].

Options were developed and assessed against qualitative criteria, those that passed were considered for shortlist selection.

2.1 Longlist Definition

2.1.1 Route Options

Two general abstraction locations were initially adopted (Deerhurst and Gloucester Docks) and route corridors were then generated to transfer flow to the River Thames at Culham. Figure 2.1 shows the longlist routes identified and assessed.

2.1.2 Intake Location Options

2.1.2.1 Pipeline Intake

The potential locations for the pipeline intakes are constrained on the northern boundary by the confluence of the River Severn and the River Avon as it is proposed that both rivers are used for the transfer of water to the interconnector. The southern boundary is defined by the limit of saline ingress and tidal effects. Between these two extents potential abstraction locations are further constrained by the extent of the flood zone and built-up urban areas close to the river.

The potential location of intakes can be split into three main areas, north of Deerhurst, Deerhurst and South of Deerhurst, labelled respectively as Pipeline Intakes 1, 2 and 3 on Figure 2.1.

2.1.2.2 Canal Intake

The canal intake locations were identified to facilitate transfer of flows to the Gloucester and Sharpness (G&S) canal which is used both to provide storage (allowing reduced daily pumping schedule to operate around the tides) and to transfer flows on the first leg of the journey.

The northern limit of the intake location is constrained by proximity to the G&S Canal. The most northerly location of the canal is at Gloucester Docks, positioning the intake further north than this would result in the need to pump flows through built up areas in Gloucester to transfer the river water into the G&S Canal, so this is considered the northern limit.

The southern limit for the canal intake option is constrained by both the tidal influence on the River Severn and resulting effect on the quality of water that would be transferred into the canal. For the purposes of this study, it was assumed that intakes south of Netheridge Sewage

[4] Discharge locations higher up the River Thames have been considered but environmental constraints result in such options being unpromotable for flows above 100 or 200Ml/d (dependent on location). Staged discharge options have been considered but savings would not be significant in terms of option selection so have not been considered further at this stage.

Treatment Works (STW) are likely to be problematic due to the potential water quality risks, particularly to Bristol Water's Purton intake from the Gloucester and Sharpness Canal. The southernmost intake option considered, is situated just south of Netheridge (STW) to test this assumption.

Two groups of canal intake location options were identified (see Figure 2.1), four around Gloucester Docks (labelled as Canal Intake 1 on Figure 2.1) and two southwest of Gloucester (labelled as Canal Intake 2 on Figure 2.1) where the River Severn and the G&S Canal are closer to each other.

2.1.3 Treatment Options

Treatment is required to both improve the quality of the water abstracted from the lower River Severn before discharge into the upper River Thames and to minimise the risk of transferring Invasive Non-Native Species (INNS) between locations.

The following different treatment technologies were identified and assessed:

- Conventional treatment - As per Gate 1 solution: Inlet screening, ferric chloride coagulation, clarification in flat-bottomed clarifiers, rapid gravity filtration and washwater recovery
- Constructed wetland - Nature-based solution that uses natural functions (vegetation, soil, and organisms) to improve the quality of water
- Settlement lagoon - Lagoon or pond that uses sedimentation to remove suspended solids and other settleable matter from water
- Pile cloth media filtration technology - Filter units normally used for tertiary wastewater treatment for suspended solids and phosphorous removal
- Settlement Lagoon and pile cloth media filtration - Combined option: Preliminary settlement lagoon reduces solids load to filters, enabling greater removal across pile cloth filters.

In addition, a number of different treatment locations were identified and assessed. Whilst the specific details of location would be confirmed at a later date, generic locations were identified, particularly where the location of the treatment would have an effect on its efficacy. The generic locations are shown on Figure 2.1.

2.2 Longlist Appraisal

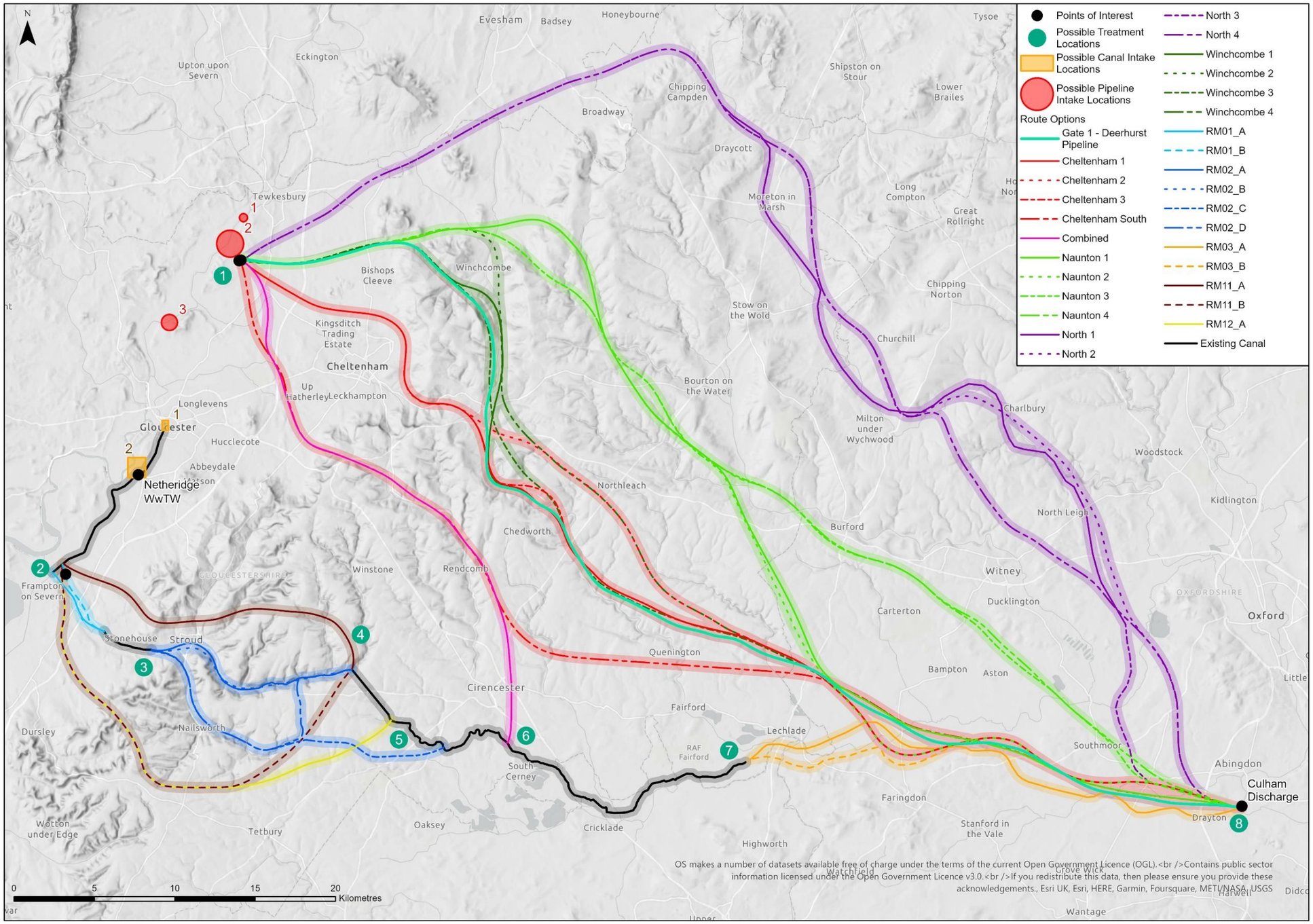
2.2.1 Longlist Appraisal Criteria

Assessment of longlist options was carried out against a series of criteria selected for the identification of a best value option:

- Environmental and social impact
- Resilience
- Cost (including engineering risk and procurement / delivery complexity)
- Potential to deliver biodiversity net gain
- Other social and environmental benefits that would be delivered by the scheme

The longlist options appraisal approach used a "traffic light" red / amber / green (RAG) system to demonstrate how each option performs against the assessment criteria. The appraisal against each of the assessment criteria was used to select the best performing components of the potential conveyance options. In this regard a red rating does not necessarily mean that an option is unviable but helps identify where there may be potentially major or significant constraints.

Figure 2.1: Indicative map of longlist options



2.2.2 Longlist Route Options Appraisal

The following routes were rejected in a pre-screening exercise prior to undertaking the longlist appraisal:

- Naunton 1 and 4 – additional head and length compared to Naunton options 2 and 3 and no additional benefits
- Winchcombe 3 – additional head compared to other Winchcombe routes
- North 1 and 3 – additional length compared to North 2 and problematic environmental pinch point near Charlbury
- Cheltenham South - additional head when compared to other options
- RM02_D - additional head and length compared to RM02_A and RM02_B.

These routes were typically the least favourable of a group of similar routes and so could be removed whilst retaining a sufficiently diverse range of alternative routes for the longlist appraisal.

Table 2.1 shows the longlist RAG appraisal undertaken on the remaining pipeline options.

Table 2.2 details the conclusions from the longlist route assessment, including the reasoning behind the rejection or selection of options.

Table 2.1: Longlist Routes RAG Assessment

	Engineering Construction		Engineering Cost						Engineering Operation	Resilience		Cost (% of Gate 1 cost)			Environmental - Impact									
Name	Access during construction	Buildability	Length (km)	No. of major crossings	Length with narrow working width (<50m) (km)	Length of trenchless excluding crossings (m)	Static lift (m)	Power (MW)	Access during operation	Resilience- vulnerability to other failure modes	Operational Complexity	CAPEX	OPEX	CAPEX+ OPEX	Biodiversity- Flora and Fauna	Biodiversity Net Gain	Soil	Water- flood risk	Water resources	Air	Historic Environment	Landscape	Human Health	Population- recreation	Population- economy
Deerhurst to Culham																									
Deerhurst	R	A	86	34	9	590	211	12.3	G	A	G	100%	100%	100%	R	R	A	A	A	G	A	A	A	A	A
Cheltenham 1	A	A	85	27	7	1070	188	11.6	G	A	G	90%	94%	91%	R	A	A	A	A	R	A	A	A	A	A
Cheltenham 2	A	G	82	24	4	700	227	13.1	G	A	G	87%	106%	93%	A	A	A	G	G	R	A	A	A	A	A
Cheltenham 3	A	A	85	24	5	1070	223	13.1	G	A	G	93%	106%	97%	A	A	A	G	G	R	A	A	A	A	A
Naunton 2	A	G	85	23	5	130	229	12.9	G	A	G	87%	105%	92%	A	A	A	G	G	A	A	A	A	A	A
Naunton 3	A	G	80	29	5	130	229	12.9	G	A	G	84%	105%	90%	A	A	A	G	G	A	A	A	A	A	A
Winchcombe 1	A	G	89	28	8	960	225	12.9	G	A	G	97%	104%	99%	R	A	A	A	A	A	A	A	A	A	A
Winchcombe 2	R	G	92	28	8	750	224	13.0	G	A	G	98%	104%	100%	R	A	A	A	A	A	A	A	A	A	A
Winchcombe 4	A	G	84	22	6	350	225	12.7	G	A	G	93%	103%	96%	A	A	A	G	G	A	A	A	A	A	A
North 2	A	G	102	40	3	500	146	9.8	G	A	G	139%	80%	121%	R	R	A	G	G	A	A	A	A	A	A
North 4	A	G	100	35	1	310	171	11.4	G	A	G	128%	92%	117%	R	R	A	G	G	A	A	A	A	A	A
Combined Pipeline	A	G	41	24	1	120	250	17.5	G	G	G	N/A	N/A	N/A	A	A	A	G	A	A	A	A	A	A	G
Gloucester Docks to Culham components																									
RM01_A	A	G	5	4	0.17	0	23	32	G	A	A	100%	100%	100%	G	A	A	R	G	G	A	G	G	G	G
RM01_B	R	G	5	5	0.17	0	26	35	G	A	A	91%	110%	100%	G	A	A	G	G	G	A	G	G	G	G
RM02_A	A	R	15	24	9.58	1196	108	134	G	A	A	100%	100%	100%	A	R	A	A	A	G	A	R	A	A	G
RM02_B	R	R	15	26	7.56	1508	108	134	G	A	A	105%	100%	102%	A	R	A	A	A	G	A	R	A	A	G
RM02_C	R	R	24	10	17.00	3298	136	163	G	R	A	142%	123%	132%	R	R	A	G	A	G	R	R	A	A	G
RM11_A	A	A	24	7	*	*	253	272	G	A	G	81%	165%	123%	A	G	A	G	G	G	A	R	A	A	G
RM11_B	A	A	34	13	*	*	230	245	G	A	G	99%	151%	125%	A	A	A	G	G	G	R	R	A	A	G
RM12_A	A	A	34	11	*	*	230	245	G	A	G	95%	151%	123%	A	A	A	G	G	G	A	R	A	A	G
RM03_A	A	R	34	17	1.90	0	19	37	G	A	G	100%	100%	100%	A	A	A	A	G	A	A	A	G	A	A
RM03_B	A	A	33	9	1.17	0	13	31.5	G	A	G	93%	82%	91%	A	A	G	G	G	A	A	A	G	A	A

* Not assessed at Gate 2: Longlist stage

Table 2.2: Longlist Route Option Selection

Name	Description	Rejected Options	Preferred Options	Rejection/ Selection Reasoning
Deerhurst to Culham Routes				
Deerhurst	Pipeline between Deerhurst intake and Culham discharge point	✓		This was the Gate 1 pipeline route. It is rejected due to potential effects on biodiversity, flora and fauna including impacts on sections of Ancient Woodland. Alternative routes have been developed in this study that avoid the Ancient Woodland constraint and perform better overall.
Cheltenham 1	Pipeline running north and east of Cheltenham, from WTW to Culham discharge point	✓		This route has been rejected due to a combination of environmental and engineering constraints. This route would require work in close proximity to extensive areas of ancient woodland areas near Chedworth. The route involves work within an Air Quality Management Area (AQMA), however, this is considered manageable as temporary construction effects could be managed. Close proximity of this route to the A40 and Dowdeswell Reservoir present additional engineering constraints.
Cheltenham 2	Pipeline running north and east of Cheltenham, from WTW to Culham discharge point		✓	Low Capex and Opex but concerns around construction in AQMZ and proximity of this route to the A40 and Dowdeswell Reservoir. This option provides a shorter route than others whilst retaining the flexibility for an early discharge into the River Thames.
Cheltenham 3	Pipeline running north and east of Cheltenham, from WTW to Culham discharge point	✓		This route has been rejected due to a combination of environmental, engineering and cost constraints. This route involves work within an Air Quality Management Areas (AQMA). Close proximity of this route to the A40 and Dowdeswell Reservoir present engineering constraints. This route avoids the areas of ancient woodland near Chedworth but is higher cost that Cheltenham 2.
Naunton 2	Pipeline running to the North of Winchombe, from WTW to Culham discharge point		✓	Solution with most potential for release of some flows into the River Thames upstream of Culham.
Naunton 3	Pipeline running to the north of Winchcombe, from WTW to Culham discharge point		✓	Shorter length and slightly lower capex but marginally less favourable to Naunton 2 based on potential for release of some flows into the River Thames upstream of Culham.
Winchcombe 1	Pipeline running south of Winchcombe from WTW to Culham discharge point	✓		This route includes works in close proximity to extensive areas of ancient woodland areas near Chedworth. This route has also been rejected on a cost basis as the associated capital and operational costs are higher than Winchcombe 4.
Winchcombe 2	Pipeline running north of Winchcombe from WTW to Culham discharge point	✓		This route includes works in close proximity to extensive areas of ancient woodland areas near Chedworth. This route has also been rejected on a cost basis as the associated capital and operational costs are higher than Winchcombe 4.
Winchcombe 4	Pipeline running south of Winchcombe from WTW to Culham discharge point		✓	This option offers an alternative to Cheltenham 2, avoiding the AQMA and close proximity of this route to the A40 and Dowdeswell Reservoir present engineering constraints.
North 2	Pipeline running to the north of Dover's Hill (south of Mickleton), from WTW to Culham discharge point	✓		This route has been rejected based upon a combination of engineering and environmental factors. This route runs adjacent to Cothill Fen SAC and may cause potential groundwater impacts on this designated site. This route also has a direct impact on a registered park and garden. In addition, the extra length associated with this route results in an unfavourable capital cost when compared to other pipeline routes without sufficiently compelling operational benefit.
North 4	Pipeline running to the north of Dover's Hill (south of Mickleton), from WTW to Culham discharge point	✓		This route has been rejected based upon a combination of engineering and environmental factors. This route runs adjacent to Cothill Fen SAC and may cause potential groundwater impacts on this designated site. In addition, the extra length associated with this route results in an unfavourable capital cost when compared to other pipeline routes without sufficiently compelling operational benefit.
Combined Option	Pipeline from Deerhurst to the Thames Severn Canal.		✓	This option has a shorter length than others in this list as it would deliver water to the Thames and Severn Canal for onward transfer. From there additional components (an open water transfer via a reconstructed Thames Severn Canal to Lechlade, and pipeline RM03 from Lechade to Culham) would be required to deliver the flow to Culham. Not directly comparable to the other routes above. The longlist stage confirmed that there are no environmental constraints preventing this passing to shortlist stage where this component will be combined with other canal and pipeline components to make a full option.
Gloucester Docks to Culham Routes				
RM01_A	Gate 1 route - G&S canal near Saul Junction to Newton Pound	✓		Rejected due to length of pipe within flood plain and intake/PS within flood plain. Superseded by RM01_B.
RM01_B	RM01_A route adjusted to avoid flood zone	✓		This route has not been rejected in its own right but it can only be selected with an RM02 option, all of which have been rejected. Therefore, it must be rejected as there is no suitable onward route available.
RM02_A	Gate 1 route - Newton Pound to Daneway Portal	✓		Rejected due to constructability concerns centred on the length of route within Frome and Stroud River valleys and the route running through irreplaceable priority habitat. The constrained working areas would make it harder to work safely when compared to other possible, less constrained route options.
RM02_B	Variation on RM02_A developed to reduce length along canal tow path and within the canal.	✓		Rejected due to constructability concerns with construction within constrained river valley, and the route running through irreplaceable priority habitat. The constrained working areas would make it harder to work safely when compared to other possible, less constrained route options.
RM02_C	Newton Pound to Coates Portal - eliminates requirement to refurbish Sapperton Tunnel	✓		Rejected due to constructability concerns centred on the length of route within Nailsworth Stream Valley and environmental concerns such as impact on Minchampton Common SSSI, the Woodchester Roman Villa Scheduled Monument and impact on priority habitats including some irreplaceable habitat.
RM11_A	G&S canal near Saul Junction to Daneway Portal - Alternative to RM01 + RM02 to improve buildability and reduce impact on environmental constraints		✓	This route links the Gloucester and Sharpness canal to upstream of Sapperton tunnel via a route to the north of Stroud and requires the Sapperton tunnel to be refurbished. Onward transfer would be through the restored Thames and Severn Canal to Lechlade, then RM03_B to Culham.
RM11_B	Alternative to RM11_A	✓		Rejected due to unfavourable cost comparison with RM11_A, mainly due to its increased length. This route also has potential issues with environmental constraints with the route crossing part of the Grade 1 Registered Park and Garden (Cirencester Park).
RM12_A	G&S canal near Saul Junction to Coates Portal - Alternative to RM01 + RM02_C to improve buildability and reduce impact on environmental constraints		✓	This route links the Gloucester and Sharpness canal to downstream of Sapperton tunnel via a route to the south of Stroud. Onward transfer would be through the restored Thames and Severn Canal to Lechlade, then RM03_B to Culham.
RM03_A	Gate 1 route - Lechlade to Culham	✓		Rejected due to preference for improved route (RM03_B) which has a reduced impact on grade 3 agricultural land and flood zones 2 and 3
RM03_B	Alternative to RM03_A adjusted to avoid environmental constraints		✓	This route conveys water from Thames and Severn Canal to Culham and can be used with either of one of the options above.

2.2.3 Longlist Intake Location Options Appraisal

A number of different intake options were reviewed to test the validity of the Gate 1 locations. As detailed below, whilst minor changes in location have been identified, the character of the preferred intake locations remains the same as in Gate 1, with the pipeline intake in the Deerhurst area and the canal intake in the Gloucester Docks area.

2.2.3.1 Pipeline Intake Location

Pipeline intake options within the three separate areas (as shown Figure 2.1) were identified and assessed against the longlist appraisal criteria. A single intake option was selected to characterise intake options within each area.

Pipeline intake options in the southern area were rejected due to the potential for water quality issues due to closer proximity to the tidal limit (and a subsequent risk of a reduction in pumping time during high tides and hence requirement for additional storage). In addition, options to the south require an extension of circa 3km to the main transfer pipeline.

The pipeline intake option within the northern area was also rejected. This option is close to heritage areas and requires a long raw water pipeline due to the width of the floodplain in this location.

Therefore, it was concluded that an intake in the Deerhurst area should be selected. Four options in this area were identified, all of which are generically similar. The Gate 1 intake solution was chosen to characterise intakes in this area and taken forward to the shortlist appraisal.

2.2.3.2 Canal Intake Location

The southern group of options were assessed as being less complex to construct than options in the Gloucester Docks area as the sites are on agricultural land and less space constrained. However, these options were rejected due to the potential water quality issues as a consequence of a greater salinity and suspended solids in the abstracted water, prompted by a greater tidal influence and the sewage discharge from the sewage treatment works.

The location of the canal intakes within the Gloucester Docks area is constrained due to the built-up nature of the area. Two options were rejected due to buildability concerns. Two remaining options were identified as preferred. An option to the north of the area was selected to characterise the canal intake location in the shortlist appraisal.

2.2.4 Longlist Treatment Options Appraisal

2.2.4.1 Treatment Technology

An initial assessment was undertaken of the possible treatment technologies. The constructed wetland and settlement lagoon options were rejected primarily due to concerns that they would not provide a sufficient barrier against INNS transfer. The pile cloth media filtration option was rejected due to a risk in the consistency of outcome resulting from a single stage of treatment. Both the conventional treatment option and the combination option of a settlement lagoon with a secondary stage of pile cloth media filtration were selected as preferred options. The preferred option to be carried forward for the shortlisting stage is the conventional treatment option. This is the most developed of the options as it was previously selected at WRMP19 and Gate 1 and hence provides most cost surety for the shortlist option selection stage.

The sizing, and thus capital cost, of the settlement lagoon is dependent on the retention time. The proposed sizing provides 12 hours of settling time; however, a longer period may be required, which would increase the footprint and capital cost. This option, along with alternative

nature-based solutions, will be further investigated at Gate 3, as there may be advantages for these alternative treatment options over a conventional works in terms of environmental, operational costs, waste generation and sludge disposal and resilience. It is noted that the selection of treatment technology will be the same for all shortlisted options so will not impact on the selection being undertaken at this stage.

2.2.4.2 Treatment Location

The following two location options were selected as preferred:

- Deerhurst Intake Water Treatment Works (WTW) – Gate 1 Location (Treatment location 1 as shown in Figure 2.1)
- Gloucester and Sharpness Canal intake to pipeline Location (Treatment location 2 as shown in Figure 2.1)

The Deerhurst Intake WTW would be suitable for the Deerhurst pipeline route options, and the Gloucester and Sharpness Canal intake to pipeline would be suitable for the canal options. Both options would locate the WTW close to the main abstraction location within the Severn catchment, which would improve the quality of the water for pumping thereby reducing roughness and operational issues and ensuring that INNS removal occurs close to source (reducing the risk of INNS transfer to the Thames catchment).

The preferred canal routes as identified in Table 2.2 bypass all canal sections within the Severn catchment, which means that water can be treated at the intake from the Gloucester and Sharpness Canal before being pumped directly into the Thames catchment. The open water canal in the Thames catchment could provide an enhanced pathway for INNS to move within the catchment or provide a receptor water body for jump dispersal from another location but treating at source will reduce the risk of providing a new pathway between the catchments. Water quality could deteriorate during travel within the open canal following a pollution incident or run off into the canal from surrounding farmland that could result in a breach of the required discharge quality in the River Thames. Therefore, active monitoring of the Thames Canal section is proposed to determine if any additional treatment is required.

3 Shortlist Option Definition and Appraisal

3.1 Shortlist Option Definition

Four direct pipeline options passed the Longlist appraisal and could have been included on the shortlist. They were technically similar (i.e., they would utilise the same transfer facilities but have differing routes) and therefore one of the four options was selected to represent this option type in the shortlist assessment. This approach ensured that the Stage 2 Shortlist assessment was focussed on the fundamental differences between options such as different intake locations or use of pipelines vs open water transfer rather than comparing options that are generically similar.

Three shortlist options were identified that would reconstruct sections of the Cotswold Canals for open water transfer. The canal route cannot be used for the whole transfer as the two rivers are separated by the Cotswold hills and the canal corridor drops away from the summit pound towards each river. Therefore, the canal-based options include pumped pipelines to transfer water uphill as appropriate. The four shortlist options are shown below.

Figure 3.1: Map Showing Indicative Shortlist Options

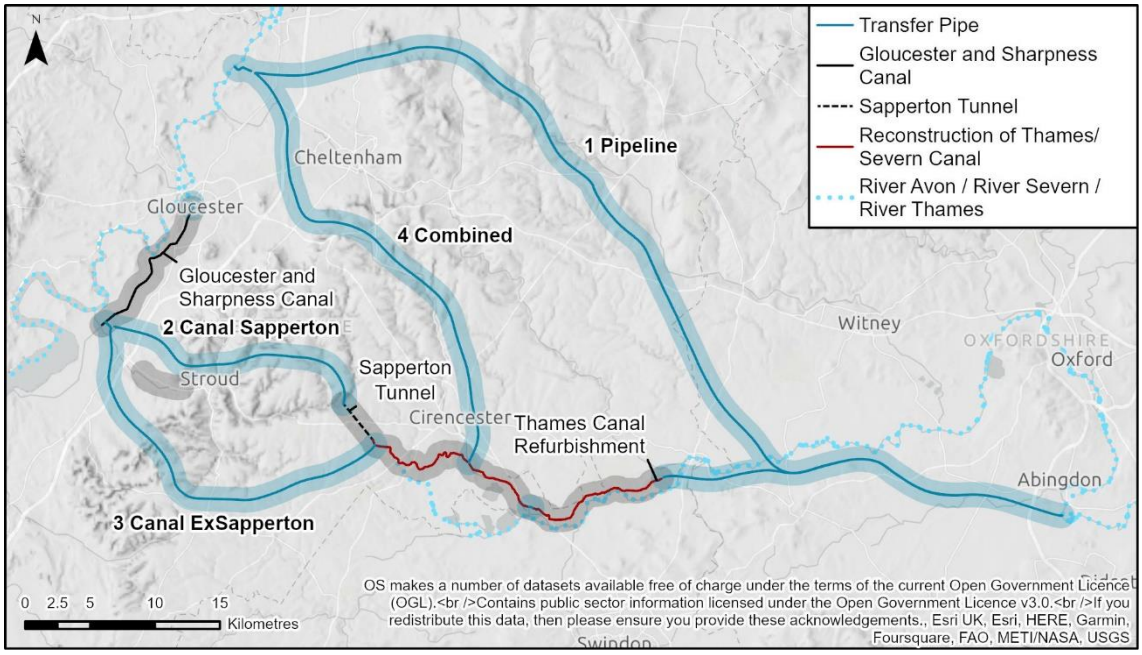


Table 3.1: Summary of shortlist options

Option	Inlet Location	Route	Treatment Location & Approach
Option 1 Pipeline	Deerhurst	Naunton 2	Deerhurst (conventional treatment)
Option 2 Canal Sapperton	Gloucester Docks	G&S Canal from Gloucester to Saul Junction, RM11_A, Reconstructed Sapperton Canal Tunnel, Reconstructed canal from Coates Portal to Dudgrove Double Upper Pound, RM03_B	Gloucester Sharpness (conventional treatment) + Active monitoring of the Thames & Severn Canal section
Option 3 Canal ExSapperton	Gloucester Docks	G&S Canal from Gloucester to Saul Junction RM12_A, Reconstructed canal from Coates Portal to Dudgrove Double Upper Pound, RM03_B	Gloucester Sharpness (conventional treatment) + Active monitoring of the Thames & Severn Canal section
Option 4 Combined	Deerhurst	Combined Option, Reconstructed canal from South Cerney Upper Pound to Dudgrove Upper Pound, RM03_B	Deerhurst (conventional treatment) + Active monitoring of the Thames & Severn Canal section

3.2 Shortlist Appraisal Criteria

The Shortlist options were assessed against a more detailed set of assessment criteria, once again focusing on best value themes. At this stage the assessment of full options enabled a more thorough and holistic assessment to be undertaken, including an assessment of potential benefits. Carbon could also be costed in a more useful way to establish any significant differences in the carbon impact between option types. Where possible, assessments were monetised following HM Treasury Green Book guidance to facilitate comparison between options across different parameters. However, the monetised assessment was supplemented by a qualitative appraisal and the overall performance of each option was considered in the round to establish a preferred Shortlist option.

The shortlist option appraisal cost and benefits assessment were split into those aspects that could be usefully monetised and those for which monetisation is less suitable. Table 3.2 shows the assessment strategy for the shortlist criteria.

Table 3.2: Assessment Strategy for Shortlist Criteria

Criteria	Quantitative (Monetised)	Qualitative (RAG)
Financial	CAPEX & OPEX	
Carbon Impact	Carbon	
Resilience		Ability to persist with planned functions The resilience of supporting services Ability to respond and to recover from unexpected failures Flexibility and diversity of options Deliverability of planned changes
Socio-economic costs and benefits	Recreational/ tourism wellbeing benefit House price benefit Local economic benefit Negative impact on existing recreational sites	Additional tourism and recreation opportunities
Natural Capital	Climate regulations (carbon sequestration) Natural hazard regulation (flooding) Agriculture ecosystem services value	Biodiversity Water purification
Other Environmental Criteria		Nature conservation and biodiversity Land Use and Soil Water Air Quality Landscape Historic Environment Population and Human Health Tourism and Recreation Material Assets

3.3 Shortlist Appraisal

Table 3.3: Shortlist Qualitative RAG Assessment

	Name	Description	Option 1 Pipeline	Option 2 Canal inc Sapperton	Option 3 Canal Ex Sapperton	Option 4 Combined
Resilience	Ability to persist with planned functions	Risk of failure due to physical hazards				
	The resilience of supporting services	Catchment/raw water quality risks				
	The resilience of supporting services	Risk of failure of supporting service due to exceptional events				
	Ability to respond and to recover from unexpected failures	Operational complexity and flexibility				
	Flexibility and diversity of options	Scalability and modularity of interventions				
	Deliverability of planned changes	Intervention lead times				
	Deliverability of planned changes	Reliance on external bodies to deliver change				
Qualitative Environmental	Nature Conservation and Biodiversity	Extent of construction and operational effects on European designated sites and their qualifying features (SPA, SAC, Ramsar)				
	Nature Conservation and Biodiversity	Extent of construction and operational effects on nationally designated sites and their qualifying features (SSSI)				
	Nature Conservation and Biodiversity	Extent of construction and operational effects on non-statutory designated sites (Ancient woodland, NNR) and priority habitats				
	Nature Conservation and Biodiversity	Extent of construction and operational effects on invasive and non-native species (INNS)				
	Land use and Soil	Extent of construction and operational effects on nationally designated sites and their qualifying features (SSSI (geodiversity)				
	Land use and Soil	Extent of construction and operational effects on agricultural land (Agriculture land classification)				
	Land use and Soil	Extent of construction and operational effects on landfill sites (historic and permitted landfill sites)				
	Land use and Soil	Extent of construction and operational effects on nationally significant infrastructure including mineral sites (NSIP land and mineral safeguarded land)				
	Water	Extent of construction and operational effects on the floodplain				
	Water	Extent of construction and operational effects on water features – flows and geomorphology				
	Water	Extent of construction and operational effects on water quality				
	Air Quality	Extent of construction and operational effects on Air Quality Management Areas (AQMAs)				
	Landscape	Extent of construction and operational effects on national landscape designations (National Parks / AONB)				
	Landscape	Extent of construction and operational effects on greenbelt designated land (Greenbelt)				
	Historic Environment	Extent of construction and operational effects on statutory designated heritage assets, including overall setting (LB's, Scheduled Monuments, Conservation Areas)				
	Historic Environment	Extent of construction and operational effects on non-statutory designated heritage assets, including overall setting (Registered Parks and Gardens and Battlefields)				
	Population and Human Health	Extent of construction and operational effects on the health, amenity, and wellbeing of local communities (Built up areas)				
	Tourism and Recreation	Extent of construction and operational effects on recreational activities and / or tourism (National trails, country parks, open access land, PRoW)				
	Material Assets	Extent of construction and operational effects on built assets and infrastructure				
Other	Biodiversity	Pre-mitigation (habitat affected)				
	Water Purification	Potential to change water purification service provision	None	Moderate benefit	Moderate benefit	Minimal benefit
	Additional tourism and recreation opportunities	Extent of any opportunities for enhancement of tourism and recreational facilities				

Table 3.4: Summary of Shortlist Monetised Assessments (£m 2022/23 Cost base)

Scenario	01_Pipeline	02_Canal_ Sapperton	03_Canal_ Ex_Sapperton	04_Combined
Present Cost Best Estimate (CAPEX+OPEX)	***£1,062.90m***	***£1,374.90m***	***£1,363.85m***	***£1,403.54m***
Present Carbon Cost	***£85.85m***	***£93.88m***	***£97.45m***	***£104.85m***
Present Benefits				
Recreation, tourism, volunteering, and land value	*-£0.35m*	*£22.25m*	*£16.12m*	*£9.48m*
Carbon Sequestration	*£0.05m*	*£0.54m*	*£1.62m*	*£1.09m*
Natural Hazard Regulation	*£0.39m*	*£0.48m*	*£0.03m*	*£0.07m*
Agriculture	*-£0.04m*	*-£0.08m*	*£0.04m*	*£0.03m*
Total Present Benefits	***£0.05m***	***£23.18m***	***£17.82m***	***£10.68m***
Net Present Cost (NPC)	***£1,148.70m***	***£1,445.60m***	***£1,443.49m***	***£1,497.71m***
% Difference to Option 01	100%	126%	126%	130%

Note: Costs included within this table have been developed for the comparison of shortlist options only and may not reflect final Gate 2 costs reported elsewhere.

3.4 Preferred Shortlist option

This study sought to identify a resilient water supply to the South East of England which would deliver best value to water company customers when considering environmental and social impacts and benefits, resilience and cost. Based on the assessment results Option 1, which would transfer water from the River Severn to the River Thames through a direct pipeline from Deerhurst to Culham, was chosen as the preferred option to deliver a 300Ml/d water supply transfer.

The direct pipeline option performed better overall in the qualitative environmental, resilience and natural capital assessments including criteria relating to the impact of invasive non-native species (INNS); construction and operation of the option; and flood zone impact. Options that abstract from the River Severn at Gloucester Docks and utilise the Cotswold Canal refurbishment were assessed as generally less favourable, with the potential impact on water flows and the geomorphology in the Eastern Channel of the River Severn identified as an issue that would need to be reviewed further and addressed.

It is recognised that options that utilised reconstructed sections of the Cotswold Canals would provide significantly better opportunities for enhancement of tourism and recreation. However, it should be noted that the STT work would only deliver the canal restoration needed for water transfer and not a fully navigable canal system. As such the opportunities for such enhancements associated with these canal-based options are limited.

The direct pipeline option also had the lowest capital and operating costs and the lowest Net Present Cost (i.e. the whole life cost added to monetised social, natural capital and carbon impacts and benefits), being approximately 25% lower in cost than options utilising reconstructed sections of the Cotswold Canals.

The monetisation of benefits undertaken in this appraisal shows that, whilst the options involving the canal result in greater potential to deliver benefits, the additional whole life financial costs of the canal options are far higher than the monetised value of the benefits, and therefore selecting an option that utilises sections of canal for water transfer would not provide good value

4 Validation – Potential Futures Appraisal

This supplementary study considered a number of potential future scenarios for delivery of a water supply transfer from the River Severn to the River Thames and restoration of the historic Cotswold Canals in order to test the robustness of the option selection and to explore the decision alongside potential wider societal goals. The scenarios also include water supply transfers greater than 300 Ml/d capacity to validate the findings of Stages 1 and 2 of the STT interconnector options appraisal. The scenarios were evaluated in a similar exercise to the shortlist assessment and the results were considered against the following questions:

- If only a water transfer option is required, which scenario is preferred and why?
- If only a navigable canal is required, which scenario is preferred and why?
- If a water transfer AND a navigable canal are required, which scenario is preferred and why?
- If a navigable canal is restored before the transfer is developed, which scenario is preferred and why?

4.1 Potential Futures Options

Table 4.1: Potential Futures Options

Potential future scenario	Navigation	Water Transfer	Inclusion Reasoning
A: Do nothing	No navigation	No STT water transfer	A base case scenario
B: STT piped connection only	No navigation	Pipeline water transfer between the River Severn and River Thames (300 or 500 Ml/d)	Preferred option from interconnector options Stage 1 and 2 assessments
C: Two connections: STT piped connection and canal connection is restored (but only for navigation)	Navigation occurs (CCT funded)	Pipeline water transfer between the River Severn and River Thames (300 or 500 Ml/d)	To determine whether the independent delivery of a water transfer and separate delivery of the canal for navigation represents the best value for society
D: STT canal connection (SRO funded transfer and navigation)	Navigation occurs (SRO funded)	Raw water transfer (300Ml/d) is achieved through a series of canal pounds and pipelines	To determine whether SRO funding of both transfer and navigation represents the best value for society
E: Canal restored for transfer only (no navigation)	No navigation	Raw water transfer (300Ml/d) is achieved through a series of canal pounds and pipelines	Assumes a future where completion of the canal for navigation fails to occur (i.e., lack of funding or regulator opposition)
F: SRO restores sections required for transfer, CCT restores other sections required for navigation	Navigation occurs (CCT funded)	Raw water transfer (300Ml/d) is achieved through a series of canal pounds and pipelines.	To determine whether joint funding of transfer and navigation in which the SRO funds canal and bypasses for transfer and the CCT funds further works for navigation represents the best value for society.

Potential future scenario	Navigation	Water Transfer	Inclusion Reasoning
G: Canal restoration for navigation only	Navigation occurs (CCT funded)	No STT water transfer	A potential future where the STT is not required but the canal is delivered for navigation by the CCT.
H: Two connections: STT piped connection and canal connection is restored	Navigation occurs (SRO funded)	500Ml/d transfer total. Raw water transfer (300Ml/d) is achieved through a series of canal pounds and pipelines and an additional 200Ml/d pipeline	To explore a potential joint solution that both meets the maximum volume of water required (500Ml/d) and delivery of navigation.
I: Canal restoration delivered first by CCT with bridges and other canal infrastructure sized to facilitate later addition of water supply transfer for 300Ml/d by the SRO	Navigation occurs first (CCT funded)	Raw water transfer is achieved through a series of canal pounds and pipelines. (Only pipelines and associated infrastructure are funded by the SRO)	To explore the potential impact on STT delivery cost if the canal is restored by others and already exists when the transfer is constructed. This scenario could potentially provide an income for canal operation and a second (potentially more resilient) source of water for the canal.

4.2 Potential Futures Appraisal

Table 4.1 shows the qualitative RAG assessment of scenarios.

Table 4.2 and Figure 4.1 summarise the monetised assessment.

Table 4.4. provides a summary of the assessment.

Table 4.2: Summary of qualitative assessment for scenarios that facilitate water transfer

	Name	Description	Scenario B	Scenario C	Scenario D	Scenario E	Scenario F	Scenario G	Scenario H	Scenario I
Resilience	Ability to persist with planned functions	Risk of failure due to physical hazards						n/a		
	The resilience of supporting services	Catchment/raw water quality risks						n/a		
	The resilience of supporting services	Risk of failure of supporting service due to exceptional events						n/a		
	Ability to respond and to recover from unexpected failures	Operational complexity and flexibility						n/a		
	Flexibility and diversity of options	Scalability and modularity of interventions						n/a		
	Deliverability of planned changes	Intervention lead times						n/a		
	Deliverability of planned changes	Reliance on external bodies to deliver change						n/a		
Qualitative Environmental	Nature Conservation and Biodiversity	Extent of construction and operational effects on European designated sites and their qualifying features (Special Protected Area, Special Area of Conservation, Ramsar Sites)								
	Nature Conservation and Biodiversity	Extent of construction and operational effects on nationally designated sites and their qualifying features (Site of Special Scientific Interest)								
	Nature Conservation and Biodiversity	Extent of construction and operational effects on non-statutory designated sites (Ancient woodland, National Nature Reserve) and priority habitats								
	Nature Conservation and Biodiversity	Extent of construction and operational effects on invasive and non-native species (INNS)								
	Land use and Soil	Extent of construction and operational effects on nationally designated sites and their qualifying features (Site of Special Scientific Interest) (geodiversity)								
	Land use and Soil	Extent of construction and operational effects on agricultural land (Agriculture land classification)								
	Land use and Soil	Extent of construction and operational effects on landfill sites (historic and permitted landfill sites)								
	Land use and Soil	Extent of construction and operational effects on nationally significant infrastructure including mineral sites (Nationally Significant Infrastructure Project land and mineral safeguarded land)								
	Water	Extent of construction and operational effects on the floodplain								
	Water	Extent of construction and operational effects on water features – flows and geomorphology								
	Water	Extent of construction and operational effects on water quality								
	Air Quality	Extent of construction and operational effects on Air Quality Management Areas (AQMAs)								
	Landscape	Extent of construction and operational effects on national landscape designations (National Parks / Area of Outstanding Natural Beauty)								
	Landscape	Extent of construction and operational effects on greenbelt designated land (Greenbelt)								
	Historic Environment	Extent of construction and operational effects on statutory designated heritage assets, including overall setting (LB's, Scheduled Monuments, Conservation Areas)								
	Historic Environment	Extent of construction and operational effects on non-statutory designated heritage assets, including overall setting (Registered Parks and Gardens and Battlefields)								
	Population and Human Health	Extent of construction and operational effects on the health, amenity, and wellbeing of local communities (Built up areas)								
	Tourism and Recreation	Extent of construction and operational effects on recreational activities and / or tourism (National trails, country parks, open access land, Public Rights of Way)								
	Material Assets	Extent of construction and operational effects on built assets and infrastructure								
Other	Biodiversity	Pre-mitigation (habitat affected)								
	Water Purification	Potential to change water purification service provision								
	Additional tourism and recreation opportunities	Extent of any opportunities for enhancement of tourism and recreational facilities	Not RAGed as considered to be included within benefits assessment							

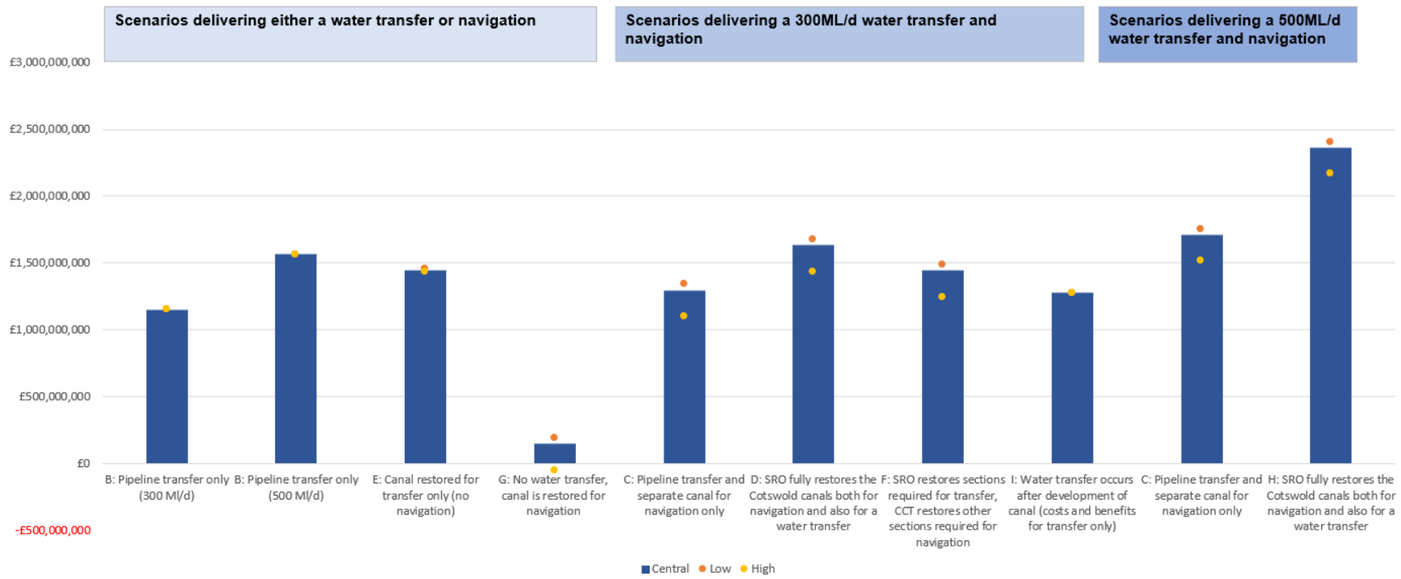
Potential future scenario
A: Do nothing
B: STT piped connection only
C: Two connections: STT piped connection and canal connection is restored (but only for navigation)
D: STT canal connection (SRO funded transfer and navigation)
E: Canal restored for transfer only (no navigation)
F: SRO restores sections required for transfer, CCT restores other sections required for navigation
G: Canal restoration for navigation only
H: Two connections: STT piped connection and canal connection is restored
I: Canal restoration delivered first by CCT with bridges and other canal infrastructure sized to facilitate later addition of water supply transfer for 300Ml/d by the SRO

Table 4.3: Summary of present cost for potential future scenarios (£m 2022/23 Cost base)

	Scenarios delivering either transfer or navigation				**Scenarios delivering 300ml/d transfer and navigation**				**Scenarios delivering 500ml/d transfer and navigation**	
Scenario	**B:** Pipeline transfer only (300 Ml/d)	**B:** Pipeline transfer only (500 Ml/d)	**E:** Canal restored for transfer only (no navigation)	**G:** No water transfer, canal is restored for navigation	**C:** Pipeline transfer and separate canal for navigation only (300 Ml/d)	**D:** SRO fully restores the Cotswold canals both for navigation and for a water transfer	**F:** SRO restores sections required for transfer, CCT restores other sections required for navigation	**I:** Water transfer occurs after development of canal (costs and benefits for transfer only)	**C:** Pipeline transfer and separate canal for navigation only (500 Ml/d)	**H:** SRO fully restores the Cotswold canals both for navigation and also for a water transfer
Present Cost Best Estimate (CAPEX+OPEX)	£777.23m	£997.10m	£962.92m	£129.96m	£907.20m	£1,172.99m	£1,007.21m	£782.56m	£1,127.06m	£1,593.41m
Present Carbon Cost	£85.95m	£119.67m	£93.88m	£17.83m	£103.78m	£100.24m	£100.48m	£88.30m	£137.50m	£165.25m
Present Benefits										
Recreation, tourism, volunteering, and land value	-£0.51m	-£0.51m	£16.71m	£82.24m	£81.85m	£81.37m	£81.37m	-£0.43m	£81.85m	£81.13m
Carbon Sequestration	£0.05m	£0.05m	£0.54m	£0.87m	£0.66m	£0.93m	£0.93m	£0.23m	£0.66m	£0.94m
Natural Hazard Regulation	£0.39m	£0.39m	£0.48m	£0.24m	£0.75m	£0.61m	£0.61m	£0.32m	£0.75m	£0.84m
Agriculture	-£0.04m	-£0.04m	-£0.08m	£0.00m	-£0.04m	-£0.08m	-£0.08m	-£0.02m	-£0.04m	-£0.12m
Total Present Benefits	-£0.11m	-£0.11m	£17.64m	£83.34m	£83.21m	£82.82m	£82.82m	£0.08m	£83.21m	£82.78m
Net Present Cost (NPC)	£1,148.96m	£1,564.05m	£1,434.89m	£142.66m	£1,291.63m	£1,628.90m	£1,423.54m	£1,271.99m	£1,706.73m	£2,342.76m
% of Scenario B	100%	136%	125%	12%	112%	142%	124%	111%	149%	204%

Note: Costs included within this table have been developed for the comparison of shortlist options only and may not reflect final Gate 2 costs reported elsewhere.

Figure 4.1: Impact of low, central, and high benefit scenarios upon net present costs



A central benefit scenario has been used for the results summarised above. Figure 4.1 shows the sensitivity of those results to high and low benefit scenarios. The graph shows that a separate canal for navigation and pipeline for transfer, is better value than an integrated transfer/navigation solution, irrespective of the benefit scenario used. It also indicates that there may be an economic case for restoring the canal, depending upon how you value the benefits, but the analysis suggests that it will be better value to develop the transfer and canal restoration independently.

Potential local economic benefits have not been included in the assessment as the appraisal has been undertaken from a national viewpoint, but high-level review indicates that there could be a potential local benefit value of £78.3m. Sensitivity testing indicates that inclusion of this benefit would reduce the %difference to Scenario B figures given in the table by around 6% for options that include canal restoration and would not materially affect the overall conclusions of this study.

Table 4.4: Potential Futures – Results Summary

Potential future scenario	Navigation	Water Transfer	Summary of Results
A: Do nothing	No navigation	No STT water transfer	The assessment process has not identified any costs or benefits associated with maintaining the status quo. However, there is an identified need for additional water resources to serve the south east of England that could be partially solved by a transfer from the River Severn to the River Thames and therefore failure to pursue this option would reduce the water resources options available and potentially increase the costs of resolving the predicted deficit.
B: STT piped connection only	No navigation	Pipeline water transfer between the River Severn and River Thames (300 or 500 Ml/d)	The 300Ml/d Scenario B has the lowest monetised assessment except for Scenario's A and G (which do not provide a water supply transfer). Although the monetised benefits are far lower than other scenarios, they are outweighed by the lower costs of delivering the transfer scheme. The 500Ml/d scenario B has a 36% higher NPC for a 66% increase in capacity. The scenario performs well in the qualitative assessment.
C: Two connections: STT piped connection and canal connection is restored (but only for navigation)	Navigation occurs (CCT funded)	Pipeline water transfer between the River Severn and River Thames (300 or 500 Ml/d)	The NPC for Scenario C indicates an increase of 12% for 300Ml/d capacity compared with Scenario B. Scenario C performs well in the water supply resilience assessment but poorly in the qualitative environmental assessment against INNS, water quality and geomorphology criteria. Compared with other scenarios that enable navigation, Scenario C, (which provides a separate canal for navigation and pipeline for transfer) has a lower NPC than Scenarios D and F (that provide an integrated navigation and transfers solution)
D: STT canal connection (SRO funded transfer and navigation)	Navigation occurs (SRO funded)	Raw water transfer (300Ml/d) is achieved through a series of canal pounds and pipelines	Scenario D has the highest NPC of the options that deliver a 300Ml/d transfer, despite inclusion of the benefits associated with canal restoration. Performs poorly in the water supply resilience assessment and moderately in the qualitative environmental assessment.
E: Canal restored for transfer only (no navigation)	No navigation	Raw water transfer (300Ml/d) is achieved through a series of canal pounds and pipelines	The NPC for Scenario E is 25% higher than the 300Ml/d pipeline transfer (Scenario B), despite the higher benefit value. Water supply resilience is slightly improved compared with scenarios that integrate transfer and canal restoration for navigation and the scenario performs moderately in the qualitative environmental assessment.
F: SRO restores sections required for transfer, CCT restores other sections required for navigation	Navigation occurs (CCT funded)	Raw water transfer (300Ml/d) is achieved through a series of canal pounds and pipelines.	The NPC for Scenario F is 24% higher than a pipeline only transfer (Scenario B); In this scenario it is assumed that the restoration of pounds not needed for transfer would be achieved by CCT at some point in the future, and this is included in the benefits assessment but doesn't outweigh the overall cost. Performs poorly in the water supply resilience assessment and moderately in the qualitative environmental assessment.
G: Canal restoration for navigation only	Navigation occurs (CCT funded)	No STT water transfer	The NPC for Scenario G is the lowest of the scenarios considered as it only includes infrastructure required to restore navigation, not for water transfer. Sensitivity analysis shows that depending upon the valuation of benefits the NPC may be negative (i.e., there could be a net economic benefit from canal restoration). The qualitative environmental assessment raises concerns around INNS, water quality and geomorphology criteria. Water supply resilience is not applicable to this scenario.
H: Two connections: STT piped connection and canal connection is restored	Navigation occurs (SRO funded)	500Ml/d transfer total. Raw water transfer (300Ml/d) is achieved through a series of canal pounds and pipelines and an additional 200Ml/d pipeline	Scenario H would effectively require two schemes, with their related costs and benefits, to transfer 500Ml/d. It has the highest monetised assessment, performs poorly in the resilience assessment, and does not perform well in the qualitative assessment.
I: Canal restoration delivered first by CCT with bridges and other canal infrastructure sized to facilitate later addition of water supply transfer for 300Ml/d by the SRO	Navigation occurs first (CCT funded)	Raw water transfer is achieved through a series of canal pounds and pipelines. (Only pipelines and associated infrastructure are funded by the SRO)	The NPC for Scenario I is 11% higher than the direct pipeline transfer (Scenario B), assuming that the restored canal was designed to facilitate later addition of a transfer (e.g., amendments to bridges over the canal are implemented). It is noted that there is no certainty at the current time that the canal will be fully restored and thereby facilitate implementation of this scenario. The scenario performs poorly in the water supply resilience assessment and moderately in the qualitative environmental assessment. The assessment assumes that the costs and benefits brought about by restoration of the canal to full navigation would have been realised prior to construction of the transfer infrastructure and therefore only additional costs and benefits are included.

4.3 Potential Futures Conclusions

The conclusions indicate that any benefits gained by integrating canal restoration with a water supply transfer are outweighed by the impacts and costs. Furthermore, a direct pipeline is likely to be the only cost-effective solution for transfers larger than 300 Ml/d. These conclusions validate the selection of the preferred water supply solution identified at the shortlist stage, of a direct pipeline from the River Severn to the River Thames.

5 Conclusions and Next steps

Based on the Gate 2 assessment a preferred Interconnector option has been selected that would transfer water from the River Severn to the River Thames through a direct pipeline from Deerhurst to Culham (Option 1 Pipeline).

It performed better overall in the qualitative environmental, resilience and natural capital assessments including criteria relating to the impact of invasive non-native species (INNS); construction and operation of the option; and flood zone impact.

The direct pipeline option had the lowest capital and operating costs and the lowest Net Present Cost (i.e., the whole life cost added to monetised social, natural capital and carbon impacts and benefits), being approximately 25% lower on this measure than other options that would reconstructed sections of the Cotswold Canals.

The monetisation of benefits undertaken in this appraisal show that, whilst the options involving the canal result in greater potential to deliver benefits, the additional whole life financial costs of the canal options are far higher than the monetised value of the benefits indicating that selecting an option that utilises sections of canal for water transfer would not provide good value.

The validation stage reviewed the costs, impacts and benefits of a fully navigable canal alongside a water transfer and concluded that any benefits gained by integrating the water supply transfer with a fully navigable canal are outweighed by the impacts and costs.

Additionally, the draft WRSE regional plans have indicated the requirement for a 500Ml/d capacity transfer. The maximum transfer capacity of options utilising reconstructed canal sections is limited to 300Ml/d. A canal-based option could not meet the indicated WRSE requirement for a 500Ml/d capacity transfer.

Therefore this report recommends that Option 1 Pipeline is taken forward for inclusion in the Gate 2 submission to RAPID. This option characterises a direct pipeline option for comparison against materially different options that utilised the Cotswold Canal corridor.

Whilst this reflects the findings for Gate 2, before any final decisions are made and as part of any future phases of the STT development, the preferred option and other alternatives considered will be subject to further engagement and consultation with stakeholders.

It is envisaged that the STT project will progress to Gate 3 and the following activities are proposed to further support the option selection during Gate 3:

- Further consultation with the EA and other regulators on the methodology and outcomes of this option appraisal study
- Further review of the alternative direct pipeline options identified at the longlist stage including land referencing and desk top geotechnical studies to inform refinement of the pipeline route selection
- Public consultation on this study and the various pipeline transfer routes
- Further development of other technical aspects of the scheme design, such as the approach to treatment and resilience to rising sea levels generated by climate change, although these issues are not expected to materially affect option selection.
- Back-checking of this report when the wider STT system benefits study is completed and as more information becomes available in Gate 3 (such as responses to consultations)