Thames Water WRMP19 Supply Options

Cotswold Canal Transfer - Methodology Working Paper

October 2015

Thames Water Utilities Limited

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Mott MacDonald
CASCADE

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Contents

1 Introduction

The purpose of this working paper is to set out the proposed method and high-level programme for the Feasibility Study of the Cotswold Canal Transfer. This paper is to facilitate early project engagement with Thames Water Utilities Limited (TWUL) and key stakeholders, allowing feedback to be incorporated in sufficient time such that the agreed project objectives are met without delay to the programme.

This working paper expands upon the content of the Project Brief (C855.C.OP1.60), which was updated following the kick-off meeting held on 2nd September 2015. Since that kick-off meeting, much information has been received and reviewed by the project team. However, no information has been gathered which requires any aspect of the brief to be modified.

The content of the working paper has been shaped by our review of available information from previous studies, discussions with the Cotswold Canal Trust (CCT) and from a site visit to the canal.

The output of this study will be a report recommending several transfer arrangements via the canal that have been identified as optimal in terms of cost and risk. A maximum feasible transfer capacity will be identified. This will enable the canal transfer option to be compared to other (pipeline) transfer options. This comparison will be undertaken as a separate study, which is not discussed in this working paper.

2 Study Scope & Approach

2.1 Study Scope

The working paper has been informed by the Project Brief (C855.C.OP1.60). The agreed objectives in the Project Brief were:

Table 2.1: Agreed Study Objectives

Reference	Objective
O1	Agreement with CCT and CRT over scope of this review (constraints and risks to be quantified, analysis to be undertaken)
O2	Identification of capacity constraints and determination of capacity limit related to each, leading to a Cotswold canal transfer capacity limit to be used in the STT feasibility report
O3	Identification of key construction and operational risks
O4	Investigation of alternative operational regimes to combine transfer and navigational uses
O5	Development of canal transfer scheme CAPEX and OPEX costs for up to three transfer capacities (to be agreed)

Source: Project Brief (C855.C.OP1.60)

The agreed scope / study activities in the Project Brief were:

Table 2.2: Agreed Study Scope

Reference	Scope / Study Activity
S1	Review of previous work completed including information from CCT and CRT
S2	Agreement of canal operational criteria with CRT, CCT and EA to inform canal design
S3	Engineering appraisal of canal options and identification of preferred option(s) to proceed with modelling
S4	Selection of modelling assessment to inform capacity constraints
S5	Development of high-level capital and operational cost estimates
S6	Development of risk register
S7	Review findings with Cotswold Canal Trust and independent consultant (CRT)

Source: Project Brief (C855.C.OP1.60)

2.2 Key Stakeholders

The key stakeholders relevant to the Feasibility Study of the Cotswold Canal Transfer are listed in Table 2.3 below:

Table 2.3: Key Stakeholders

Stakeholder	Relationship to Project
Thames Water Utilities Limited (TWUL)	Seeking to identify, as part of the Water Resources Planning process, the best value long term water resource solutions to address projected resource deficits in London and potentially also the wider south east of England. This includes assessing opportunities for water transfer between the River Severn and River Thames.
Cotswold Canal Trust (CCT)	Long term objective of restoring the Cotswold Canal for navigation. Has

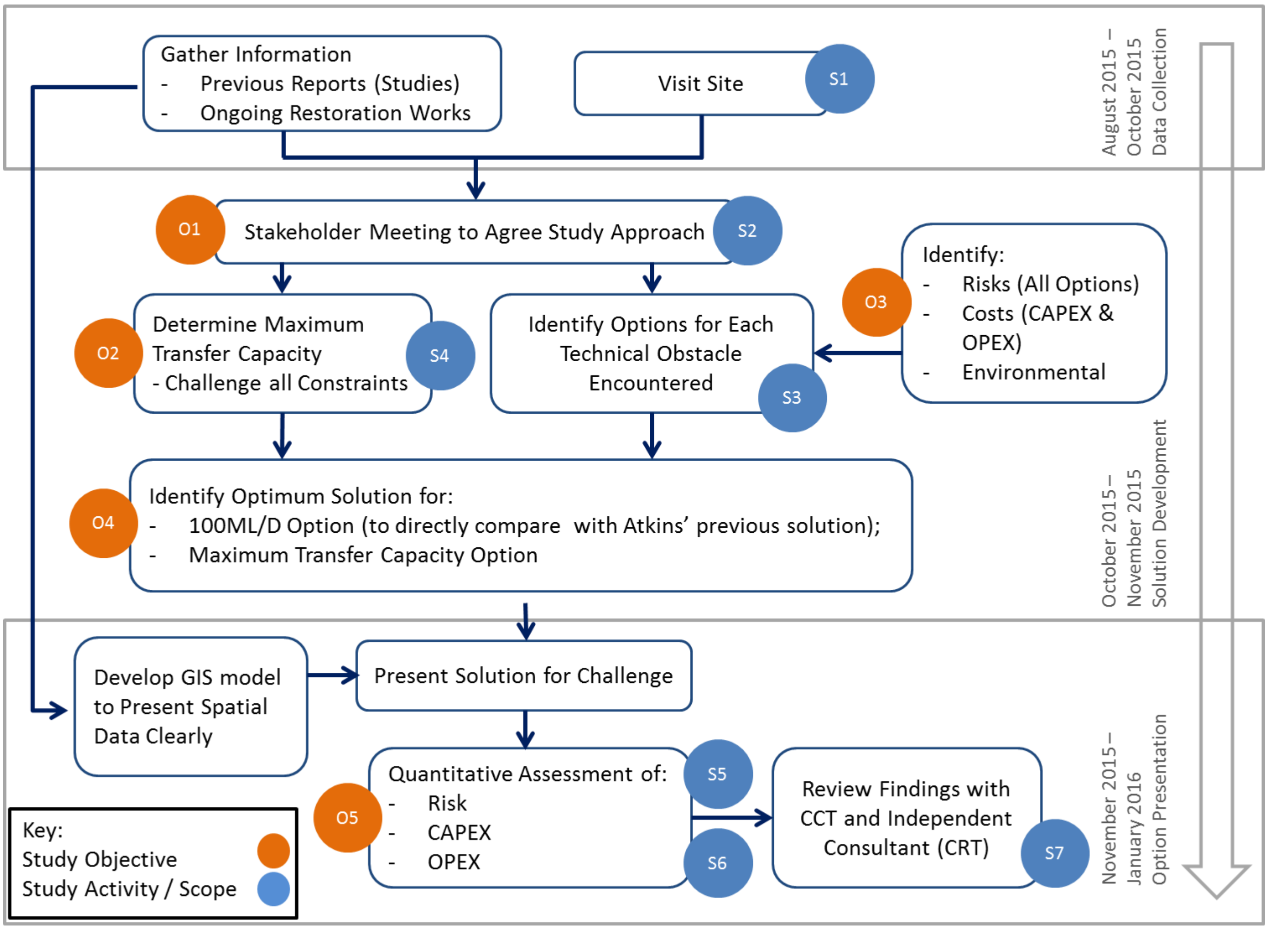
Stakeholder	Relationship to Project
	carried out rehabilitation works at many sites along canal, and has secured funding to restore large sections within the Severn catchment (western end). Owns land along original route of canal.
Canals and Rivers Trust (CRT)	Charitable trust set up to look after the waterways of England and Wales. Able to advise on design criteria for restoration of canal.
Environment Agency (EA)	Will review and provide feedback on study outputs. Provider of appropriate permissions to carry out activities associated with the project, including rehabilitation works, water abstraction and water transfer.

Source: Mott MacDonald

2.3 Study Approach

With reference to the agreed study objectives and scope items (refer to Tables 2.1 and 2.2), the approach to this study is set out in the flow chart shown in Figure 2.1.

Figure 2.1: Study Approach Flowchart



Source: Mott MacDonald

As noted in the flow chart it is propose to divide the study into three distinct phases:

- 1. Data Collection Phase (completed):
  - Kick-off meeting with TWUL;
  - Review of applicable previous studies;
  - Site visit and meeting with CCT;
  - Development of detailed study plan;
  - Creation of working paper for discussion at Stakeholder meeting on 6th November 2015;
- 2. Solution Development Phase:
  - Engage internal specialists to carry out technical assessments (tunnelling, pumping, hydraulics);
  - Determine maximum transfer rate relating to each technical constraint;
  - Propose sub-options for each technical obstacle encountered;
  - Compile comprehensive risk register for each sub-option;
  - Identify optimum solution for (i) 100ML/D option to compare directly with previous Atkins study; (ii) 'maximum credible' capacity option, assuming navigation is allowed during transfer; (iii) 'maximum credible' capacity option, assuming navigation is restricted during transfer (potentially allowing higher velocities);
- 3. Option Presentation Phase (Quantitative assessment of options taken forward from previous phase):
  - Develop GIS model to present spatial data and inform costing;
  - Environmental assessment and costing;
  - Populate comprehensive risk register for the proposed transfer arrangement;
  - Compile cost (CAPEX) buildup using F909 format;
  - Compile OPEX cost buildup;
  - Undertake carbon estimates for recommended options;
  - Creation of Canal Transfer Capacity and Scheme Elements Report;
  - Review study findings with TW, CCT and CRT.

2.4 Schedule of Key Dates

The key dates relevant to the Feasibility Study of the Cotswold Canal Transfer are listed in Table 2.4:

Table 2.4: Schedule of Key Dates

Item	Date
Project Kickoff Meeting	2nd September 2015
Canal Site Visit	30th September / 1st October 2015
Submission of Cotswold Canal Transfer Working Paper (to TWUL)	16th October 2015
Stakeholder technical group meeting	6th November 2015
Submission of Interim Report with technical details of the proposed transfer arrangement	15th December 2015
Compile Cost (CAPEX / OPEX) + Carbon Estimates for recommended options, incorporating comments from stakeholders on interim report, issue final report with sufficient details of recommended options to allow comparison with other transfer options	Spring 2016

Source: Mott MacDonald

3 Data Collection

3.1 Review of Previous Studies

The concept of transferring flow from the Severn to the Thames via the Cotswold Canal has been investigated previously by a number of organisations. This includes parties working on behalf of TWUL, including Atkins (2013) and Jacobs (2010). In addition, the CCT has commissioned several studies relating to rehabilitating the canal for the purpose of navigation (without transfer).

The studies which have been reviewed by the project team to date are listed in Table 3.1, along with some comments as to their relevance:

Table 3.1: Relevant Studies Reviewed

Study Details	Comments	Relevance
Severn Thames Transfer Unsupported Cotswold Canals, London and SWOX options (RWT-STT-USC-01, 02) Atkins Ltd., November 2013	Work forms the basis of our study. Extensive report commissioned on behalf of TWUL. Two transfer options based on a maximum transfer capacity of 100M/D and 50ML/D were assessed in terms of technical risks, cost and environmental impact.	High
Technical Note: Severn Thames Transfer via the Cotswold Canal Atkins Ltd., July 2012	Technical note examining the feasibility of transferring water using Cotswold Canal. The note concludes that transfer options greater than 100Ml/d should be excluded on technical grounds.	High
Severn – Thames Transfers via the Cotswold Canal Jacobs Ltd., May 2010	Short report commissioned by TWUL to justify further investigation into the canal transfer. Includes estimates of CAPEX construction costs and OPEX energy use for pumping (both with/without tunnel transfer). Describes status of ongoing rehabilitation work.	High
Report into the Feasibility of Restoring the Cotswold Canal British Waterways, July 2001	General high level feasibility report. Considerable sections on environmental impacts and Cost/Benefit analysis considering social benefits.	Medium
Restoration of the Thames and Severn Canal in the Central Section Halcrow Ltd., February 1996	Report commissioned by the CCT assessing rehabilitation of the canal between the Coates portal and Spine Road at the Cotswolds Water Park. Contains assessment of technical risks, costs, environmental impact and water management. Appendices contain detailed engineering drawings of a number of canal crossing structures.	High
The Stroudwater and Thames & Severn Canals: Feasibility Study of Restoration Aktins Ltd., June 1992	Feasibility study commissioned by the Stroud District Council on restoring the canal between Stonehouse and the Daneway Portal. Presents a comprehensive schedule of conditions of locks, pounds, bridges, obstacles and buried services. Contains series of plans along the canal but these are likely to be out of date, superseded by subsequent rehabilitation works and studies. Contains cost buildup and considerations for water supply.	Low
Restoration of the Thames and Severn Canal in the Cotswold Water park Halcrow Ltd., December 1991	Report commissioned by the CCT assessing the rehabilitation of the canal between the Spine Road in the Cotswolds Water Park and the termination point at Inglesham. Contains assessment of technical risks, high level costs, environmental impact and water management. Appendices contain detailed	High

Study Details	Comments	Relevance
	engineering assessment of restoration of the canal and associated structures.	
Preliminary Engineering Report on the Feasibility of Restoring the Canal to Through Navigation Freeman Fox Blaine & Partners, August 1976	Report commissioned by the Stroudwater, Thames & Severn Canal Trust focused on engineering aspects of removing blockages. Includes detailed text description of interior of Sapperton tunnel, including chainages and dimensions. Report provides high-level estimates of water requirements and groundwater availability at tunnel, but is likely to be superseded by subsequent completed rehabilitation work. No detail of cost estimate.	High (To inform tunnel assessment only)
Taunton, Sapperton Tunnel on the Thames and Severn Canal J Taunton, 1870	Paper describing construction of Sapperton Tunnel. Includes long section of tunnel indicating structural arrangement and surrounding geology.	Medium (To inform tunnel assessment only)
Restoration Phase 2 Environmental Impact Assessment, Cotswold Canal Trust, November 2013	Provides detailed information on the current condition of the canal from Cerney Wick to Lechlade	High

Source: Mott MacDonald

The work undertaken by Atkins Ltd. in WRMP14 (Report RWT-STT-USC-01, 02) forms the basis of our study. MML will robustly challenge the outcomes of this study, amend where appropriate and further develop that work. Atkins developed two transfer options based on a maximum transfer capacity of 100M/D and 50ML/D. The transfer capacity was limited to 100ML/D by the following considerations:

- Transfers in excess of 100 Ml/d were calculated as likely to exceed 2 km/hour anticipated to be the maximum threshold for navigation under narrow bridges (following British Waterways guidelines);
- Transfers less than100ML/D were considered to require smaller pumping stations and associated infrastructure, which would have less impact on the heritage landscape along the scheme.

The project team will challenge these constraints and progress an option for transfer of greater than 100ML/D if found feasible, as described in Section 4.2 below.

3.2 Site Visit

The project engineers met with representatives from the CCT to inspect the route of the Cotswold Canal. A number of critical structures along the proposed route were visited. Sites to the east of the Sapperton Tunnel were visited on 30th September 2015 and those on the west visited on 1st October 2015.

On 1st October the existing CRT pumping station at Gloucester was also visited by the team, where discussions were held with CRT representatives relating to its operational constraints.

Comprehensive notes from the site visit, including comments from Ken Burgin of CCT, can be found in Appendix A.

4 Solution Development – Considerations

4.1 Concept

The development of the canal transfer solution will focus on transferring flows from the Severn to the Thames by means of:

- Abstraction of River Severn water using an intake pump station at Gloucester, discharging into Gloucester Docks;
- Transfer by gravity from the docks, via the Gloucester & Sharpness Ship Canal to Saul Junction (where it connects to the Stroudwater Navigation);
- Pumping from the Gloucester Sharpness Ship Canal into the Stroudwater Navigation at Saul junction;
- Transfer using the Stroudwater Navigation from Saul Junction to Stroud, using pumps and pipeline buried in the tow-path to bypass locks / sets of locks;
- Transfer using the Thames and Severn Canal from Stroud to the Sapperton Tunnel western portal at Daneway, using pumps and pipeline buried in the tow-path to bypass locks / sets of locks;
- Transfer using the Sapperton Tunnel from Daneway to Coates either using the canal for conveyance or using a pipeline in the bed of the tunnel;
- Transfer by gravity using the Thames and Severn Canal from Coates portal of the Sapperton Tunnel to Inglesham (the existing end of the canal);
- Discharge into the Thames, either with an outfall at Inglesham or a pump and pipeline to Culham for all or part of the transfer flow
- Rehabilitation of canal sections to be used for water transfer where not already rehabilitated for navigation;
- Rehabilitation of canal sections for navigation alongside piped sections of transfer.

4.2 Transfer Capacity

In the WRMP14 Options Appraisal two transfer capacities were assessed: 50Ml/d and 100Ml/d, with 100Ml/d considered as a maximum due to concerns about high canal navigation velocities and the difficulty of locating large bypass structures in a sensitive landscape. In Jacob's 2010 feasibility study a capacity of 240Ml/d was considered viable, constrained by a 2km/hr velocity limit for navigation at bridges. A 300Ml/d transfer is also referred to in the Jacob's report from the Unsupported Transfer Report and 400Ml/d adopted in the NRA's National Water Strategy in 1994.

Constraints on transfer capacity will be reviewed and investigated at the start of the study with respect to:

- Navigation velocity;
- Bank and bed erosion;
- Land acquisition and planning constraints relating to bypass structures;
- Freeboard (where canal already rehabilitated is intended to be used for transfer);
- Environmental Constraints and Mitigation Measures;
- Others (such as obstacles such as the Sapperton Tunnel).

The implications of an option that would impose navigation restrictions along particular sections of the canal (e.g. Sapperton Tunnel) during periods of transfer will also be investigated if this would allow a greater maximum transfer capacity.

Because capital cost for this scheme will not scale linearly with transfer capacity the larger transfer options are likely to be more feasible. The feasibility of transfer capacities in the range of 100Ml/d to 300Ml/d will be considered.

Three capacity options will be carried forward for solution development, which are anticipated to be;

- the 100Ml/d capacity option as a baseline comparison;
- a 'maximum credible' capacity option, assuming navigation is allowed during transfer;
- a 'maximum credible' capacity option, assuming navigation is not allowed during transfer (potentially allowing higher velocities).

Note it is considered that "maximum credible" capacity is defined as that which does not include significant structural adjustments or tunnelling under bridges (though would include hollowing of the tow path under the bridge if necessary).

4.3 Canal Water Resources

A high level assessment of canal losses and water resource requirements will be made to understand:

- seepage and losses during transfer to determine net transfer capacity to the Thames;
- water requirements outside of transfer periods required for navigation;
- whether the transfer infrastructure is the most appropriate means of providing water resource for navigation at times of no transfer or whether other resources e.g. gravel pit storage, would be required;
- what project risks may be associated with providing sufficient water to allow navigation.

Water use and losses are understood to primarily comprise seepage, evaporation and locking losses. These will be estimated from a range of sources such as the historic water resource for the canal, previous studies into canal restoration, discussion with CCT on forecast navigational use and will be dependent on the canal lining option assumed.

4.4 Canal Design

The canal cross-section is already largely defined by the dimensions of the existing canal. Aspects of canal design to be developed for the solution comprise:

Canal lining: The existing canal is understood to be at least partially lined with puddle clay, though documentary evidence of this limited. The Sapperton Tunnel head pound, particularly east of the Coates portal is reported to have had leakage problems throughout its life and some sections were subsequently concrete lined; however it is understood that this did not significantly reduce the leakage problem. The condition of any clay lining has not been confirmed and is anticipated to have been damaged by vegetation growth in many places, though some sections of canal do hold water. Having reviewed the geology along the canal alignment, MML will consider options for canal lining which are expected to comprise: (i) a new clay lining including some re-working of the existing clay; and (ii) a geomembrane liner with a surface protection such as concrete, though alternatives will be considered.

Canal hydraulics: Basic hydraulic calculations will be carried out to check: (i) head loss across longest pounds; (ii) bridge hole hydraulics to limit velocities for navigation; (iii) requirements for additional freeboard on Gloucester and Sharpness Canal which already has tight constraints on operating water level.

Bypass structures: MML will review and optimise hydraulic structures for bypassing locks on the eastern side of Sapperton Tunnel to assess if more efficient (lower cost) structures are feasible.

Bridge structures: Review and optimisation of culverts at bridge holes will be carried out to assess if more efficient (lower cost) structures are feasible.

Habitat and biodiversity mitigation: MML will assess the scope of works that will be required to mitigate the impact on the existing habitat and biodiversity along the canal alignment affected by the scheme.

4.5 Route Constraints

Environmental constraints mapping is being carried by Cascade which will inform solution development. Impacts on the scope of the scheme are likely to include:

- Habitat compensation measures;
- Measures to control invasive species;
- Water quality constraints, in particular the chosen discharge location.

Land ownership will be divided into broad categories for the purposes of estimating land purchase costs and compensation. Sections of the canal route are under the control of CCT, but significant sections (mostly agricultural land) are understood to be in private hands. There are also sections where there may be mineral extraction benefits that can be exploited in conjunction with the landowner. It is expected that there is only one property on the route that would need to be purchased. Land values will be estimated using the Thames Water estimating system.

Particularly in the western section of the Thames and Severn Canal there are a number of services crossing the canal and in some places running along and underneath the towpath. Where a large transfer pipeline is to be laid in the towpath this may require a combination of solutions. Some details of these services have already been provided by CCT. Outline solutions for the key services clashes will be determined in order to improve the accuracy of the costing exercise.

4.6 Abstraction

The solution previously developed by Atkins for abstraction from the River Severn is based on siting an intake pump station at Gloucester Docks at an existing gap in dockside buildings to the north of the existing CRT pump station. The pump station will abstract from an arm of the Severn and discharge into the Gloucester dock basin. From the basin water would flow down the Gloucester and Sharpness Canal towards Saul junction.
A number of issues to be considered and solutions found include:

- Pumping at the CRT pump station is limited to 12 hours/day over high spring tides due to high sediment concentrations. The transfer solution will need to consider how to overcome this limitation e.g. through canal-side storage, increased dredging of the dock basin or re-location of the abstraction point;
- Limited space for construction of an intake structure at Gloucester docks.
- The range of operating water levels on the Gloucester and Sharpness Canal is understood to be limited and modification of canal embankments to raise freeboard may be required.

4.7 Western section (Saul Junction to Daneway Portal)

Throughout the western section the main focus of solution development will be to determine the optimum arrangement between pipeline and canal for water transfer. The WRMP14 solution comprised pumps and pipeline at eight locations to bypass locks or sets of locks. This will be reviewed and alternative arrangements involving fewer pump stations will be considered in terms of cost and practicality (flexibility, planning constraints etc.). The use of longer pounds to affect open channel transfer will also be challenged considering the operational risks of such an arrangement.

Other aspects of solution development on the western section will be:
- Update previous solution to take account of restoration works carried out and underway by CCT;
- Update previous solution to take account of CCT plans for Phase 1B of its restoration scheme and planned developments at Brimscombe port;
- Practical solutions for overcoming key obstructions (services, key road crossings);
- Restoration of non-restored canal sections.

4.8 Sapperton Tunnel

For the Sapperton Tunnel three primary options will be considered;
- Tunnel restoration with a transfer pipeline in the canal bed;
- Tunnel restoration with transfer via the open canal (likely requiring navigation restrictions during transfer);
- Pipeline over watershed (anticipated to be discounted on grounds of OPEX cost).

Options for tunnel restoration will be considered taking account of:
- the heritage value of the existing tunnel lining;
- potential conflict between retaining original brick lining and meeting modern safety standards;
- restoration of ventilation shafts and ventilation requirements for diesel powered craft;
- structural issues with the tunnel through the Fullers Earth sections;
- groundwater seepage into and out of tunnel.

Assumptions will be made about geotechnical conditions with reference to existing geotechnical information and conditions reported in previous studies. A support and lining option and construction methodology will be developed for the oolitic limestone section, un-collapsed Fuller Earth sections and collapsed sections. Construction access constraints at portals will also need to be considered.

4.9 Eastern Section (Coats Portal to Lechlade)

On the eastern section the main aspects of solution development include:

- Pragmatic arrangements at key obstructions (Smerill and River Churn aqueducts, key road crossings);
- Restoration of non-restored canal sections and structures;
- Developing an optimised bypass structure at locks and bridges;
- Option for storage near Latton for canal operation and transfer resilience.

4.10 Discharge Arrangement

Options to be considered for discharge comprise:

- a discharge structure at Inglesham;
- a transfer pump station and pipeline to Culham with discharge structure at Culham;
- a combination of the two arrangements above.

The preferred option is anticipated to be determined by water quality constraints, which will be assessed in other studies as part of the WRMP19 Supply Options programme.

5 Transfer Arrangement Optimisation

5.1 Optimisation Process

Once all discrete obstacles and constraints have been studied in sufficient detail during the Solution Development Phase, the optimum arrangement for the canal transfer system will be identified.

The determination of the optimum arrangement will be done by a qualitative assessment of the balance of cost and risk associated with capital delivery and operation for each sub-option. Full costing using the Thames Water estimating system will not be developed for each sub-option; instead high level estimates of cost will be used to inform judgements.

The qualitative assessment of sub-options will be recorded in a manner consistent with other feasibility reports. Evidence supporting each decision as to a preferred sub-option will be clearly stated.

The identification of optimum transfer arrangements will be done considering the maximum identified transfer capacity, which as noted above is expected to represent the most viable scheme. This arrangement will be used as the basis for detailed costing, both for the maximum credible transfer capacities (with and without navigation restrictions during transfer) and the 100ML/D capacity, as described in Section 6 of this document.

5.2 Risk and Opportunities

Assessment of the comparable risk and opportunities of each sub-option will form a critical part of the transfer optimisation process. Throughout the solution development phase, risks (and opportunities) associated with all potential sub-options will be populated on a risk register. This will include an internal risk workshop to be held with all members of the project team, including specialists. Risks will be given a consequence category, and the most feasible mitigation for each will be identified.

Once the optimum transfer arrangement has been identified, the risk and opportunity register will form a critical output for enabling comparison between the Cotswold Canal Transfer and the other large scale water resource options currently being investigated, in particular the alternative of a pipeline transfer.

The additional benefits and opportunities associated with having reopened a historic, navigable canal will be captured within the register. To ensure all opportunities are captured, the project team will liaise with the CCT and CRT and invite their comments on the risk and opportunity register.

5.3 Output

The solution development activities and analysis, and an outline of the optimum transfer arrangement will be described in an interim version of the feasibility study report, which is to be issued to Thames Water on the 15th December 2015. This will include an audit trail of the optimisation process with evidence supporting each decision made. Outline drawings of typical structures giving key dimensions will be attached to this report, including:

- Pumping Stations and Rising Mains;

- Canal Cross Section;
- Sapperton Tunnel rehabilitation cross section;
- By-pass arrangements around locks.

The risk register will also be attached, along with mapping generated by the GIS model.

Quantitative assessment of CAPEX and OPEX Cost and Risk relating to the optimum arrangement will be undertaken from the start of January to Mid-February 2016. This work is described further in Section 6 below.

6 Quantitative Assessment of Cost and Risk

Once the optimum transfer arrangements have been identified, work will commence to develop more detailed capital and operating costs using an approach that is consistent with that adopted for other large scale water resource options.

These values will be developed for the maximum identified transfer capacity (with and without navigation restrictions), and a transfer capacity of 100ML/D. This latter transfer capacity is to be costed so that this study can be directly compared to that previously undertaken by Atkins, who costed a 100ML/D canal transfer option.

This work is programmed to be undertaken from the start of January 2016 to Mid-February 2016. The output will be updated F909 and F910 spreadsheets detailing the build-up of all costs and risks, and an update to the Feasibility Report issued as interim in December 2015.

Further detail on the process of estimating capital and operational cost and risk is noted below.

6.1 Capital Cost Valuation

The assessment of capital cost will be undertaken through the completion of an F909 spreadsheet, which is used to input into Thames Water's Asset Planning System. This is the same process as undertaken by Atkins for WRMP14 and will also form the basis for WRMP19 costings.

The F909 spreadsheet developed by Atkins will be used as a basis for this costing exercise. MML will review and update this to reflect the recommended options.

Many construction activities which form part of canal rehabilitation are not anticipated to have been regularly undertaken by Thames Water, so standard cost curves from Thames Water's Engineering Estimating System (EES) may not apply. The cost for these items has previously been estimated by Atkins, with text included with each item to explain the value obtained. We will challenge these values and update them where appropriate. This will be done by obtaining costing data from recent projects involving the CCT, CRT and MML, adjusted to suit for inflation, location or other applicable influences.

For construction activities which are common to Thames Water but made complex by the unusual constraints associated with the canal, we will use the applicable standard Thames Water EES cost curves modified through application of an appropriate complexity factor. An example activity is the installation of a large diameter pipe in a tow-path or under a bridge, where the standard cost curve relates to pipelaying in a road or field. Identification of the correct complexity factor will be done in discussion with Thames Water, as well as the MML teams undertaking parallel studies of the other water resource options to ensure consistency of costing approach. The cost of the complexity factor assigned to activities of particular importance will be sense-checked by building up costs or comparison to recent projects.

The F909 spreadsheet will have sufficient detail to identify work items which are required for navigation but not transfer. This primarily relates to the rehabilitation of canal lengths and structures which will be bypassed by pipework, particularly locks.

6.2 Operational Cost Valuation

As with Capital Cost Estimation, Thames Water have developed a spreadsheet for the determination of expected operational cost for any scheme under development. This costing template is currently being reviewed and updated as part of a separate work package. A canal transfer is anticipated to have unusual implications for operational costing, primarily as:

- There will be scope to agree with the CCT on how operational and maintenance costs are to be divided between TWUL and the CCT (as well as other stakeholders using the canal) relating to assets required for navigation;
- Assets to be operated will be outside the normal TWUL operational area;
- The transfer will not operate at all times.

MML will discuss with CCT which maintenance activities relating to the canal would be undertaken by them to ensure navigation. We will agree with Thames Water a factor to be applied to OPEX costs to account for the location of assets, particularly pumping stations.

The proportion of time during which the transfer will be operated will be assessed as part of the operating strategy for the transfer (which is covered by a separate work package).

6.3 Capital Delivery and Operational Risk Valuation

It is expected that the value of risk relating to the capital delivery of this transfer option will be large in relation to the estimated construction cost. This is due to the need to:

- Arrange a pumping station within the urban Gloucester environment and potentially a reservoir in the vicinity, which can be expected to lead to some public opposition;
- Interface with stakeholders already using the Gloucester and Sharpness canal, particularly Bristol Water and the CRT;
- Rehabilitate pre-Victorian structures throughout the canal, the integrity of which cannot be fully confirmed without exposure of buried / submerged surfaces and intrusive investigations;
- Potentially rehabilitate the Sapperton Tunnel, which passes through widely differing strata and is already collapsed to an unknown extent, although is still considered to have a high heritage value;
- Liaise with and manage a large number of stakeholders who may seek to impose constraints on the scheme development, particularly relating to environmental and heritage issues;
- Consider multiple crossings of key infrastructure (motorways, dual carriageways, railways and MOD pipelines) and interfaces with other utilities (power, water, gas, telecommunications). Some road crossings will need moveable bridges.

There are also many operational risks relating to the canal transfer option which will be recorded in the risk register. At this stage in the screening process risk will be monetised using Thames Water's F910J/K forms which assign a Solution Confidence Grade and a Delivery Confidence grade. These are then used to allocate an allowance for optimism bias and uncertainty in a way that is consistent with that used for other large scale water resource options.

Appendices

Appendix A. Record of Site Visits