Stantec

Hatherton Canal - Water Supply Study

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HATHERTON CANAL - WATER SUPPLY STUDY

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Contents

1	INTRODUCTION	1
1.1	Background	1
1.2	Objective and Scope	1
1.3	Previous Reports	2
1.3.1	Ove Arup (2006)	2
1.3.2	Atkins (2009)	2
1.4	This Report	3
2	HATHERTON CANAL	5
2.1	History of the Canal	5
2.2	Current State	5
2.3	Background to the Proposed Restoration	6
3	PHYSICAL SETTING	7
3.1	Geology	7
3.2	Hydrology	11
3.3	Hydrogeology	15
3.3.1	Aquifer units and properties	15
3.3.2	Groundwater levels	15
3.4	CAMS Status	17
3.5	Anthropogenic Influences	19
3.5.1	Abstractions	19
3.5.2	Discharges	23
3.5.3	Mining	28
4	WATER SUPPLY DEMAND (WSD) ASSESSMENT	30
4.1	Assessment Approach and Model Development	30
4.2	Full Restoration	31
4.2.1	Initial fill volumes	31
4.2.2	Water losses	31

4.2.3 Lockage 32

4.3 Impact of Full Restoration on the Existing CRT Network 35

4.3.1 Additional demand on the wider CRT network as a result of the restoration 37

4.4 Summary of the Potential Water Demand 38

5 WATER SUPPLY SOURCE (WSS) ASSESSMENT 41

5.1 Availability of Water 41

5.2 Assessment Approach 41

5.3 Unconstrained List of Potential Water Sources for the Canal 41

5.3.1 New surface water abstractions 41

5.3.2 Licence trading 42

5.3.3 Groundwater 43

5.3.4 Surface water from residential development 47

5.3.5 Existing highway drains and public water sewers 48

5.3.6 Backpumping 49

5.3.7 Cannock STW 50

5.3.8 CRT, Birmingham Canal Navigations 51

5.3.9 Summary 52

5.4 Constrained List of Supply Options for Full Restoration 57

5.5 Water Source Reliability and Uncertainties 61

6 WATER REQUIREMENT FOR RESTORATION PHASES 63

6.1 Proposed Restoration Phases 63

6.2 Constrained list of Supply Options for Partial Restoration 65

6.2.1 Scenario 1 65

6.2.2 Scenario 2 66

7 CONCLUSIONS AND RECOMMENDATIONS 67

7.1 Conclusions 67

7.2 Recommendations 67

REFERENCES 69

FIGURES

Figure 1.1	Site location	4
Figure 3.1	Bedrock geology	9
Figure 3.2	Superficial geology	10
Figure 3.3	Hydrology and hydrogeology	12
Figure 3.4	Location of proposed canal route, from Sheet 8 of 16 in Arup (2006)	13
Figure 3.5	Location of proposed canal route, from Sheet 9 of 16 in Arup (2006)	14
Figure 3.6	Groundwater levels at Four Crosses	16
Figure 3.7	Groundwater and surface water abstractions	22
Figure 3.8	Discharge consents	27
Figure 3.9	Coal mining areas in relation to the proposed canal route	29
Figure 4.1	Location of CRT lockage data	33
Figure 5.1	Summary of groundwater and surface water abstraction potentially available for water supply	44
Figure 5.2	Table 8.8 from BGS (2000) Report	45
Figure 5.3	Residential development allocation	47
Figure 5.4	Ordnance Survey (1902) map showing relationship between Ridings Brook, Wyrley Brook and the canal	51
Figure 5.5	Constrained options for water source supply (WSS)	60
Figure 6.1	Potential restoration sections	64

TABLES

Table 3.1	Summary of the stratigraphic succession	8
Table 3.2	Summary groundwater level statistics	15
Table 3.3	WFD status for potential impact of groundwater abstraction on local groundwater bodies	17
Table 3.4	Cycle 2 classification for Saredon Brook Surface Water body	18
Table 3.5	Licensed groundwater abstractions within 2 km of the proposed canal route (EA data)	20
Table 3.6	Licensed surface water abstractions within 2 km of the proposed canal route (EA data)	21
Table 3.7	Discharge consents (EA data)	24
Table 4.1	Restoration section volumes	31
Table 4.2	Lining scenarios considered in CRT modelling	32
Table 4.3	Modelled loss rates	32
Table 4.4	Recorded annual lockage data	34
Table 4.5	Estimated annual lockage for the fully restored Hatherton Canal	34
Table 4.6	Results of CRT modelling for Hatherton Canal on the existing CRT Network	35
Table 4.7	Results of CRT modelling for both the Hatherton Canal and Lichfield Canal on the existing CRT Network	36
Table 4.8	Percentage increase in boat movements with distance from the restored canal	37
Table 4.9	Additional lockage demand on the wider CRT network after restoration	38
Table 4.10	Summary of water demand uncertainties	39
Table 4.11	Summary of CRT modelling of potential impacts of restoration	40

Table 5.1	Licenced abstractions and consented discharges within 500 m of the canal	43
Table 5.2	Estimated run-off from safeguarded residential development land	48
Table 5.3	Estimated run-off from highway catchments	49
Table 5.4	Summary of unconstrained options of potential water sources for the canal	53
Table 5.5	List of constrained options for full canal restoration	57
Table 6.1	Proposed restoration phases	63

APPENDICES

Appendix A Canal and River Trust Modelling Report

1 Introduction

1.1 Background

The Lichfield and Hatherton Canals Restoration Trust (LHCRT) is restoring the Hatherton branch of the Staffordshire and Worcestershire Canal. The Hatherton branch ran for approximately 6.5 kilometres from the former Rumer Hill Junction on the Cannock Extension Canal in the east, downhill to Hatherton Junction on the Staffordshire and Worcestershire Canal in the west (Figure 1.1). The Cannock Extension Canal is a branch of the Wyrley and Essington Canal (Wolverhampton Level of the Birmingham Canal Navigations (BCN)). The original route of much of the Cannock Extension Canal has since been lost due to open cast works in the Cannock area. A 2.5 km length of this route remains, stretching from Pelsall Junction to the M6 Toll motorway. For reasons described in this report the restoration of the original Cannock Extension Canal route is not achievable. As a result, an alternative route will be provided from Fishley Junction on the Wyrley and Essington Canal, re-joining the original Hatherton Canal route in the Cannock area.

The purpose of this restoration, in conjunction with the Lichfield canal restoration, is to give direct access to the under-used Birmingham Canals Navigation network, relieving overcrowding of the local Trent and Mersey/Coventry canals and to promote economic regeneration of the area. As a result, the restoration is supported by the Canal & River Trust (CRT), Cannock District, South Staffordshire District Council and Staffordshire County Council. Restoration to date has, in part, been funded by public sector grants including European Regional Development Fund (ERDF) funding.

In March 2019, Stantec was commissioned by LHCRT to undertake a formal Water Supply Study (WSS) to quantify the potential water supply requirement required to enable the Hatherton Canal to be used as a canal for navigation. Having determined the water supply demand for each potential stage of restoration, the study will then identify potential water supply sources which, in combination, can supply the predicted demand.

1.2 Objective and Scope

The objective of the work summarised in this report is to quantify the potential water supply demand (WSD) and identify the water supply sources (WSS) to enable the restored Hatherton canal to be used for navigation.

The following needs to be addressed for the WSD:

- Water volume required to fill the canal as its restoration is completed;
- Volume of residual water loss due to evaporation, leakage through canal base and lock gates;
- Water required to operate the canal (lockage water);
- Changes in WSD due to climate change scenarios, deterioration of infrastructure and changes in canal traffic.

This will determine the water supply requirements at each stage of and on completion of restoration. It will also need to consider potential long-term changes in requirements over a 50 year period. In determining the water supply requirements, sensitivity analysis is required to determine a range of supply amounts, taking into account the subjectivity of assumptions both in terms of boat traffic, lockage and losses and potential impact of climate change. Stepped increase in traffic on completion of restoration in year 1, year 5 and year 10 is to be considered.

The requirement is both for a complete canal which is open to navigation between Fishley Junction and Hatherton Junction, but also for interim states where only parts of the canal are available for use. These interim states would potentially be:

- The section from Fishley Junction through descending locks towards Cannock; or
- Upstream from Meadow Lock ascending towards Cannock; or
- Isolated sections between Meadow Lock and Hatherton Junction.

Having determined the WSD for the restoration, a WSS assessment will be required to identify potential water supply sources which in combination can supply the demand to fill and operate the canal. In identifying the sources, the study will take account of the CRT expressed desire to limit requirement to supply from the national canal network, looking firstly to locally available sources of water. The study will also take into account restrictions on abstraction due to Environment Agency (EA) policy for protection of groundwater and surface watercourses. For each source identified, the report will be required to state whether the owner of the source is willing to supply the water and what consents will be required.

The objective and scope summarised above were laid out in LHCRT's "*Hatherton Canal Restoration: Water Supply Study Requirements and Scope*" document.

The results of this study are intended to confirm the availability of a reliable water supply which will be used by Cannock Chase and South Staffordshire District Councils as justification for safeguarding the route of the canal in their adopted local plans.

1.3 Previous Reports

1.3.1 Ove Arup (2006)

In 2006 LHCRT commissioned a Restoration Feasibility Study through British Waterways (now Canal and River Trust (CRT)) which was undertaken by consultant Ove Arup (Ove Arup, 2006). This demonstrated the technical feasibility of restoration and included a consideration of water supply required for a restored and navigable canal. The study concluded that "sustainable water supply can be achieved by using a variety of sources and through extensive testing regimes". One of the report's recommendations was for the undertaking of a formal Water Supply Study (WSS).

At the time of the Ove Arup report it was intended that the eastern connection to the CRT canal network would be into Grove Basin on the Cannock Extension Canal. However, it later became clear that this would potentially cause major environmental impacts on the ecology of the Cannock Extension Canal, which has a Special Area of Conservation (SAC) status based on the presence of rare Floating Water Plantain. In order to avoid potential adverse impact of the Hatherton Canal on the SAC, an alternative route for the eastern end of the restored Hatherton Canal was identified (Figure 1.1).

1.3.2 Atkins (2009)

LHCRT commissioned a Restoration Feasibility Study, which was undertaken by consultant Atkins, with a focus on the newly proposed alternative route avoiding the Cannock Extension Canal SAC (Atkins, 2009). This study demonstrated the technical feasibility of restoration and included a consideration of water supply required for a restored and navigable canal. It summarised that the proposed alternative alignment was not only feasible but preferable to the original proposed alignment, due to the bypassing of a long deep cutting through potentially contaminated mining spoil. The report stated an assumption of water supply from the existing canal Wolverhampton Level and updated the water demand calculations originally provided with the Ove Arup study.

1.4 This Report

This report assesses the water demand and supply for the restored Hatherton Canal. Several data providers (CRT, LHCRT, EA, etc.) have been consulted for the study. Appendix A provides a list of the data sources.

Section 2 of this report presents a brief overview of the current state of the canal and a description of the various restoration phases.

Section 3 discusses the geological, hydrological and hydrogeological setting of the area covered by the proposed canal restoration. Various anthropogenic influences characterising the restoration area (surface and groundwater abstractions, discharges, mining and quarrying, etc.) are also presented as these are supportive to the water supply assessment presented in later sections.

Section 4 and Section 5 cover the WSD assessment and WSS assessments. A series of unconstrained and constrained options are provided. Section 6 addresses the water supply for the restoration phases.

Conclusions and recommendations are presented in Section 7.

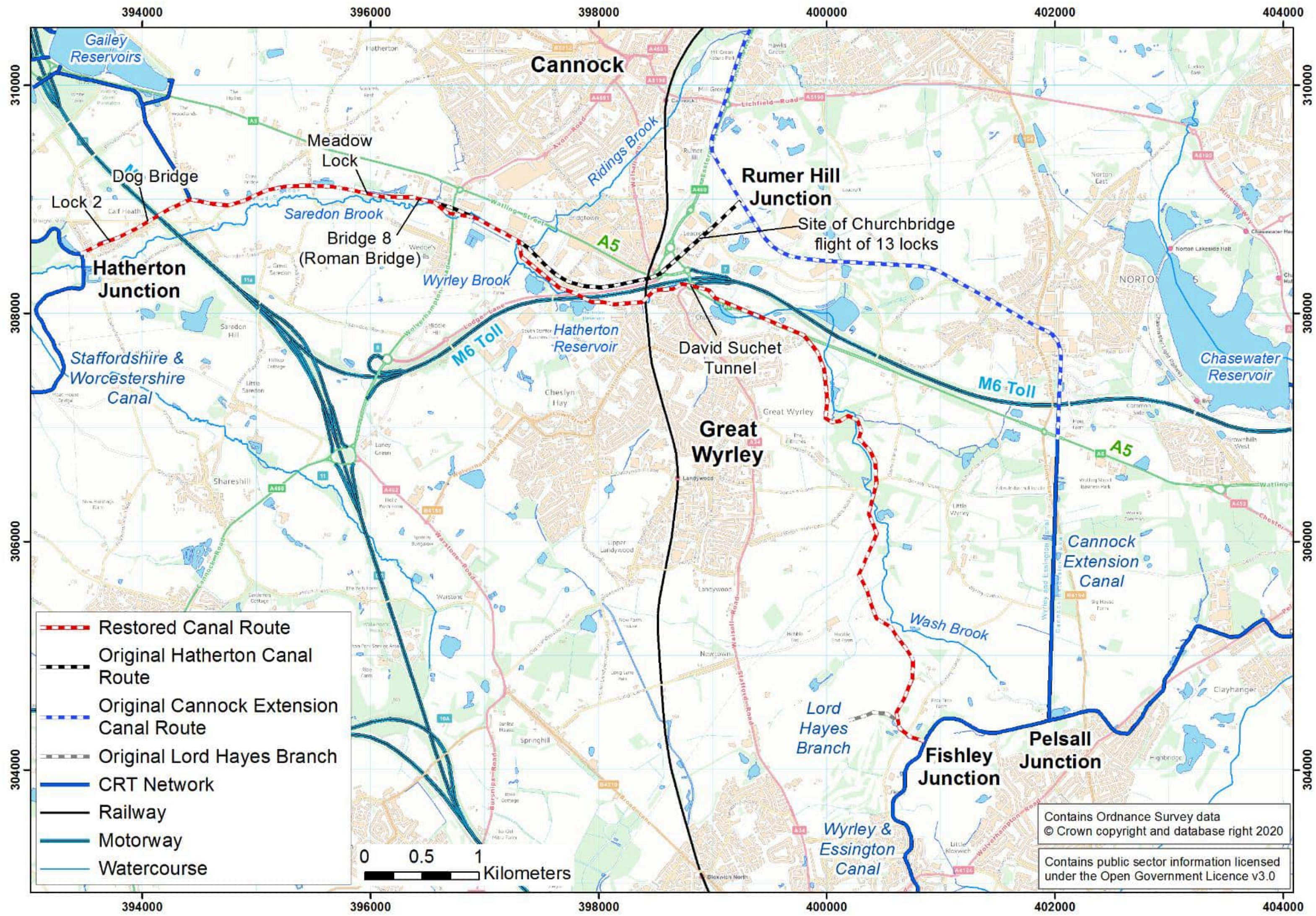

Figure 1.1 Site location

2 Hatherton Canal

2.1 History of the Canal

The Hatherton Canal is a derelict branch of the Staffordshire and Worcestershire Canal (Figure 1.1). It was constructed in two phases, the first opening in 1841 and running from Hatherton Junction to Churchbridge in Cannock, where a tramway connected to the Great Wyrley coal mines (LHCRT website, 2018). In 1863 the canal was extended eastwards to connect with the new Cannock Extension Canal by a continuous flight of 13 locks. The main freight was coal, which led in part to the canal's abandonment due to increasing subsidence during the 1940s. Commercial traffic continued to use the canal until 1949 and the canal was officially abandoned in 1955. Sections of the route, including the Churchbridge flight of locks, were subsequently destroyed by open cast coal mining and the area has since been redeveloped.

Prior to closure to navigation in 1955, water supply for the canal came from two main sources. Hatherton Reservoir was constructed to supply water to an upstream section of the canal around Locks 6 and 7. Since canal closure to navigation, the reservoir has since been split in two by construction of the M6 Toll road and no longer feeds the Hatherton Canal. A second water source was Birmingham Canals Navigation Wolverhampton Level, which is fed from Chasewater Reservoir and Bradley Pumps.

Currently, the remaining section of the Hatherton Canal owned by CRT is fed by a supply of water from the Saredon Brook via a control weir. The historically agreed maximum abstraction is 12 Ml/day. Following implementation of the Water Act 2003, CRT is regularising this abstraction with the EA and the future abstraction licence will be held by CRT.

Plans to restore the Hatherton Canal were first raised in 1975, when area planning authorities were required to produce county structure plans (Wikipedia, 2018). Since these initial plans, several external events have influenced the restoration, mainly related to the construction of the M6 Toll road that began in 2001. This led to provision of a canal tunnel beneath the M6 Toll road, and LHCRT has constructed a second tunnel under the A5 southern roundabout.

2.2 Current State

Much of the canal bed has been filled in or drained down since closure to navigation in 1955. At Hatherton Junction, a 300 m section remains in water and use up to Lock 2 (Figure 1.1), and the subsequent 400 m to Dog Bridge (Figure 1.1) has a full depth of water and could easily be turned into a navigable condition. Eastwards of Dog Bridge, the canal remains in water and semi-navigable for approximately 2.5 km to Meadow Lock, although stonework and locks are in a poor state of repair or derelict. The canal continues eastwards beyond Meadow Lock as a channel containing a minor watercourse in the base to Bridge 8, after which the channel has been completely infilled and the line lost.

The total length of the canal from Hatherton Junction to Bridge 8 (3.1 km total length) is owned, maintained and operated by CRT. The main purpose of the section upstream of Dog Bridge is to supply water abstracted from the Saredon Brook directly to the Staffordshire and Worcestershire Canal at Hatherton Junction and indirectly via Gailey Reservoir. There is additional abstraction from a weir on Saredon Brook at Meadow Lock. It is understood there are minor watercourse connections into the canal.

The canal was filled in beyond Bridge 8 in 1988 and the land developed into an industrial estate and retail park. Further upstream, the canal has been physically removed due to open cast coal mining to the east of Cannock. It is not possible to restore the canal upstream of Bridge 8 to its original line, so a new line has been identified for protection in the Local Development Framework, through to the Lord Hayes Branch of the Wyrley and Essington Canal (Figure 1.1). Some canal structures on the route have been built at the time of construction of the Birmingham Northern Relief (M6 Toll) road, including a culvert beneath the M6 Toll. There is currently no provision for the canal to pass beneath the railway or M6, although tunnels have been proposed for both of these locations.

2.3 Background to the Proposed Restoration

The proposed restoration will be undertaken over three phases, the order of which depends on potential action from Highways England regarding the M6 tunnel section (Section 6.1). Approximately 40% of the restoration is to take place along the original route of the canal, with off-line restoration in the eastern half along a new route (Figure 1.1). Once restored, the canal will join the existing national canal network at these junctions, both of which are owned by the Canal and River Trust (CRT).

Planning for the restoration has identified three major barriers that will require engineering of the proposed canal route:

- The route through the A5;
- The tunnel under the railway at Cannock
- The tunnel under the M6.

It is possible that a tunnel may be provided by Highways England if they decide to upgrade the M6 roadway by widening to create additional lanes, however, this is considered unlikely.

Initial restoration plans are to start works at Fishley Junction and work downhill towards Cannock, providing a fully navigable canal. The number of locks between these two locations is yet to be confirmed. This work would include back pumping to reduce water loses in the canal network and the potential for overspills from pounds into existing watercourses. However, no physical works are planned due to start within the immediate future.

The David Suchet Tunnel (Figure 1.1) has already been constructed beneath the A5 roundabout at its junction with the M6 Toll. However, 400 m further west there is currently no tunnel beneath the railway, which crosses the proposed canal route between the locations proposed for locks 6 and 7 (see Section 6 and Figure 6.1). West of the railway the proposed canal route passes beneath the M6 Toll, through which a culvert was installed during road construction. Restoration of the canal route from Roman Bridge westwards (Figure 1.1) is anticipated to be straightforward, largely due to the route being the original canal route and still in existence despite poor repair.

3 Physical Setting

3.1 Geology

The proposed route of the canal overlies three distinct geological successions. In the west, bedrock geology is dominated by sandstones and conglomerates of the Permo-Triassic Sherwood Sandstone Group, which overlies the Carboniferous Warwickshire Group and this in turn rests unconformably on the Carboniferous Coal Measures (Middle and Lower Pennine) in the east. The age of the bedrock strata gets progressively older moving south eastwards along the proposed canal route. Figure 3.1 shows the bedrock geology as taken from the 1:50,000 scale geological maps of the area (British Geological Survey, 1964) (British Geological Survey, 2001).

The Pennine Lower Coal Measures Formation and Pennine Upper Coal Measures Formation of the South Staffordshire Coalfield underlie the eastern two thirds of the proposed canal route. Following the younging direction of the strata from east to west, the Pennine Lower Coal Measures Formation is formed of mudstone, siltstone and sandstone interbeds, with thicker and more numerous coal seams in the upper part. This formation is conformably overlain by the Pennine Middle Coal Measures Formation, which is comprised of interbedded grey mudstone, siltstone, pale grey sandstone and common coal seams, with several fossil-bearing mudstones in the upper half of the formation. A minor sill of microgabbro has intruded into the Upper Pennine Coal Measures in the area immediately surrounding Fishley Junction.

The westernmost third of the proposed canal route overlies a variety of sedimentary deposits ranging from Carboniferous to Triassic in age. The Carboniferous Etruria Formation is the underlying bedrock for a 1 km section of the proposed canal route to the south of Cannock. Moving westwards along the proposed canal route, the Etruria Formation (predominantly mudstone) is overlain by successively younger strata. A down-faulted block exposes Early Triassic Wildmoor Sandstone Formation for 0.5 km along the route, which then returns to the slightly older conglomerates and sandstones of the Chester Formation before grading upwards back into the Wildmoor Sandstone Formation 2 km east of Hatherton Junction. Micaceous sandstones of the Alveley Member and Halesowen Formation (formerly the Keele Group), together with undifferentiated breccia and sandstone members of the Clent and Enville Formations, crop out between 100 metres to 3 km to the south of the proposed canal route.

Superficial deposits are present along most of the canal route (Figure 3.2). Alluvium deposits associated with Saredon Brook and Wash Brook are present beneath much of the proposed canal route. Quaternary till deposits are present over several sections of the proposed route, including a 1.5 km length near Hatherton Junction and 1.5 km length at Fishley Junction.

Table 3.1 summarises the geological succession in the area and provides an indication of estimated thicknesses along the canal route.

Table 3.1 Summary of the stratigraphic succession

Period	Group	Unit/ Formation	Description	Unit thickness (m)
Quaternary (Pleistocene-Holocene)	Superficial Deposits	Alluvium	Brown silty clay with sand and gravel lenses	-
		Glaciofluvial Sheet Deposits	Coarse-grained sand and gravel with silty clay layers	-
		Till	Red-brown, silty, clay-sand diamict	-
		Lacustrine	Fine grained, thinly laminated silt and clay	-
Triassic	Sherwood Sandstone Group	Wildmoor Sandstone Member	Sandstone, red with grey-green mottling, silty, micaceous, very weakly cemented; minor interbedded mudstone.	20-240
		Chester Formation	Conglomerates and reddish-brown pebbly sandstones with subordinate beds of mudstone	50-627 (~300 m along route)
Permo-Carboniferous	Warwickshire Group	Clent Formation & Enville Formation	Sub-angular breccia with mudstone matrix and Precambrian volcanic clasts, with red sandstone and lenticular conglomerates of Carboniferous limestone	138-240 (not present along route)
Carboniferous		Halesowen Formation (contains Alveley Member)	Grey-green micaceous sandstone overlying mudstone with thin coals and limestones	70-350 (not present along route)
		Etruria Formation	Mudstone with lenticular sandstones, conglomerates and rare coal seams	300
		Intrusives	Microgabbro	-
	Pennine Coal Measures	Pennine Middle Coal Measures Formation	Interbedded grey siltstone, sandstone and coal seams with marine fossil-bearing mudstones	200-650
		Pennine Lower Coal Measures Formation	Interbedded grey mudstone, siltstone and sandstone with numerous thick coal seams in the upper part	650

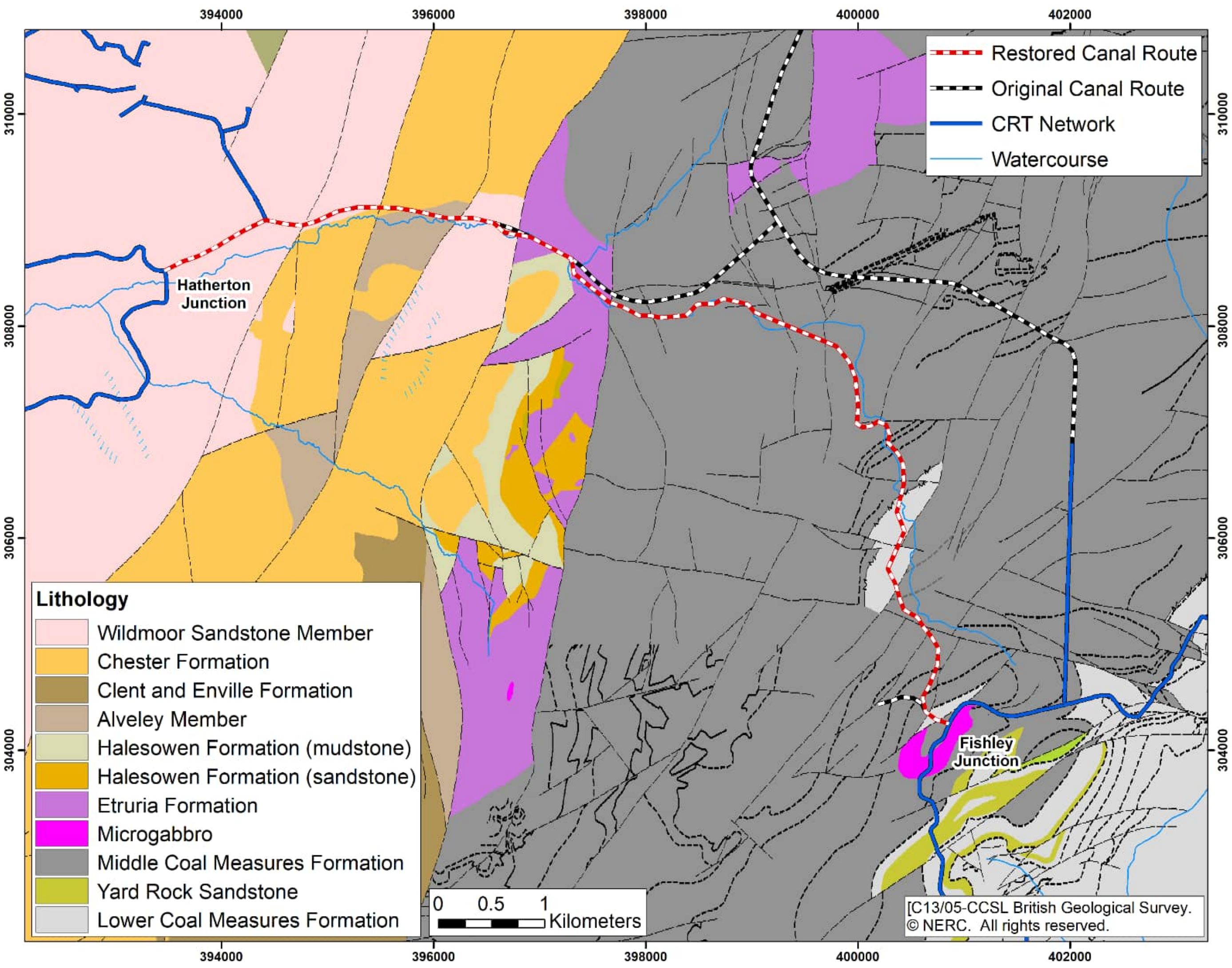

Figure 3.1 Bedrock geology

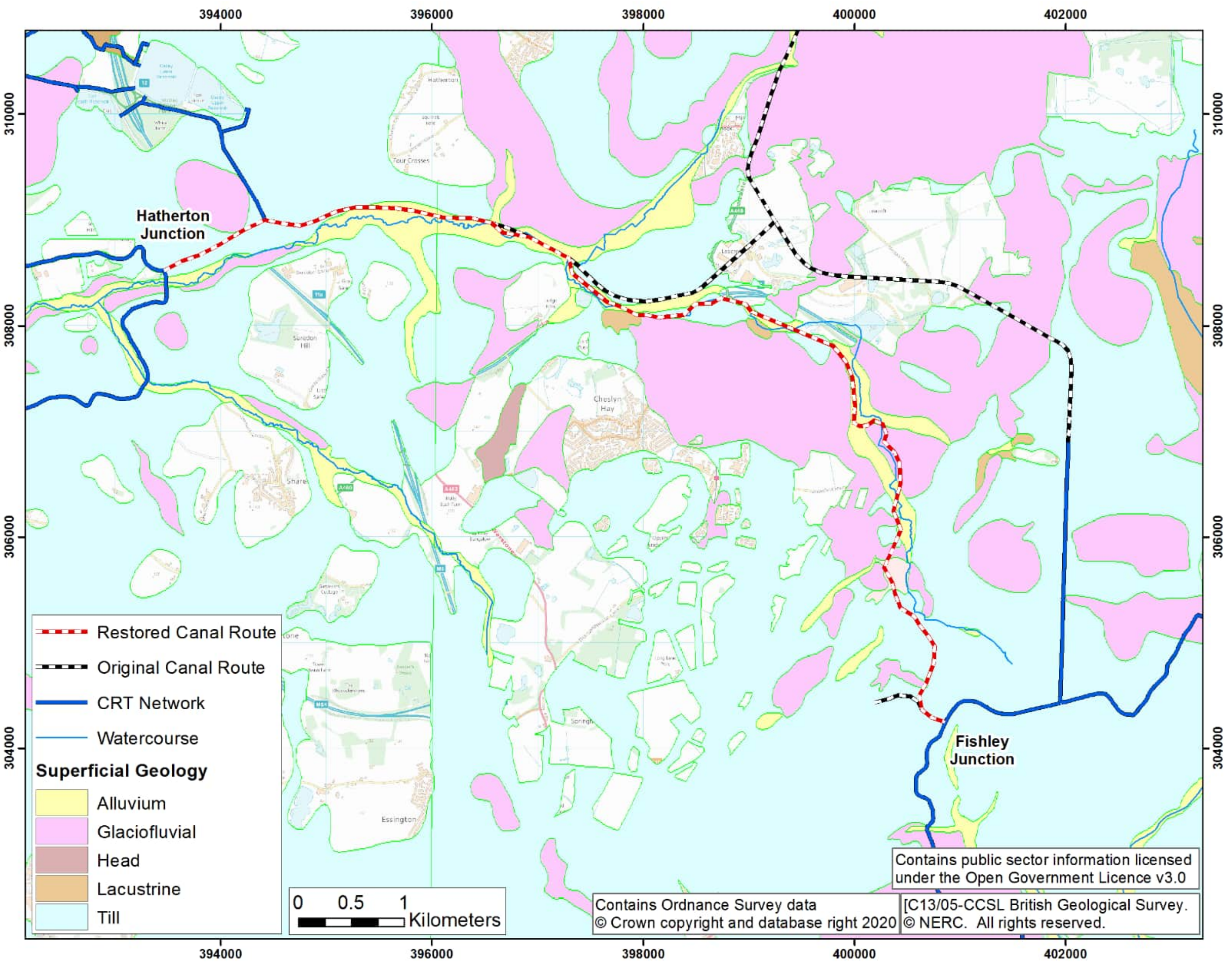

Figure 3.2 Superficial geology

3.2 Hydrology

There are a number of surface water features present in the area and around Cannock these have a complex arrangement, discharging into and from the original canal course. The Saredon Brook and the Wyrley Brook follow alongside much of the western route of the canal (Figure 3.3). These are both tributaries to the larger River Penk (see Section 3.4 for further details) which flows northwards into the River Trent.

The Wyrley Brook is impounded by Hatherton Reservoir, which was constructed in the 1840s to feed the Staffordshire and Worcestershire Canal via the Hatherton Branch. At that time it was known as Walkmill Reservoir. Hatherton Reservoir has since been cut in two following construction of the M6 Toll road, with both the upstream and downstream sides discharging into the Wyrley Brook.

Ridings Brook flows southwards through Cannock and currently discharges directly into the original canal course 350 m downstream from Hatherton Reservoir; a further 120 m downstream the Wyrley Brook merges with the original canal route to become the main watercourse feeding the Saredon Brook. Approximately 2-3 km upstream of Hatherton Reservoir, the Wyrley Brook becomes Wash Brook and continues to follow the proposed canal alignment.

The proposed canal route and its complex relationship with these watercourses along a 1.6 km stretch is shown in more detail in Sheets 8 and 9 of Arup (2006), included in this report as Figure 3.4 and Figure 3.5, respectively. The extents of Sheets 8 and 9 are shown in Figure 3.3.

Two larger reservoirs are located close to the proposed canal route.

- In the west, Gailey Lower Reservoir and Gailey Upper Reservoir lie 1.2 km northeast of Hatherton Junction. The Gailey Reservoirs feed the Staffordshire and Worcestershire Canal and are managed by CRT; they are also an important area for water birds although there is currently no citation.

- Chasewater Reservoir is located 2.9 km east of the Wash Brook area of the proposed route and was constructed in 1797 to feed and maintain levels in the Birmingham Canal Navigations network. The reservoir now forms part of Chasewater Country Park and is a popular public amenity for recreation. In 2011, Staffordshire County Council took over management of Chasewater Reservoir to ensure completion of remedial works to the eastern dam infrastructure. Typically, water levels in the reservoir are maintained at approximately 152 mAOD.

There are a number of smaller surface water bodies in the area, including Kingswood Lake (an angling lake) which is located approximately 300 m east of Churchbridge (Figure 3.3).

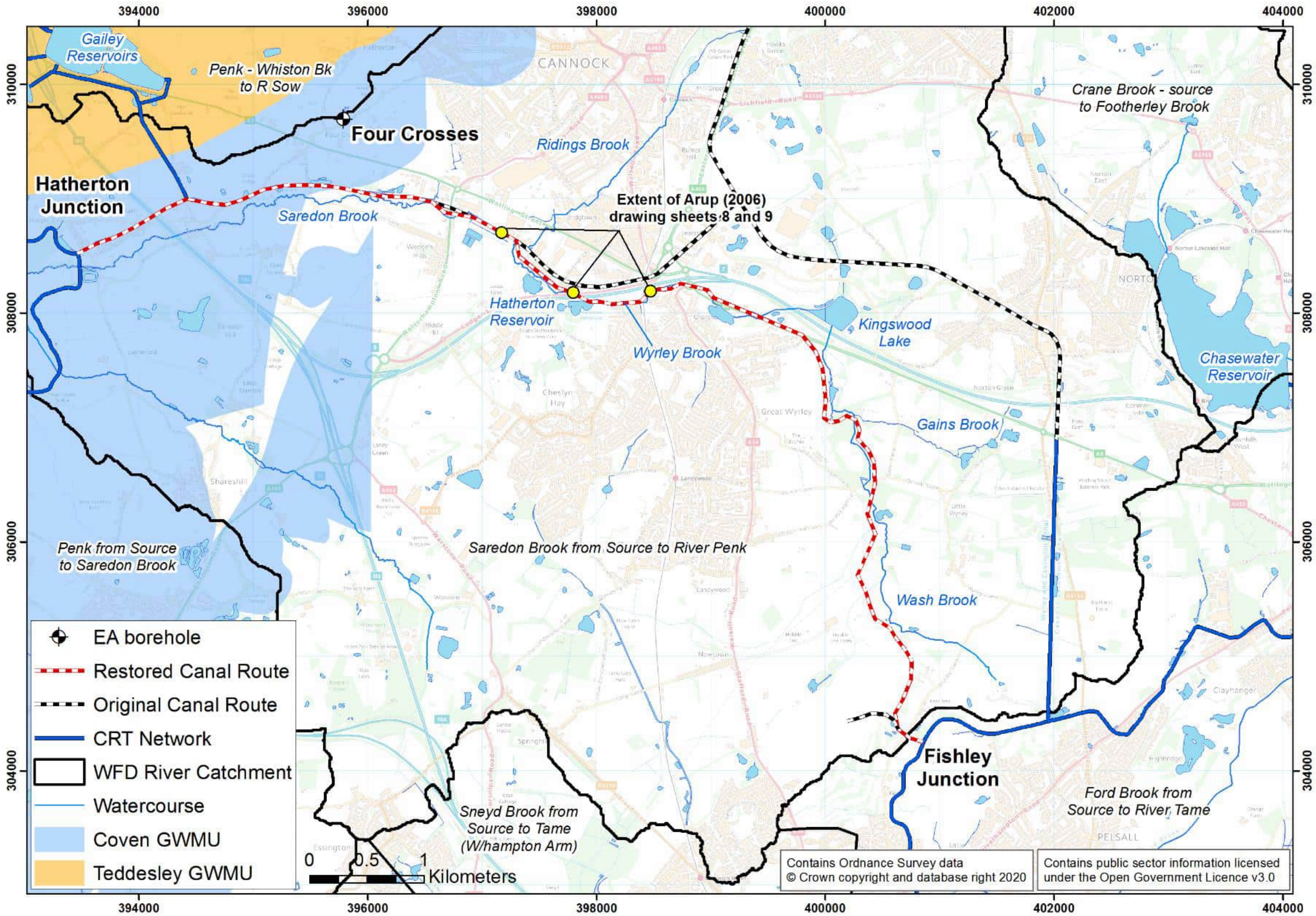

Figure 3.3 Hydrology and hydrogeology

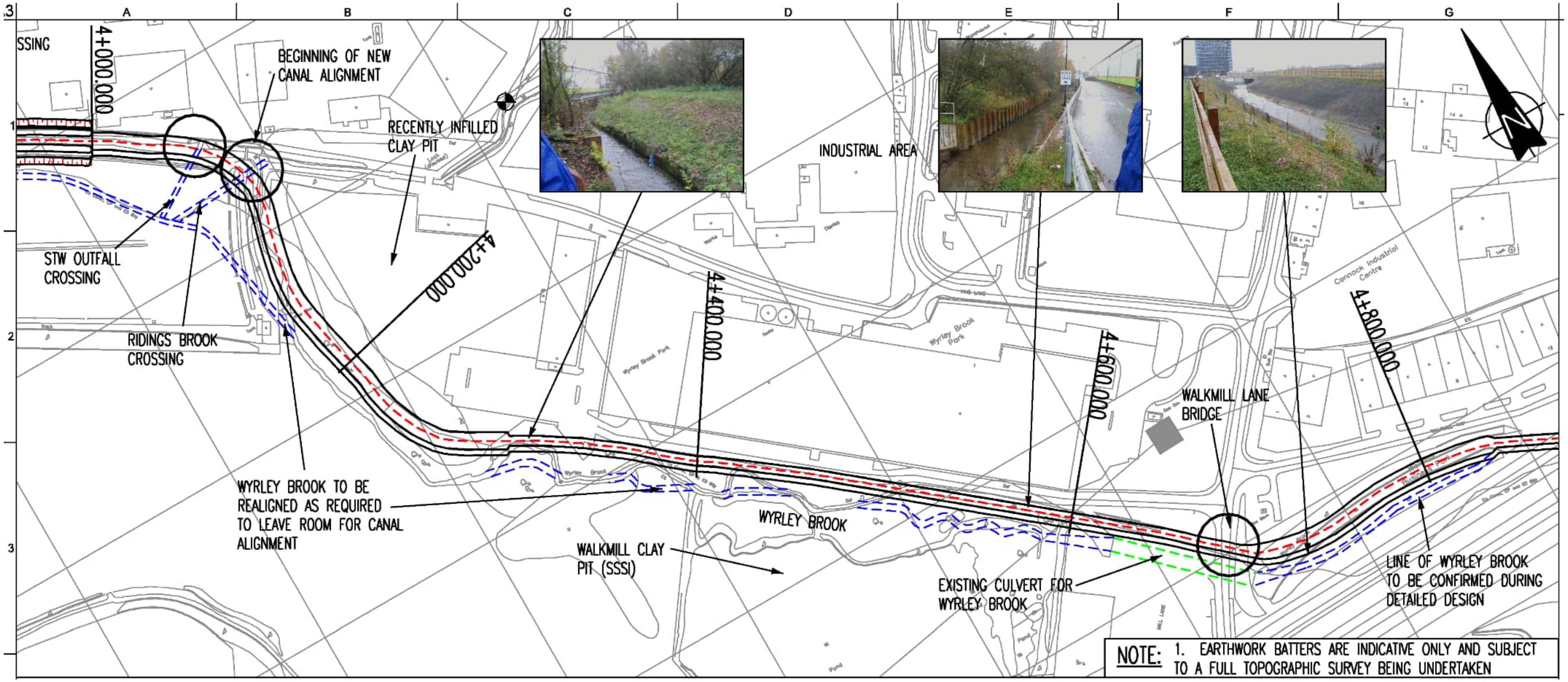

Figure 3.4 Location of proposed canal route, from Sheet 8 of 16 in Arup (2006)

The extent of this drawing from Arup (2006) stretches from the confluence of the Ridings Brook with the Wyrley Brook in the west to the M6 Toll tunnel in the east. These locations are identified as the western and central yellow points in Figure 3.3.

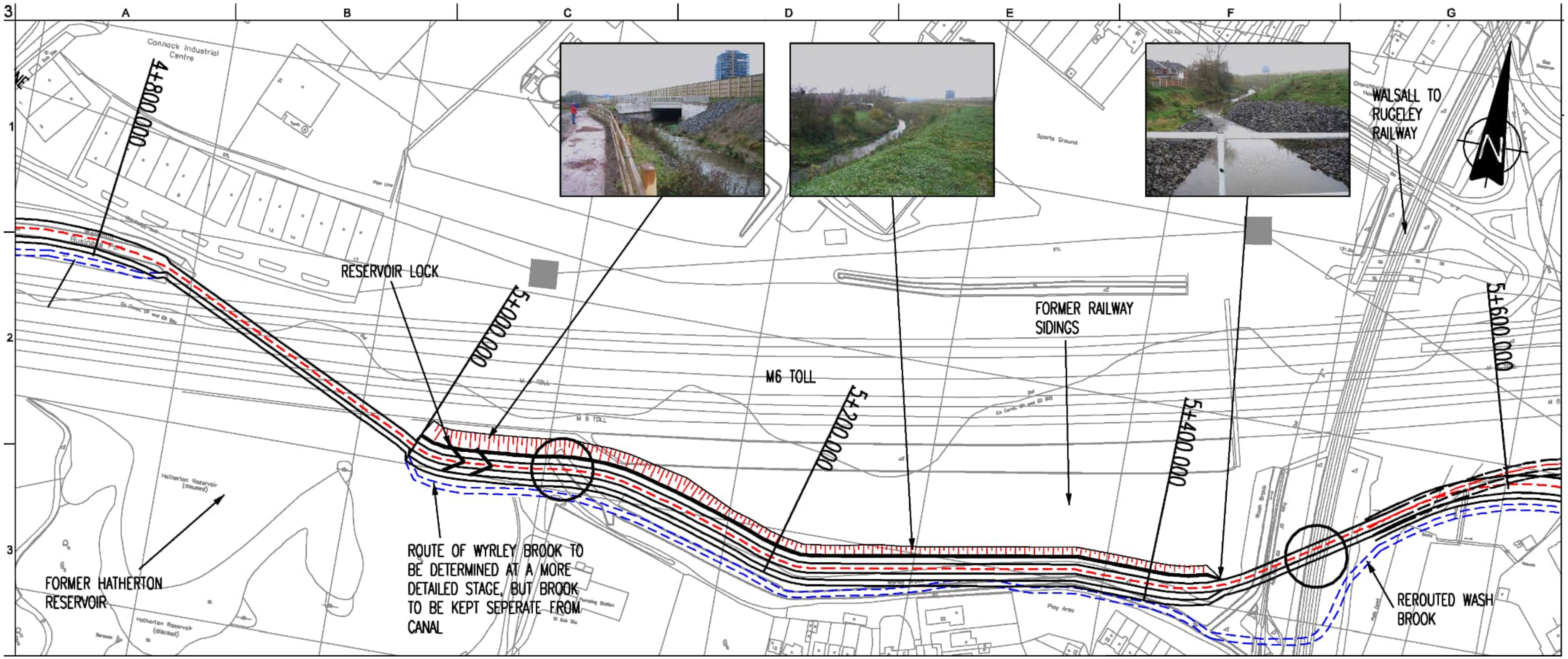

Figure 3.5 Location of proposed canal route, from Sheet 9 of 16 in Arup (2006)

The extent of this drawing from Arup (2006) stretches from the M6 Toll tunnel in the west to the crossing of the Walsall to Rugeley railway in the east. These locations are identified as the central and eastern yellow points in Figure 3.3.

3.3 Hydrogeology

3.3.1 Aquifer units and properties

Two aquifers underlie parts of the proposed canal route, with the Permo-Triassic Sherwood Sandstone in the west overlying the Pennine Coal Measures and Warwickshire Group in the east. The Sherwood Sandstone aquifer is classified as a principal aquifer (orange colour in Table 3.1). Principal aquifers are defined as layers of rock or drift deposits that have high intergranular and/or fracture permeability – meaning they usually provide a high level of water storage. They may support water supply and/or river baseflow on a strategic scale. Permeability in the Permo-Triassic Sandstones is understood to be governed by both intergranular flow and flow through small-scale fractures.

In the area of the proposed canal route, the EA has split the Sherwood Sandstone aquifer into two Groundwater Management Units (GWMU), the Coven GWMU and the Teddesley GWMU (Figure 3.3) for groundwater management purposes (see Section 3.4 for further details). From a hydrogeological point of view, the two units can be treated regionally as a single hydrogeological unit. At a local scale the Permo-Triassic Sandstones may act as a layered aquifer system due to the potential for interbedded mudstone layers.

The Pennine Coal Measures and Warwickshire Group are classified as a Secondary A aquifer. Secondary A aquifers are defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. This moderately productive aquifer is cyclic and multi-layered with moderate to large yields observed, especially from disused mine shafts. The Lower Coal Measures contain a number of springs.

3.3.2 Groundwater levels

The EA has provided groundwater levels for Four Crosses observation borehole (Figure 3.6), which is located within the Permo-Triassic Sandstone underlying the study area (see Figure 3.3 for location). Summary statistics are presented in Table 3.2.

Table 3.2 Summary groundwater level statistics

Name	Date Range	Datum (mAOD)	Groundwater Level (mAOD)		
			Min	Mean	Max
Four Crosses	Oct 08 – May 19	125.1	104.87	113.40	114.49

Groundwater levels at Four Crosses are approximately 12 m below ground level. Therefore, most of the section of the restored canal is unlikely to ever be connected to groundwater in the Permo-Triassic Sandstone aquifer and losses will occur from the base of the canal unless it is suitably lined.

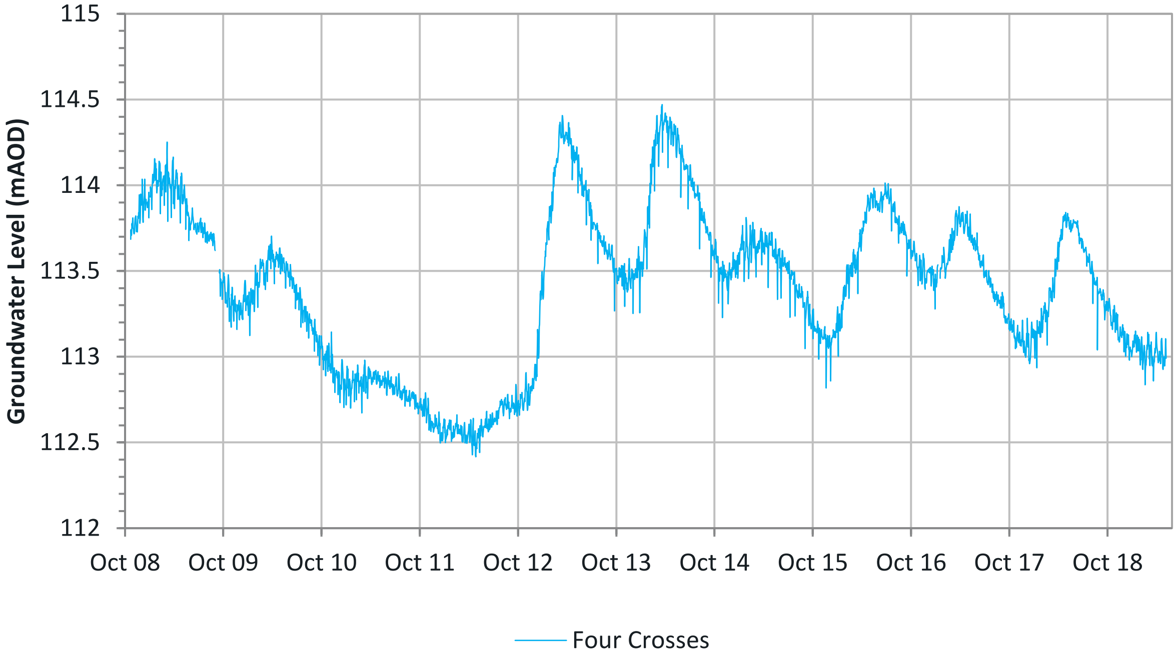

Figure 3.6 Groundwater levels at Four Crosses

Boreholes owned by the Coal Authority at Wyrley Common, approximately 2.3 km east of the proposed canal route, record groundwater levels of approximately 130 mAOD, or 25.5 m below surface (see Section 3.5.3 for further details).

3.4 CAMS Status

Groundwater

Underlying the western portion of the proposed canal route, the Staffordshire Trent Valley - PT Sandstone Staffordshire groundwater body (GWB GB40401G300500) is split into the Teddesley GWMU and the Coven GWMU. The GWB as a whole has Poor quantitative status (with low confidence), which is as a result of a combination of four tests that are listed in Table 3.3.

The Staffordshire Trent Valley Abstraction Licensing Strategy (CAMS) states that water is not available for licensing within Teddesley GWMU (EA, 2013) which is closed, due to historical over abstraction which has lowered the groundwater table resulting in a depletion of base flow to hydraulically connected surface water bodies. However, the Coven GWMU, over which the canal is routed, does have water available for licensing. Coven GWMU is "open to new licence applications if applicants can confirm no impact on other abstractors, the aquatic environment and river flows. A HOF [Hands Off Flow] may be applicable to protect flows in the River Penk."

The Secondary A aquifer of the Staffordshire Trent Valley – Mercia Mudstone East & Coal Measures (GWB GB40402G300300) underlies the majority of the proposed canal route in the centre and east. This GWB has a Good quantitative status (with low confidence), also shown in Table 3.3.

Table 3.3 WFD status for potential impact of groundwater abstraction on local groundwater bodies

WFD Groundwater Body Class	Staffordshire Trent Valley – PT Sandstone Staffordshire	Staffordshire Trent Valley – Mercia Mudstone East & Coal Measures
Groundwater Balance	Poor	Good
Dependent Surface Water Body Status	Poor	Good
Groundwater Dependent Terrestrial Ecosystems (GWDTE)	Good	Good
Saline and or other Poor Water Quality Intrusion	Good	Good
Overall quantitative status	Poor	Good
Confidence of overall quantitative status	Low	Low

Surface Water

The proposed canal route lies entirely within the north westerly flowing Saredon Brook catchment (Saredon Brook from Source to River Penk, waterbody GB104028046740). The Saredon Brook, Ridings Brook and Wash Brook are all tributaries that merge and flow into the River Penk 3.3 km west of Hatherton Junction.

The Staffordshire Trent Valley CAMS provides information on the availability of surface water for abstraction in the Saredon Brook catchment (EA, 2013). For the Saredon Brook catchment the CAMS states:

> *"For the River Penk there is water available for licensing subject to a HOF[1] of 82 Ml/d at Penkridge. This means that for new licences:*
>
> - *All new consumptive or partially consumptive licences will be issued with this HOF;*
> - *Water is only available during periods of medium to high flows due to the HOF condition;*
> - *There is a time limit of 31 March 2027."*

Abstraction from any of the local watercourses thus appears to be available for much of the time, although the possibility of providing storage for use as an alternative supply during low flow periods should be considered to allow abstraction during periods of higher flows to be stored.

The most recent Water Framework Directive (WFD) status available for the Saredon Brook waterbody is for 2016 when the overall water body had Moderate status, consisting of a Good chemical status and a Moderate ecological status (Table 3.4).

Table 3.4 Cycle 2 classification for Saredon Brook Surface Water body

WFD Surface Water Body Classification Item				2016 Status
Overall Water Body	Ecological	Supporting elements	Mitigation Measures Assessment	Moderate
		Biological quality	Fish	Good
			Invertebrates	Moderate
		Hydromorphological elements	Hydrological Regime	Supports Good
		Physico-chemical quality	Acid neutralising capacity	High
			Ammonia	Moderate
			Dissolved oxygen	Moderate
			pH	High
			Phosphate	Moderate
			Temperature	High
		Specific pollutants	Triclosan, Manganese, Copper, Iron, Zinc	High

[1] Hands off flow i.e. no abstraction when flows are below 82 Ml/d at the Penkridge gauge. This flow is equivalent to approximately Q_{75} at this gauge i.e. abstraction would not be allowed for 25% of the time. https://nrfa.ceh.ac.uk/data/station/meanflow/28053

WFD Surface Water Body Classification Item				2016 Status
	Chemical	Priority substances	Lead, Nickel and their compounds	Good
		Other pollutants		Does not require assessment
		Priority hazardous substances		Good

3.5 Anthropogenic Influences

WRGIS data for the Saredon Brook waterbody indicate that 0% of the full licence volume for surface water abstraction has been utilised according to Recent Actual data (average of the past five years). In comparison, 64% of the full licence volume for groundwater abstraction has been abstracted according to Recent Actual data. The full volume of licensed discharge is being used in the waterbody, resulting in significant surplus flow in the Saredon Brook above the natural low flow (Q_{95}).

The Saredon Brook Recent Actual Q_{95} flow is approximately 18.2 Ml/d higher than the natural flow estimate at Q_{95} for the watercourse. Based on Recent Actual data, it is estimated that approximately 11.3 Ml/d of licensed abstraction may be available for licence trading (0.7 Ml/d groundwater abstraction, 10.6 Ml/d surface water abstraction).

3.5.1 Abstractions

The EA provided details of licensed surface water and groundwater abstractions within a 2 km buffer of the proposed canal route. Details of these groundwater abstractions are summarised in Table 3.5 and surface water abstractions in Table 3.6. The location of all abstractions are shown in Figure 3.7.

Table 3.5 indicates that there is one licensed groundwater abstraction (highlighted in grey) located within 1 km of the proposed canal route. The abstraction has only small licensed daily and annual quantities. The closest major groundwater abstraction to the proposed canal route is 1800 m away at Four Ashes chemical plant (403 Ml/a).

Table 3.6 indicates that there are three licensed surface water abstractions (highlighted in grey) located within 1 km of the proposed canal route. Two sources have relatively small licensed daily (<0.9 Ml/d) and annual quantities (<12 Ml/a), while the third (Alpha Works) has a larger licensed daily and annual abstraction. The largest surface water abstraction licence within 2 km of the canal route is held by the CRT at Four Ashes for direct supply to the Staffordshire and Worcestershire Canal (<727 Ml/a). The Saredon Brook surface water catchment is open (with restrictions) to new abstractions.

Three surface water and one groundwater abstraction licences indicate a medium or high potential for licence trading according to the EA (Figure 3.7). These are located over 1.5 km from the proposed canal route, except for CRT's surface water abstraction licence (03/28/03/0205) on the Saredon Brook.

Table 3.5 Licensed groundwater abstractions within 2 km of the proposed canal route (EA data)

Site Name	Licence Number	Sector	Min Distance to Hatherton Canal (m)	Licence Max Annual Quantity (Ml/a)	Licence Max Daily Quantity (Ml/d)
Cannock Cricket & Hockey Club	03/28/03/0242/1/R01	Spray irrigation	870	8.00	0.14
Abbey Farms	MD/028/0003/008	Agriculture	1044	42.0	0.15
Mid Cannock Colliery Borehole	03/28/03/0253/R01	Transfer between sources	1085	-	-
Swan Farm	03/28/03/0168	Spray irrigation	1192	4.93	0.46
STWL - Four Ashes Treatment Works	03/28/03/0189	Water supply - 1 BH	1551	35.4	0.14
Four Ashes chemical plant	MD/028/0003/002	Pump & treat - 8 BHs	1749	110	0.30
	03/28/03/0178	Water supply - 1 BH	1810	403	1.10
	03/28/03/0178	Chemical processing - 1 BH	1810	403	1.10
Hollybush Nurseries*	03/028/03/0188	Spray irrigation	2113	22.7	0.45

* High potential for licence trading

Table 3.6 Licensed surface water abstractions within 2 km of the proposed canal route (EA data)

Site Name	Licence Number	Sector	Minimum Distance to Hatherton Canal (m)	Licence Max Annual Quantity (Ml/a)	Licence Max Daily Quantity (Ml/d)
CRT - S&W Canal **	03/28/03/0205	Spray irrigation	26	11.4	0.82
Great Saredon Farm	03/28/03/0225	Spray irrigation	139	7.37	0.32
Alpha Works	03/28/03/0122	Industrial, commercial and public services - process water	568	50.0	0.18
Swan Farm	03/28/03/0166	Spray irrigation	1092	16.4	0.46
	03/28/03/0167	Spray irrigation	1277	11.4	0.46
Abbey Farms	03/28/03/0202	Spray irrigation	1213	36.5	0.60
CRT - Calf Heath Reservoir **	03/28/03/0173	Spray irrigation	1508	11.1	0.86
Whitehouse	03/28/03/0127	Spray irrigation	1550	4.1	0.52
CRT Four Ashes - S&W Canal	03/28/03/0124	Petrochemicals - process water	1795	727	727
	03/28/03/0124	Petrochemicals - cooling	1795	727	727
Aspley Farm	03/28/03/0210	Spray irrigation	1871	2.50	0.09

** Medium potential for licence trading

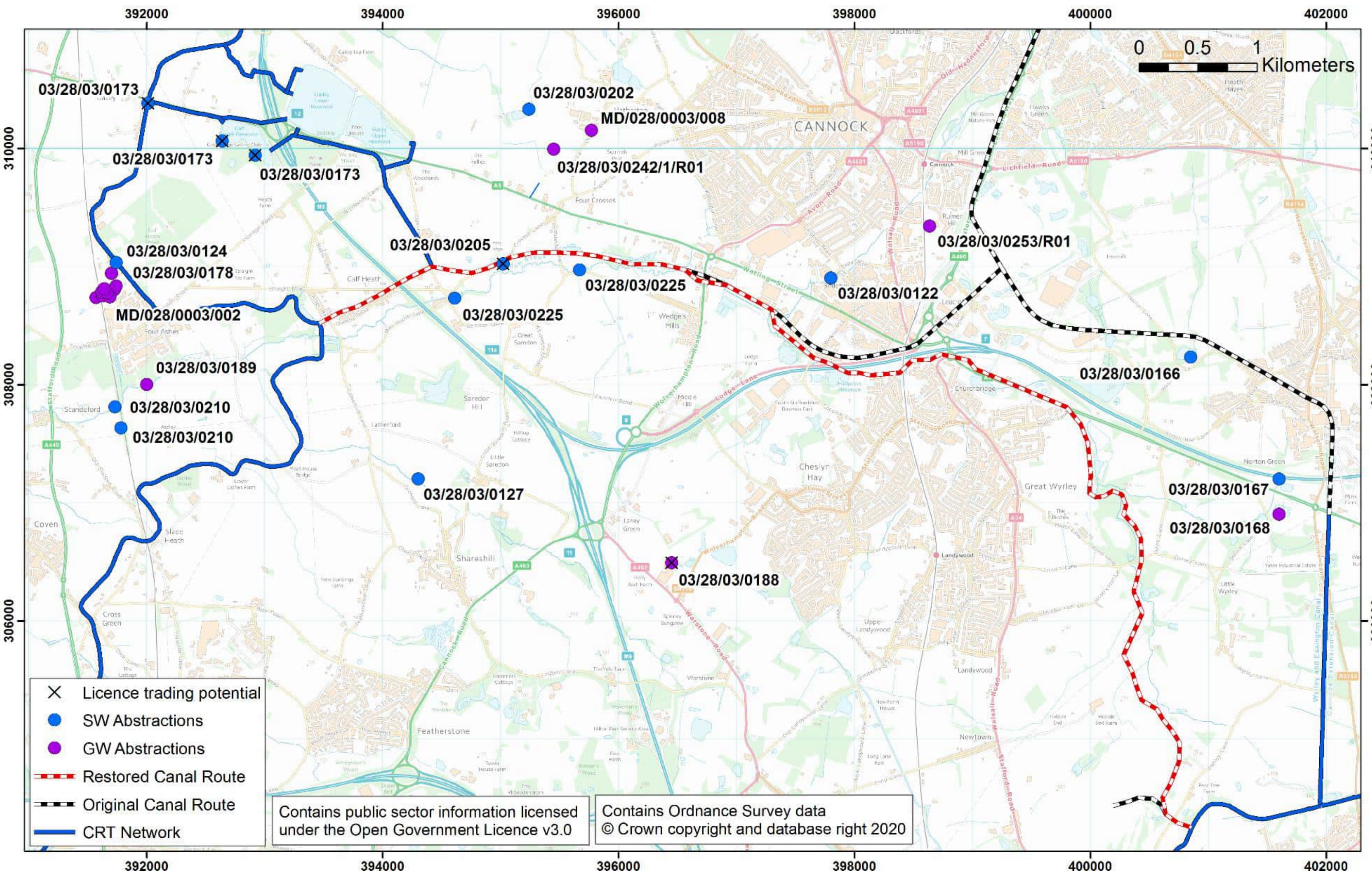

Figure 3.7 Groundwater and surface water abstractions

3.5.2 Discharges

The EA has provided data for 295 permitted discharges within 2 km of the proposed canal route. A total of 27 of these discharge consents lie within 500 m of the proposed canal route and have not been superseded by a more recent application for the same licence. This information is shown on Figure 3.8 and listed in Table 3.7.

Table 3.7 Discharge consents (EA data)

Consent Number	Consent Name	Consent Holder	Details	Revoked?	Distance to Hatherton Canal (m)	DWF (Ml/d)	Max Daily (Ml/d)
T/03/02673/W	Bridgtown Industries Limited	Severn Trent Water Ltd (STWL)	Other	27/03/2000	7	-	-
T/03/00407/T	Walkmill Lane	Schroder Exempt Property Unit Trust	Other	24/09/2015	23	-	-
T/03/20196/O	Littlewood Sewage Pumping Station	STWL	Storm Tank/CSO on Sewerage Network		57	-	-
T/03/00655/T	Garage At Churchbridge	STWL	Other	12/01/2001	93	-	-
EPRGB3399AV	Development adj. to Link Way Retail	Aviva Investors Pensions Ltd	Warehousing + Support Activities for Transportation		104	-	0.02
TSC3791	Queens Road Albrighton at Calf Heath	STWL	Storm Tank/CSO on Sewerage Network	12/08/2011	124	-	-
T/03/07950/O	Longford House Pumping Station	STWL	Pumping Station on Sewerage Network		132	-	-
TSC3555	Latherford Lane SPS	STWL	Pumping Station on Sewerage Network		150	-	-
T/03/12336/O	Calf Heath No 3 (Queens Road)	STWL	Pumping Station on Sewerage Network		150	-	-
T/03/12335/O	Latherton Lane	STWL	Pumping Station on Sewerage Network	31/05/2017	203	-	-
T/03/08134/W	Wedges Mill Housing Estate	STWL	Other	27/03/2000	247	-	-

Consent Number	Consent Name	Consent Holder	Details	Revoked?	Distance to Hatherton Canal (m)	DWF (Ml/d)	Max Daily (Ml/d)
T/03/20275/R	Four Crosses WWTW	STWL	WWTW Treatment Works	08/10/2001	259	0.006	-
T/03/35615/R		STWL			259	0.006	-
T/03/14132/SG	Four Crosses Inn	Marstons Plc	Food + Beverage Services/ Cafe/ Restaurant/ Pub	01/10/1996	260	-	0.006
T/03/21341/R	Cannock Sewage Treatment Works	STWL	WwTW/Sewage Treatment Works	08/01/1998	268	17.6	-
T/03/35236/R		STWL		29/12/2005	268	17.6	-
T/03/36222/R		STWL			268	17.6	-
3/28/03/0867	1 The Malthouses	Mr & Mrs D J Reynolds	Domestic property (single) (incl farm house)		278	-	0.001
T/03/12304/O	Woodlands Lane	STWL	Pumping Station on Sewerage Network		309	-	-
T/03/01630/O	Longford Industrial Estate	STWL	Other	27/03/2000	310	-	-
T/03/01489/O	Wellington Drive Pumping Station	STWL	Pumping Station on Sewerage Network		327	-	-
T/03/21346/T	Sutherland Opencast Coal Site	British Coal Opencast	Mining of Coal + Lignite	08/10/1996	332	-	6.48
T/03/12884/O	New Bridgetown SPS	STWL	Pumping Station on Sewerage Network		350	-	-
T/03/21951/T	Premises At Coppice Lane	B S Eaton Ltd	Making of Glass/Ceramics/ Cement/Cutting Stone		389	-	0.06
T/03/30249/O	Wellington Drive SPS	STWL	Storm Tank/CSO on Sewerage Network		405	-	-

Consent Number	Consent Name	Consent Holder	Details	Revoked?	Distance to Hatherton Canal (m)	DWF (Ml/d)	Max Daily (Ml/d)
T/03/00250/O	Cheslyn Hay/Great Wyrley/Saredon	STWL	Storm Tank/CSO on Sewerage Network		447	-	-
T/03/21311/O	Station Road/103 Walsall Road CSO	STWL	Storm Tank/CSO on Sewerage Network		470	-	-

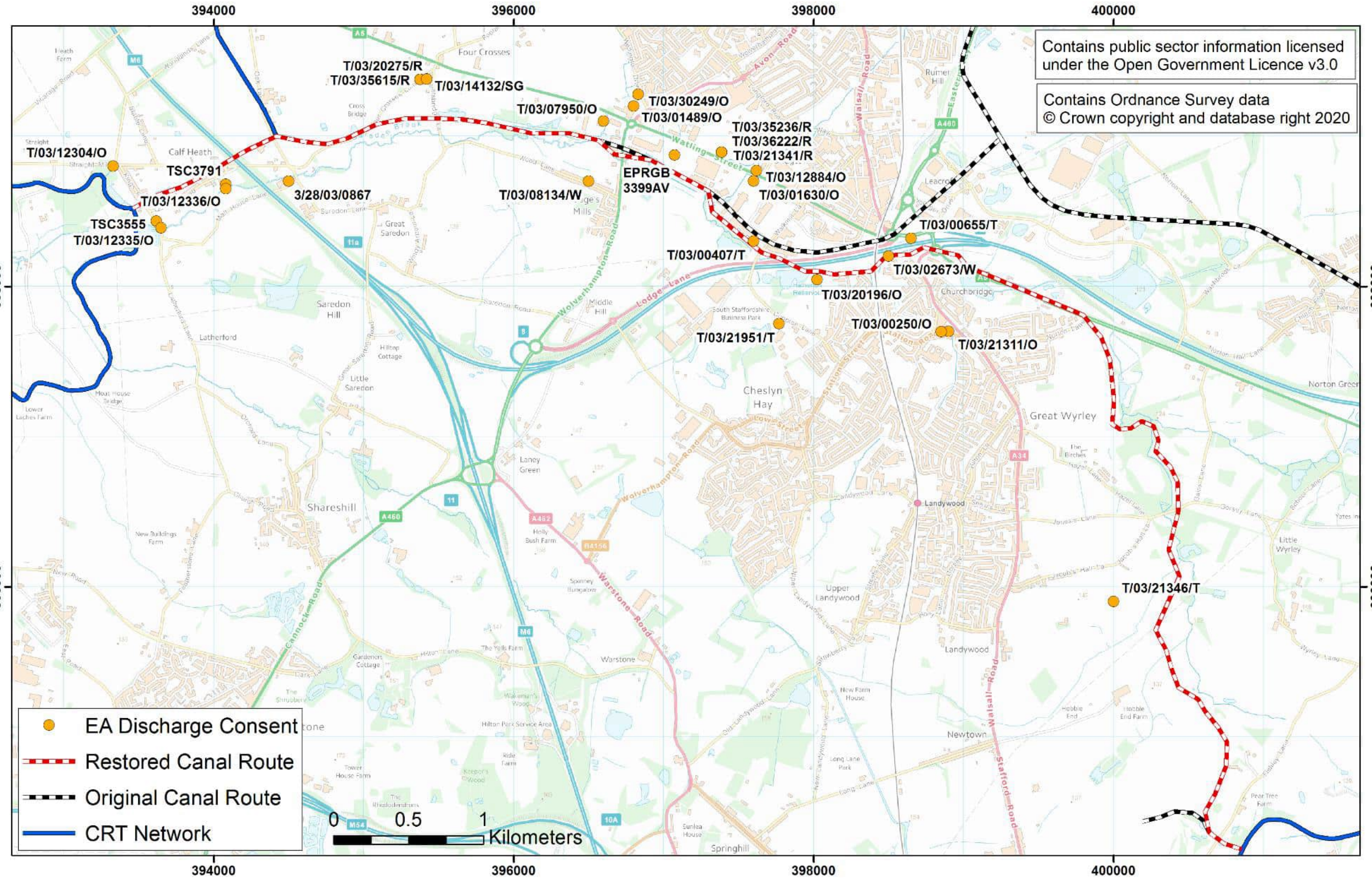

Figure 3.8 Discharge consents

3.5.3 Mining

The whole length of the proposed canal route lies within the South Staffordshire coal mining reporting area (Figure 3.9). The Coal Authority's reporting boundary falls 0.8 km west of Hatherton Junction and 3 km east of Cannock Extension Canal. Any underground works that are undertaken within this area require permits from the Coal Authority.

Brownhills area, 1.3 km to the east of Cannock Extension Canal, and Great Wyrley beneath Great Wyrley town, both have an extensive history of coal mining. Coal was extracted from the Upper Coal Measures and several historical coal mining pits and their associated shafts were located in the area, including Wyrley Grove Pit which is located in Wyrley Common. The location of Wyrley Grove Pit and two Coal Authority boreholes, School Lane and Cathedral Pit, are shown on Figure 3.9 as these may represent potential sources of water for the canal. Groundwater levels at Wyrley Common are at c.130 mAOD (pers. comm. Lee Wyatt, Coal Authority, 15/09/2015 & 25/11/2015). The Coal Authority borehole at Cathedral Pit lies on Wyrley Common and has a datum of 155.5 mAOD, therefore it is expected groundwater levels in the locality are approximately 25.5 metres below surface. The Coal Authority does not hold water quality records for this location.

The Canal route crosses several historical mine working areas, passing numerous shafts around Churchbridge and coming within 300 m of several shafts at The Birches, approximately 1.5 km south-east of Churchbridge. Several more shafts lie within 100 m of the proposed canal route at the junction with the Lord Hayes Branch, close to Fishley Junction. It will be necessary to investigate the potential for mining-induced land subsidence that has been recorded in the Cannock Chase area.

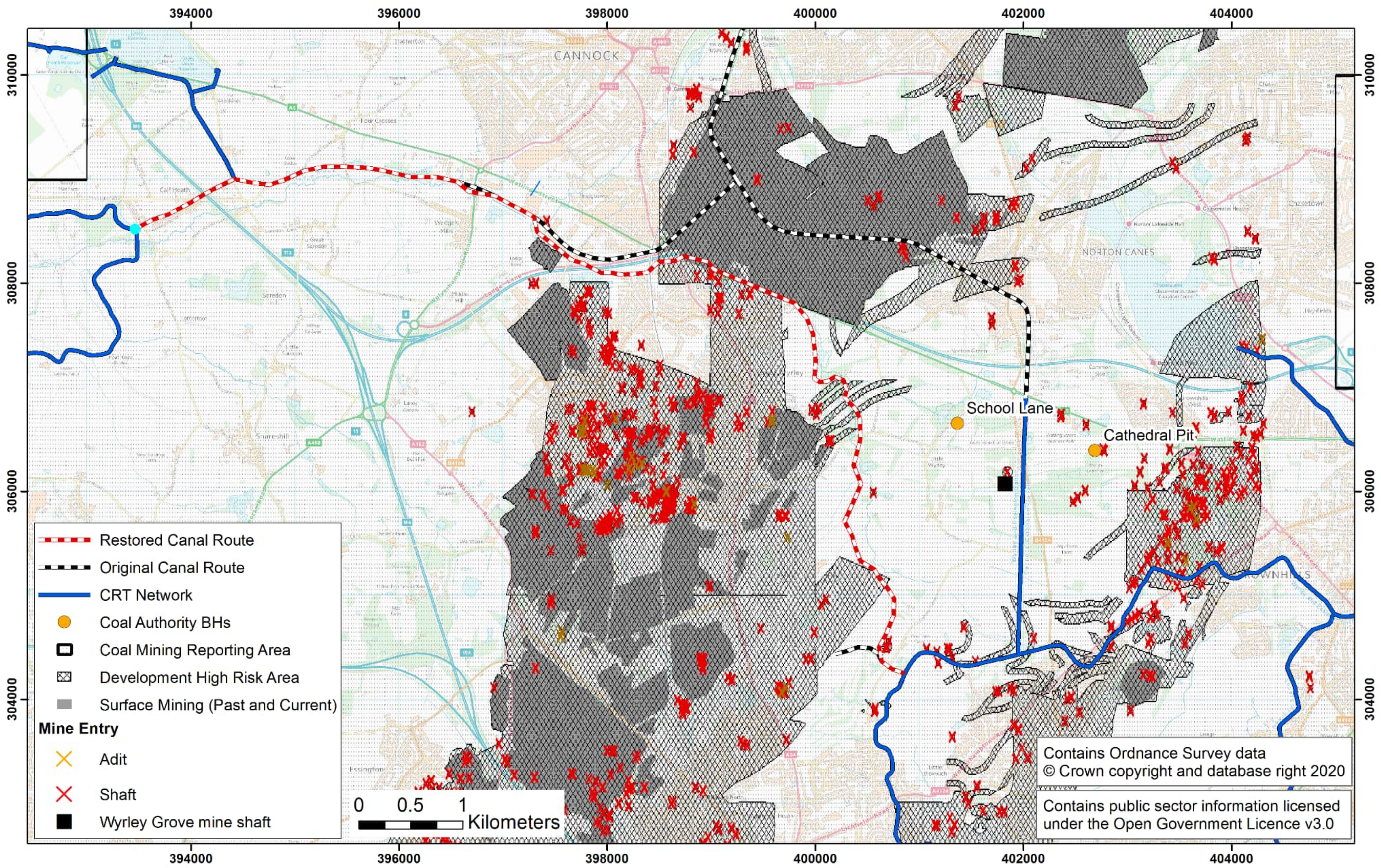

Figure 3.9 Coal mining areas in relation to the proposed canal route

4 Water Supply Demand (WSD) Assessment

The EA is responsible for the regulation of water abstraction though the issuing of abstraction licences for removal of water from watercourses or groundwater. Following the enactment of secondary legislation permitted under the provision of Water Act 2003 Section 5, EA regulation now extends to navigation authorities including CRT. This recent change may have implications for the availability of water from CRT's network. The EA has concerns regarding the availability of water for abstraction along the route of the canal and has recommended that a WSS is undertaken before full restoration takes place.

In addition to any licence issued by the EA for abstraction from watercourses (which includes CRT's canal network) or groundwater, CRT may need to agree to supply water from the canal network, whether on a temporary (back-pumping) or permanent basis. CRT will need to understand the potential demand and implications for CRT across its wider canal network in supplying such demand and take into account the impact, if any, on water availability due to the removal of the abstraction-for- navigation exemption mentioned above.

4.1 Assessment Approach and Model Development

The modelling work presented here is based on bespoke models and methodologies developed by CRT to manage its canal network. The results are therefore expected to be acceptable to CRT. CRT has been provided with input data from Stantec for its leakage models, lockage models and boat traffic models. All model outputs are discussed in the sections below for water supply demand purposes.

The water demand for the initial infill volume of the fully restored canal was calculated using the canal geometry outlined in Atkins (2009). This is presented in Section 4.2.1. Water demands resulting from the operation of the fully restored canal (evaporation losses, losses through the base of the canal and lockage water) were calculated by CRT (Appendix A) and presented in Sections 4.2.2 and 4.2.3.

CRT calculated lockage estimates based on radial decay functions that account for the distance of the proposed restored canal to the existing canal network (Appendix A). This method was used to account for the increase in boat traffic resulting from the following two scenarios:

- Full restoration of the Hatherton Canal;
- Full restoration of both the Hatherton and Lichfield Canals.

CRT then assessed the potential impacts of the two scenarios above on the existing CRT network – full restoration of the Hatherton Canal alone, and full restoration of the Hatherton and Lichfield Canals in combination.

The results for both these scenarios were extrapolated to assess how water demands change based on likely restoration scenarios as outlined in Section 6.1.

4.2 Full Restoration

4.2.1 Initial fill volumes

As well as a water supply to sustain operating conditions, the canal would need to be filled during the initial restoration. The canal remains constructed and in water from Hatherton Junction to Meadow Lock (Figure 1.1), and the section from Meadow Lock to Fishley Junction that remains to be filled is 8.7 km in length.

It has been assumed from the Atkins feasibility report (Section 2.1.3, Atkins, 2009) that the average width of the canal is 9 m and an initial depth of the cut will be 1.5 m. Small sections, including pinch points, bridges, locks and winding holes will vary from these dimensions but they represent a reasonable average for the canal. Based on these assumptions the volume required to fill each section is shown in Table 4.1.

Table 4.1 Restoration section volumes

Section	NGR start point	NGR end point	Length (m)	Volume (Ml)
Hatherton Junction to Meadow Lock	SJ 393461 308520	SJ 395964 309054	(2660)	Already filled
Meadow Lock to M6 Toll tunnel	SJ 395964 309054	SJ 397860 308141	2224	30.0
M6 Toll tunnel to Fishley Junction	SJ 397860 308141	SJ 400856 304251	6469	87.3
		Totals	**8693**	**117.4**

It is likely the volumes in Table 4.1 represent an overestimate for the initial fill. This is due to the assumption of a rectangular canal cross section: the canal profile is estimated to have a trapezoid shape with “at least a 7.2 m wide section” at the base (Atkins, 2009).

The initial infill rate would have to be corrected (increased) to account for the losses during the infill period (Section 4.2.2).

4.2.2 Water losses

Loss estimates have been undertaken for the fully restored canal using the existing bespoke loss model produced by CRT to assess the impacts of the Lichfield Canal Restoration in 2015. This model includes the same climatic inputs as those applied to the Lichfield Canal Restoration as the Hatherton Canal is a maximum of 18 km from the Lichfield Canal. The soil permeability and landscape codes have been updated to reflect the differences in soil type, underlying geology and terrain between the two planned routes. The loss model includes evaporation and is derived from loss profile records derived in the period 1918 – 2003.

Losses have been estimated based on four lining scenarios and a summary of CRT’s calculations is presented below (Table 4.2).

Table 4.2 Lining scenarios considered in CRT modelling

Lining scenario number	Lining scenario	Type	Length	Loss (%)
1	Best case	Geomembrane (e.g. Bentomat)	Whole canal	10
2	Less best case	Very Low Density Polyethylene (VLDP) or New Puddle Clay		30
3	Less worst case	New concrete		35
4	Worst case	Lining in just a few selected areas		45

The CRT model allows a further "worst case", 'no lining over deep coarse sand/gravel' but this was considered unrealistic and not used. The numbers following each scenario are factors used in the CRT model and are not arithmetic – bentonite is more than 10 times more efficient than no lining for example – and include factors other than permeability.

The results of the modelling to estimate loss rates on the fully restored canal are shown below in Table 4.3.

Table 4.3 Modelled loss rates

Lining scenario	Average summer loss rate (Ml/km/wk)	Summer range (Ml/km/wk)
Geomembrane (e.g. Bentomat)	0.50	0.20 – 0.80
VLDP* or new Puddle Clay	1.11	0.45 – 1.78
New concrete	1.25	0.50 – 2.00
Lining in just a few selected places	1.70	0.68 – 2.73

*VLDP = Very low density polyethylene

Based on the assumption that the fully restored canal will be 8.7 km in length between Fishley Junction and Meadow Lock (i.e. not including the section already constructed and in water), the average summer weekly loss rate is estimated to range from 4.4 Ml/wk to 14.8 Ml/wk, depending on the lining type chosen. On a daily basis, this is equivalent to an average loss demand of between 0.6 Ml/d and 2.1 Ml/d.

The loss rates, being expressed by CRT as average loss rates, have accounted for infrastructure deterioration. It is anticipated that the canal would lose less water in the initial years and gradually lose more water as the infrastructure deteriorates.

4.2.3 Lockage

Losses due to lockage (i.e. the movement of boats through the Canal), requires the modelling of boat traffic through the canal. This has initially been estimated using CRT traffic data from surrounding areas (data taken from the CRT Annual Lockage Reports, 2000 onwards). Figure 4.1 is taken from the CRT (2019) report and shows the approximate line of the restored canal in red and the locations of annual lockage totals available from CRT represented by lock symbols.

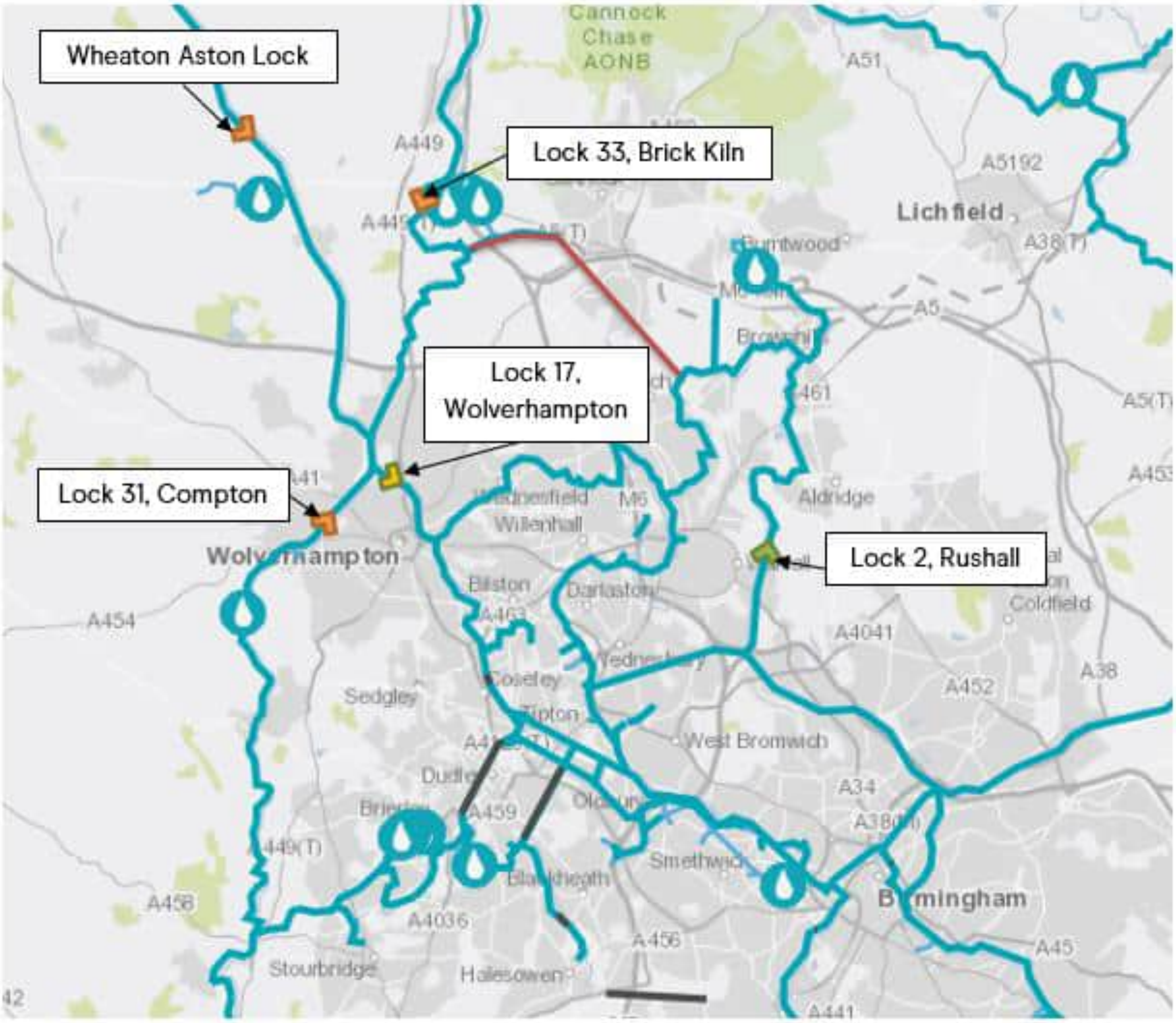

Figure 4.1 Location of CRT lockage data

The estimated number of lockages on the restored canal from each of the recorded lockage locations above are shown in Table 4.4.

Table 4.4 Recorded annual lockage data

Lock	Min	Max	Latest	LTA[1]	Period
Lock 2, Rushall	143	356	155	253	2009-18, 2014 missing
Lock 17, Wolverhampton	1350	2819	1754	1809	2000-18, 2007 missing
Lock 31, Compton	3468	4661	3468	3497	2002-17
Lock 33, Brick Kiln	4982	7044	5182	5128	2002-18, 2006 missing
Wheaton Aston Lock	5486	8630	5558	5625	2000-18, 2006-08 missing

[1] LTA based on previous 3 years data (where available)

Summating the boat traffic that will approach the canal from all available routes provides an estimate of total lockage in the restored canal. Using the CRT boat traffic model, the total number of lockages on the restored canal at Fishley Junction is estimated to be 32 lockages per year and at Hatherton Junction is estimated to be 4636 lockages per year, giving a total estimated annual lockage on the Hatherton Canal from both Junctions of 4668.

The CRT boat traffic model assumes:

- Traffic flows in the new network will divide equally at Hatherton Junction and Fishley Junction, with half the traffic at each junction going in each direction;
- All boat movements from the above locations are in the direction of the nearest proposed junction with the restored canal (shortest distance chosen if more than one option).

With the total number of lockages on the restored Hatherton Canal estimated to be 4668 at current rates, this gives a corresponding annual water demand of 791 Ml (Table 4.5).

Table 4.5 Estimated annual lockage for the fully restored Hatherton Canal

Year	Total Number Lockages	Total Lockages (Ml/yr)	Peak Weekly Lockage (Ml/wk)	Average Daily Lockage in a Peak Week (Ml/d)	Peak Daily Lockage (Ml/d)
Baseline	4668	*791*	35.6	5.08	8.89
1	4738	802	36.1	5.16	9.03
5	5018	850	38.2	5.46	9.56
10	5368	909	40.9	5.85	10.23

The volume of water required per lock was initially calculated based on the dimensions of a standard narrow lock which were stated in the feasibility study (Ove Arup, 2006); these were also the dimensions used to generate results from the CRT boat traffic model. Lock chambers will be 2.3 m in width and 26.3 m in length. However, there was a discrepancy over the maximum depth of lock chambers. According to Ove Arup (2006), lock chamber depths vary between 1.3 m and 2.7 m depending on location, with the deepest lock chamber being 2.7 m deep. However, Atkins (2009) designed almost all lock chambers to be 2.8 m depth, with an exception at Colliery Lock (3.0 m deep).

For the above calculations (Table 4.5), a maximum lock chamber depth of 2.8 m was used in order to determine the most realistic lockage estimates. This value results in a maximum lock chamber volume of 0.169 Ml. This is <4% increase above the lockage estimates based on the Ove Arup (2006) dimensions (2.7 m maximum depth). However, lock chamber dimensions are preliminary and yet to be finalised.

Peak weekly lockage is then calculated based on the assumption that it is equivalent to 4.5% of the annual total and that the peak daily lockage is 25% of peak weekly lockage. Future lockage was estimated by using existing annual lockage totals, 2000 onwards, then applying a non-compounded percentage increase of 1.5% per year in boat movements/lockage in future (the current national growth in boat numbers, (British Waterways, 2011)).

4.3 Impact of Full Restoration on the Existing CRT Network

CRT assessed the potential impacts of the full restoration of the Hatherton Canal on the existing CRT network. This was assessed using the CRT Water Resources Model that looked at the impacts of adding a virtual customer to the model at both Ogley and Huddlesford Junctions. This assessed whether the demand on the restored canal could potentially be met by existing CRT resources. This stage of the modelling did not account for any additional boat traffic that may be created on the wider connected CRT canal network as a result of the full restoration of the Hatherton Canal.

A total of six scenarios were run. These are detailed in Table 4.6 along with the results of the modelling. Best case scenarios include the estimated demands assuming the canal is lined with a geomembrane (e.g. Bentomat) along the whole of the canal and the baseline annual lockage estimate (Table 4.5). Worst case scenarios include the estimated demands assuming the canal is lined in only a few selected areas and the Year 10 annual lockage estimate (Table 4.5).

Table 4.6 Results of CRT modelling for Hatherton Canal on the existing CRT Network

Scenario	Description	Result
1	Best Case – 100% of demand at Hatherton Junction, SU and S&W	Net impact on the level of service of the SU and S&W Hydrological Unit.
2	Worst Case – 100% of demand at Hatherton Junction, SU and S&W	Net impact on the level of service of the SU and S&W Hydrological Unit.
3	Best Case – 100% of demand at Fishley Junction, Wolverhampton, BCN	No net impact on the level of service of the BCN Hydrological Unit, nor the wider canal network.
4	Worst Case – 100% of demand at Fishley Junction, Wolverhampton, BCN	No net impact on the level of service of the BCN Hydrological Unit, nor the wider canal network.

5	Best Case – 50% of demand at Hatherton Junction, SU and S&W, 50% of demand at Fishley Junction, Wolverhampton, BCN	Net impact on the level of service of the SU and S&W Hydrological Unit.
6	Worst Case – 50% of demand at Hatherton Junction, SU and S&W, 50% of demand at Fishley Junction, Wolverhampton, BCN	Net impact on the level of service of the SU and S&W Hydrological Unit.

Two further scenarios were run to assess the impact of both the Hatherton and Lichfield Canal Restorations together on the Trust's network (Table 4.7).

Table 4.7 Results of CRT modelling for both the Hatherton Canal and Lichfield Canal on the existing CRT Network

Scenario	Description	Result
7	Hatherton Canal Worst Case with Lichfield Canal Worst Case: • Hatherton Scenario 2 (100% demand at Hatherton Junction) • Lichfield Scenario 4 (50% demand at Ogley Junction and 50% demand at Huddlesford Junction)	Net impact on the level of service of the SU and S&W Hydrological Unit.
8	Hatherton Canal Best Case with Lichfield Canal Best Case: • Hatherton Scenario 3 (100% demand at Fishley Junction) • Lichfield Scenario 1 (100% demand at Ogley Junction) • [Both from Wolverhampton Level]	No net impact on the level of service of the BCN Hydrological Unit, nor the wider canal network.

All eight of the above scenarios were run using the CRT Boat Traffic Model and an assumption that the maximum lock volume is 0.163 Ml, rather than the more probable 0.169 Ml used to calculate estimates in Table 4.5. Further communication from CRT has advised that it is unlikely that the minimal increase in lockage demand as a result of the revised lock volume would change the overall outcome of their modelling (pers. comm. Kathryn Maye, CRT, 03/02/2020). Therefore, the conclusions of CRT remain as described below.

The results show that for the full restoration of the Hatherton Canal alone, there is no net impact on the level of service of the BCN or any neighbouring hydrological unit on the CRT network, providing 100% of the demands are met from the BCN Hydrological Unit. In conclusion, the demands on the fully restored canal could potentially be met from the CRT network.

For the full restoration of both the Hatherton and Lichfield Canals in combination, the results showed that there is no net impact on the level of service of the BCN or any neighbouring hydrological unit on the CRT network, again, providing 100% of the demands are met from the BCN Hydrological Unit. In conclusion, the demands on both fully restored canals could potentially be met from the CRT network.

4.3.1 Additional demand on the wider CRT network as a result of the restoration

Impact of additional demand on the wider CRT network has been estimated for the restoration of the Hatherton Canal. Following this, modelling results of the wider impact of the restoration of the Lichfield Canal (ESI, 2015) have then been considered together with modelling of the Hatherton Canal, to estimate impacts of additional demand on the wider CRT network from restoration of both the Hatherton and Lichfield Canals together.

Additional boat movements, from current baseline, within 5 km of either end of the restored Hatherton Canal have been estimated based on a percentage increase. This suggested that an increase in annual boat movements of 50% could be expected in the immediate vicinity of the restored canal. A decay rate was then applied up to a distance of 50 km from each junction of the restored canal, reducing the number of expected boat movements with increasing distance from Hatherton Canal (see Table 4.8). This methodology is based on work undertaken by CRT in 2000 to estimate boat movements in association with the restoration of Droitwich Canal.

Table 4.8 Percentage increase in boat movements with distance from the restored canal

Distance from Canal Junction (km)	Percentage Increase in Boat Movements (%)
< 5	50
< 10	40
< 20	25
< 30	15
< 40	7.5
< 50	3.75

Using the above methodology, an increase in annual boat movements has been estimated at strategic locks within five hydrological units within 50 km of the restored canal. In order to assess the impact of these additional boat movements on the CRT network, boat movements were converted to lockage using a boat to lockage ratio of 1.4:1 for narrow locks and 2.6:1 for broad locks. These were then converted to lockage demands using a lock volume of 0.1 Ml and 0.2 Ml for narrow and broad locks, respectively. This additional lockage demand was then added to the current demand for each hydrological unit. Results of the modelling are presented in Table 4.9, showing the additional lockage demands estimated for each hydrological unit within 50 km of the Hatherton Canal restoration, and the Hatherton and Lichfield canals both restored.

Table 4.9 Additional lockage demand on the wider CRT network after restoration

Hydrological Unit	Hatherton Canal		Hatherton & Lichfield Canals	
	Additional Annual Lockage Demand (Ml/yr)	Net impact[1]	Additional Annual Lockage Demand (Ml/yr)	Net impact[1]
BCN	287	No	502	No
Oxford & GU	0	No	163	No
10 Mile	14	No	57	No
Peak & Potteries	321	No	432	No
Shropshire Union/S&W	771	Yes	866	Yes

[1] Net impact of additional demand on the wider CRT network after full restoration

The results of this modelling show that for both restoration scenarios there is no net impact on the level of service of the BCN, Oxford & GU, 10 Mile or Peak & Potteries Hydrological Units. However, for restoration of the Hatherton Canal (and therefore for the combined scenario of both canal restorations), there is a net impact on the level service of the Shropshire Union and Staffordshire & Worcestershire Canals Hydrological Unit.

The additional water demand resulting from the full restoration of the Hatherton Canal could not currently be met by CRT's network alone. Alternative sources of supply to meet the estimated demands on the wider CRT network as a result of the restoration of the Hatherton Canal will therefore need to be investigated by Stantec/LHCRT.

4.4 Summary of the Potential Water Demand

There is significant uncertainty over the actual water demand required to operate the canal, arising principally from choice of lining material, popularity of the route, the overall growth in boating and the success of the associated marinas. These uncertainties are summarised in Table 4.10, where the likely maximum and minimum water requirements are shown for each of these uncertainties and a "most probable" estimate made for each. The columns are all additional, so adding up water requirements across the table provides an estimate of the highest, lowest and most likely water requirements for the restored canal over the next 10 years.

Table 4.10 suggests that the average daily water demand is most likely to be around 6.7 Ml/d but could peak at 11.3 Ml/d in periods of high demand. The following assumptions have been made to calculate the water demand shown in Table 4.10:

1. The loss rates assume an "average" level of maintenance, so the canal might achieve a lower loss rate in the first few years but then settle to an average loss similar to that in Table 4.10.
2. Good lining installed along the whole length (bentonite over most of the canal's route over Permo-Triassic sandstone where groundwater is largely depressed, see Figure 3.1 and Figure 3.2);

3. Traffic volumes between annual average and peak rates;
4. Annual growth between historic 1.5% per year and no growth.

Beyond ten years the uncertainties increase even further, particularly with economic circumstances determining overall usage and deterioration of infrastructure becoming more significant if not adequately managed.

Table 4.10 Summary of water demand uncertainties

	Loss Rate (Ml/d) *	Traffic (Ml/d) **	10 years Additional Annual Growth (Ml/d) ***	Total (Ml/d)
High	2.11	8.89	0.32	11.3
Low	0.62	2.17	0.00	2.79
Most Probable	1.38	5.08	0.23	6.69

* High = canal lined in a few selected places, Low = geomembrane lining, Most probable = approximate average of high and low values, which corresponds to puddle clay lining for 100% of the canal length
** High = peak daily lockage, Low = annual lockage/365, Most probable = average daily lockage in a peak week
*** High = 1.5% per year growth, Low = no growth, Most probable = 1% per year growth

Table 4.11 summarises CRT modelling results on the potential impacts on the wider CRT network of full restoration of the Hatherton Canal and the Hatherton and Lichfield Canals together.

Table 4.11 Summary of CRT modelling of potential impacts of restoration

	Full restoration of Hatherton Canal	Full restoration of both Hatherton and Lichfield Canals
Impact of demand on the restored canal(s)	No net impact on the CRT network, providing 100% of demand is met from the BCN Hydrological Unit. Demands, including lockage and losses, on the fully restored canal could potentially be met from the CRT network.	No net impact CRT on the network, providing 100% of demand is met from BCN Hydrological Unit. Demands, including lockage and losses, on both fully restored canals could potentially be met from the CRT network.
Impact of additional demand on wider CRT network	No net impact on the BCN, Oxford & GU, 10 Mile or Peak & Potteries Hydrological Units. Net impact on Shropshire Union and Staffordshire & Worcestershire Canals for restoration of the Hatherton Canal (and therefore for the combined restoration). Additional demands could not currently be met by CRT’s network alone.	

5 Water Supply Source (WSS) Assessment

5.1 Availability of Water

The proposed route for the restored Hatherton Canal is located in a relatively elevated area near a watershed. There are no major watercourses in the area, and the watercourses that are in the vicinity are smaller headwater tributaries. Groundwater resources in the Sherwood Sandstone Group beneath the western third of the proposed route are also exploited for public water supply and the groundwater table is generally several metres below ground level. This means that local watercourses are generally losing water through the stream bed, as will the canal if left unlined, due to being perched above the groundwater level.

The above factors have resulted in a lack of abundant local water resource in the area. The EA has advised that abstraction from local surface watercourses will be permitted with a HOF restriction (see Section 3.4), while some groundwater resources may also be available provided there is no deterioration to the current WFD status.

There are also some more innovative potential sources of water supply that may be available to the canal which are presented in the following sections.

5.2 Assessment Approach

The assessment is undertaken by providing a list of unconstrained water supply source options in the following sections. These options are then reduced (constrained list of options) based on those that are most likely to be more technically feasible. The constrained list of options can then be assessed against cost/benefit criteria, although this is outside the scope of this work.

5.3 Unconstrained List of Potential Water Sources for the Canal

5.3.1 New surface water abstractions

The proposed canal route would interact closely with the Saredon Brook and the upstream tributaries of the Ridings Brook, Wyrley Brook and Wash Brook. This would mean that it would be relatively straightforward to set up an abstraction from this watercourse (even as a temporary supply).

Based on the waterbody CAMS status, the EA has advised that abstraction from surface watercourses in the Saredon Brook catchment will likely be licensed subject to a HOF restriction downstream at Penkridge (Section 3.4). The HOF indicates there will be no licensed abstraction when flows are below 82 Ml/d at the Penkridge gauge. This flow is equivalent to approximately Q_{75} at this gauge, meaning abstraction would not be allowed for 25% of the time – generally summer months when demand is likely to be highest.

The WRGIS data (Section 3.5) suggests a significant surplus in the Saredon Brook, as 0% of the full licence volume for surface water abstraction has been utilised in the past 5 years while the full volume of licensed discharge is being utilised. The Recent Actual Q_{95} flow is approximately 18.2 Ml/d higher than the natural Q_{95} estimate, indicating that there is a reasonable prospect of the EA granting a new surface water abstraction licence.

Abstraction from the Saredon Brook and upstream tributaries thus appears to be available for much of the year, and is expected to have a yield sufficient to supply the daily lockage volume in a peak week (5.08 Ml/d, see Section 4.2.3). The possibility of a storage solution should be considered to allow abstraction during periods of higher flows and consequent provision of additional flow during lower flow periods.

5.3.2 Licence trading

Several options for purchasing/trading water from existing abstractors and discharge consent licence holders (excluding PWS licences) within 500 m of the proposed canal route have been identified for the initial infill and operation of the canal (see Section 3.5, Figure 3.7 and Figure 3.8). These are listed in Table 5.1.

It is assumed that, for locations over 500 m away from the canal, the cost to acquire land ownership to pipe water to the canal would be prohibitive. Mean daily flow or DWF data are not available for many of the discharge consents and it is recommended that relevant consent owners are contacted to clarify their consent conditions. It is anticipated this would result in most of the discharge consents being discounted from the unconstrained options list due to low discharge volumes.

Two surface water abstractions are included for consideration in Table 5.1. Abstraction license 03/28/03/0205 held by CRT is listed by the EA as having a medium potential for a trade. However, additional headroom in abstraction licences may not be available for use if there is a possibility of causing environmental deterioration.

Table 5.1 Licenced abstractions and consented discharges within 500 m of the canal

Type	Name	Licence Number	Licensed Annual Volume (Ml/a)	Licensed Daily Volume (Ml/d)
SW abstraction	CRT - S&W Canal	03/28/03/0205	11.4	0.82
SW abstraction	Great Saredon Farm	03/28/03/0225	7.37	0.32
Discharge consent	Littlewood Sewage Pumping Station (STWL)	T/03/20196/O	Not available	Not available
Discharge consent	Longford House Pumping Station (STWL)	T/03/07950/O	Not available	Not available
Discharge consent	Latherford Lane SPS (STWL)	TSC3555	Not available	Not available
Discharge consent	Calf Heath No 3 (Queens Road) (STWL)	T/03/12336/O	Not available	Not available
Discharge consent	Cannock Sewage Treatment Works (STWL)	T/03/36222/R	-	17.6
Discharge consent	Woodlands Lane (STWL)	T/03/12304	Not available	Not available
Discharge consent	Wellington Drive Pumping Station (STWL)	T/03/01489/O	Not available	Not available
Discharge consent	New Bridgetown SPS (STWL)	T/03/12884/O	Not available	Not available
Discharge consent	Wellington Drive SPS (STWL)	T/03/30249/O	Not available	Not available
Discharge consent	Cheslyn Hay/Great Wyrley/Saredon (STWL)	T/03/00250/O	Not available	Not available
Discharge consent	Station Road/103 Walsall Road CSO (STWL)	T/03/21311/O	Not available	Not available

5.3.3 Groundwater

This section discusses various groundwater abstraction options to provide sufficient resource to meet demand for the restored Hatherton Canal. These options, together with surface water and discharge consent licence trading options, are summarised in Figure 5.1.

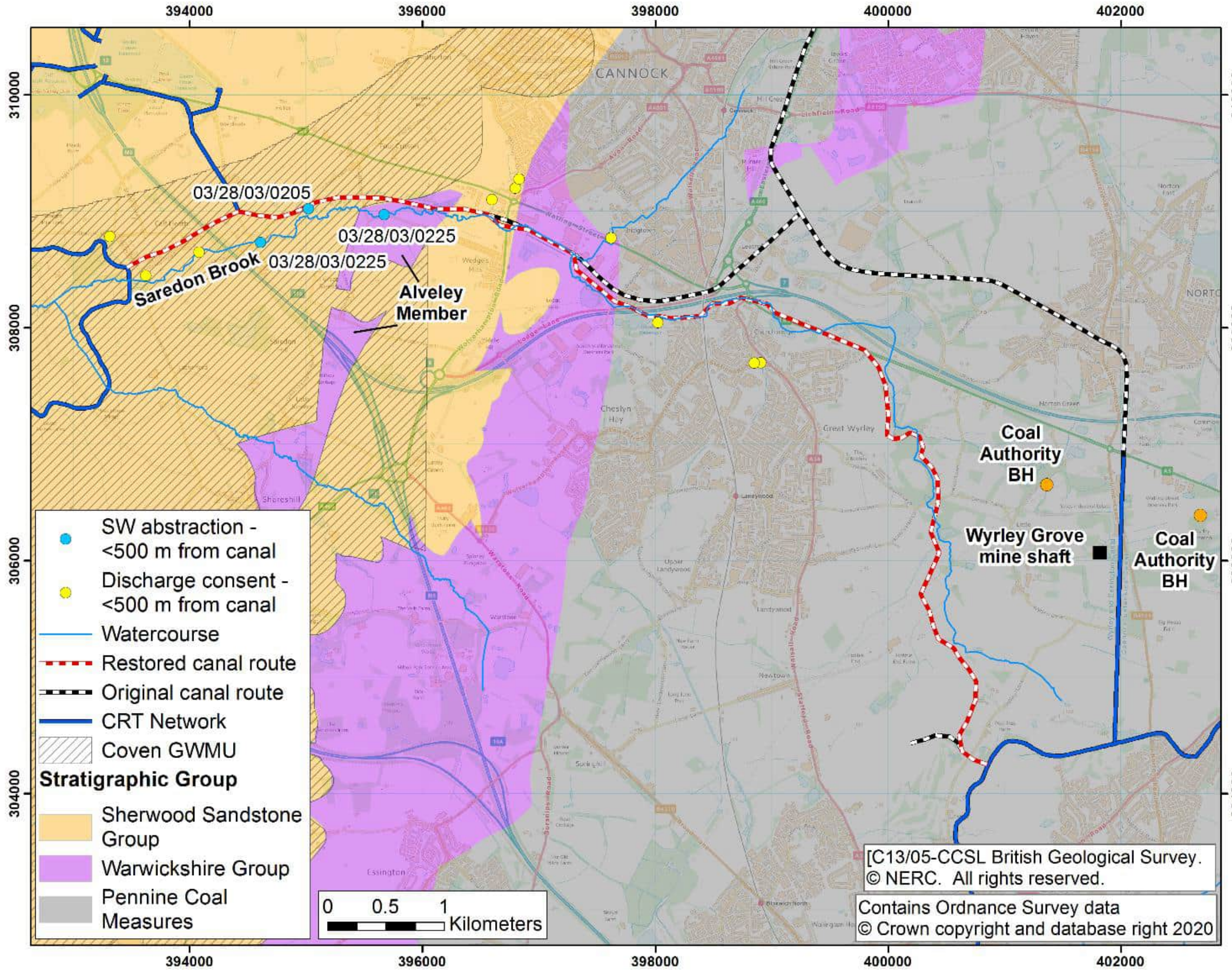

Figure 5.1 Summary of groundwater and surface water abstraction potentially available for water supply

<u>Principal Aquifer – Sherwood Sandstone Group</u>

The western third of the proposed route is underlain by a major aquifer that is abstracted for public water supply (Section 3.5.1 and Figure 3.1). The Staffordshire Trent Valley - PT Sandstone Staffordshire groundwater body in the area is partially open to new abstractions, with Coven GWMU accepting new applications if applicants can ensure no deterioration to the current WFD status. Expected yields from the Sherwood Sandstone aquifer range between 2 – 5 Ml/d; this would provide sufficient supply to cover the daily lockage requirement in a peak week, however 5 Ml/d is at the upper end of achievable yield for this groundwater source. There is already some flow in the lower reaches of the canal and it would be costly to pump sufficient water from the western (downstream) end of the canal up to Fishley Junction, at least 6.7 km away.

However, there is a possibility that abstraction from Coven GWMU and discharge into the lower reaches of Hatherton Canal could partially resolve the potential issue of under-supply in the Staffordshire and Worcestershire Canal, should CRT agree to meet the demand following restoration of the Hatherton Canal.

Secondary A Aquifers – Warwickshire Group

Below the central and eastern sections of the proposed canal route, and below the Sherwood Sandstone aquifer in the west, lie deeper Carboniferous rocks of the Warwickshire Group (sandstones, mudstones and thin coal seams) (Figure 5.1). The proposed canal route crosses the Alveley Member near Four Crosses and the Enville Formation rises approximately 3 km to the south of Four Crosses (Figure 3.1).

Reasonable yields of up to 0.55 Ml/d can be obtained from the red mudstone and sandstone of the Alveley Member (Halesowen Formation, obsolete name Keele Formation), especially from larger diameter boreholes and shafts. This preliminary advice is based upon data presented in Table 8.8 of Jones et al., (2000) which is reproduced in Figure 5.2 below.

Formation	**Member**	**Yield (m^3/d)**			
		Borehole diameter (mm)			
		Up to 203	*203 to 406*	*406 to 610*	*Shafts with or without adits*
Salop or lower Meriden Formation (S Staffs/Warwics)	Enville Member/ upper part Whitacre Member	33.6 to 64.8	108 to 874	no data	2160 to 4320
	Alveley Member/ lower part Whitacre Member (Keele Formation)	Up to 108	Up to 545	Little increase in yield over 406 mm diameter	

Figure 5.2 Table 8.8 from BGS (2000) Report

The Carboniferous strata may be locally in connection with the overlying Permo-Triassic Sandstone and any abstraction from this strata may have some effects on the overlying aquifer which cannot be fully assessed unless more detailed investigations are undertaken.

Secondary A Aquifer – Pennine Coal Measures

The eastern half of the canal route overlies the sandstones, siltstones, mudstones and thick coal seams of the Pennine Coal Measures (Figure 5.1). These have been worked for coal in the past and represent another water resource, independent of the Permo-Triassic Sandstone strata, which might potentially be available.

When undertaking the Lichfield Canal WSS (ESI, 2016), the Coal Authority confirmed that they were not actively pumping in the immediate vicinity of the proposed route and that piezometric heads in the Carboniferous[2] were not far from ground level (c. 130 mAOD) at their Wyrley Common boreholes (2.3 km east of the proposed route). Water could be abstracted from these boreholes, however, rates are likely to be limited (ESI, 2016)

A mine shaft has been identified within the Wyrley Common area, Wyrley Grove, which is located in close proximity to the existing CRT network (Figure 5.1). The Coal Authority has indicated that there may be potential to pump water from this shaft into the existing network, as the CRT is currently

[2] Likely to be representative of the Upper Coal Measures rather than the single Enville/Alveley Members.

doing for the Wolverhampton Canal Network from mineshafts at Bradley, Bilston, which is located approximately 10 km south west of Fishley Junction. If sufficient yields were available, pumping costs would not be prohibitive.

Although pumping from mine shafts is identified as an option, there are several other considerations (abstraction induced subsidence, health & safety from working near abandoned coal mines, etc.) that could discount this option altogether and the risk of these would need to be assessed in more detail with the Coal Authority providing significant backing of the option.

Concerns over water quality (mostly iron and high salinity water) could also make this solution impractical, although water quality generally becomes an issue only when pumping from deep Coal Measures. Water quality may be acceptable if pumping took place in the shallower Carboniferous and avoided drawing in water from deeper coal workings. Abstracted water could potentially be treated and/or mixed with water from other sources to provide an acceptable supply. The availability of this water would be less susceptible to short-term droughts and HOF restrictions due to its depth and the size of the resource, so this source could be usefully kept for drier periods. It is also usefully situated at the top of the proposed canal route, close to Fishley Junction.

Following CRT's experience of pumping mine water from Bradley, it is noted that mine water used to supply the canal is likely to have a high metal content, specifically high concentrations of iron, cadmium, zinc, lead and copper that are usually associated with mine water (email Kathryn Maye, CRT, 08/04/2020). However, there is no current requirement for CRT to undertake any water treatment. CRT has never been required to hold an environmental permit for this abstraction nor a discharge consent (email Kathryn Maye, CRT, 25/03/2020).

Information shared by Phil Sharpe (Inland Waterways) indicates that, in the 1990s, groundwater levels in the Hatherton area were generally high and sometimes under artesian pressure (email Derek Lord, LHCRT, 13/03/2020). Phil Sharpe recommended that abstracting water from existing mine shafts would likely be problematic, but large volumes could be abstracted using new boreholes sunk alongside existing mine shafts and pumping the stored water. He advised there could be significant treatment requirements, which contrasts with the current information that CRT is not treating mine water abstraction from Bradley.

As Hatherton Canal will be linked to the Staffordshire and Worcester Canal, CRT wants to be assured that under the Water Framework Directive, the introduction of any new water feed will not cause a deterioration to the WFD classification assigned to the Staffordshire and Worcester Canal (email Kathryn Maye, CRT, 08/04/2020). A study will have to be undertaken to determine the current water quality of the mine water and nearby canal network and then determine the potential impact of the proposed new feed.

It is recommended that LHCRT approaches the EA, as the regulator, to discuss any requirements in terms of water quality from abstraction at the Wyrley Grove mine shaft. CRT wishes to be made aware of any response or advice from the EA regarding water quality issues from mine water pumping.

Costs of providing a borehole to exploit this source, and the likely quality of the water abstracted, will require further investigation.

5.3.4 Surface water from residential development

There is limited extent of allocated development that could discharge to the canal (Figure 5.3). South Staffordshire District Council have published a Site Allocation Document showing two sites close to the proposed canal route that have been safeguarded for residential development under policy SAD2.

Cannock Chase District Council has not designated any land within 2 km of the proposed canal route as a Strategic Housing Site or Safeguarded Land for Possible Development Post 2028 (both under Policy CP6). However, in the CCDC's 2018 Strategic Housing Land Availability Assessment, three sites in Bridgetown (south Cannock) close to the proposed canal route were allocated as 0-5 year development sites or 6-15 year development sites.

Walsall District Borough Council has no development plans or allocated land for development close to the proposed canal route.

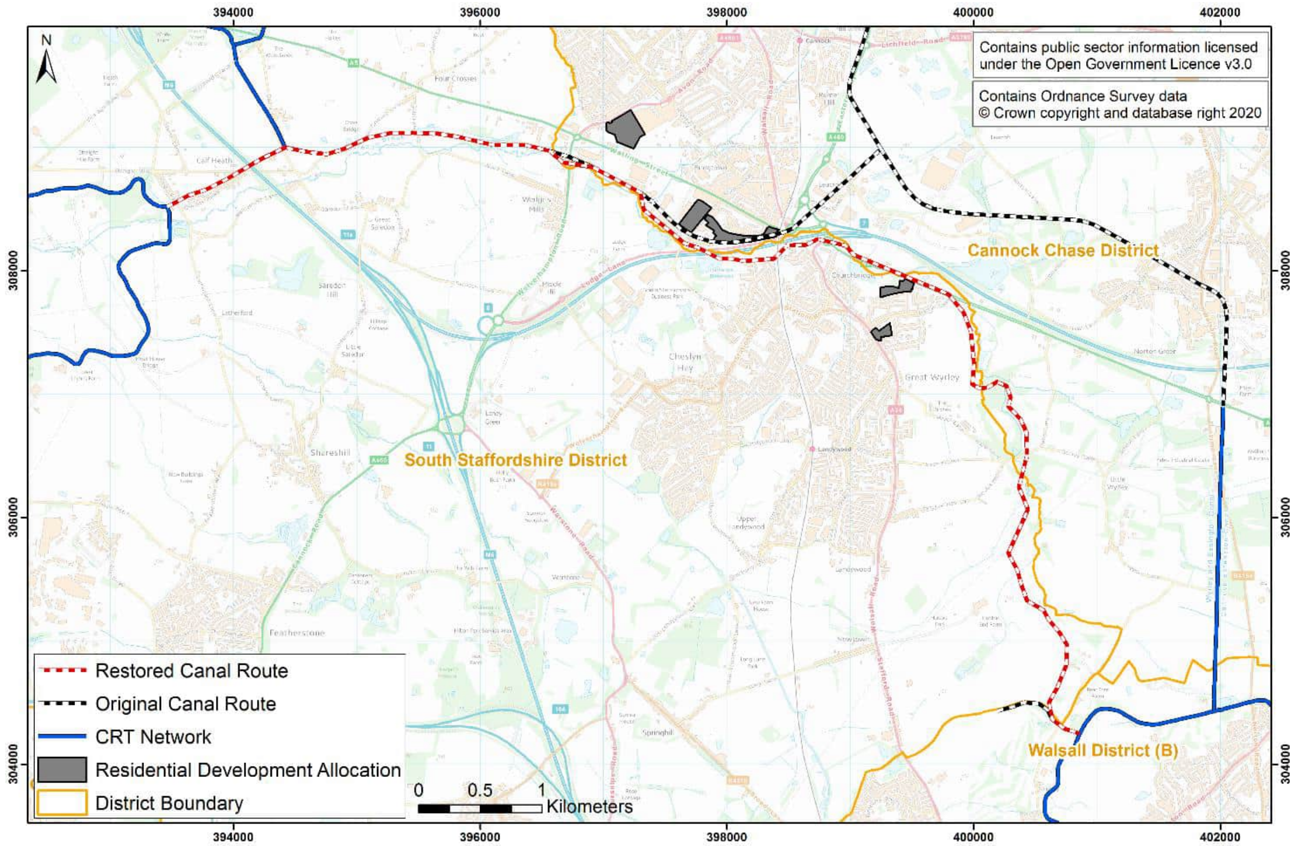

Figure 5.3 Residential development allocation

Table 5.2 shows the estimated size of each development[3] and the estimated run-off that would be generated from each. To estimate the potential runoff that could be captured from these sites it has been assumed that each has 60% impermeable cover (roofs, roads and driveway/car parking areas), with the remaining 40% being gardens and public open space that are not formally drained.

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[3] Catchment size for the Great Wyrley sites is based on information provided by South Staffordshire County Council. The catchment size for the Bridgetown sites was based on estimations using Cannock Chase Council online mapper.

Estimates are based on the daily recorded rainfall at Rodbaston station between 1986 and 2019, located approximately 3.4 km north west of Hatherton Junction. Run-off is then calculated to be 60% of the annual average rainfall minus a 5 mm per day interception rate. This accounts for industry best practice to prevent any runoff from the first 5 mm of rainfall in a new development[4].

Table 5.2 Estimated run-off from safeguarded residential development land

Name	Total Size (Ha)	Run-Off (Ml/yr)	Run-Off (Ml/d)
South Staffordshire District Council – site reference 141	1.2	1.7	0.005
South Staffordshire District Council – site reference 139	2.2	3.2	0.009
Cannock Chase District Council – 0-5 year site	4.4	6.3	0.017
Cannock Chase District Council – 6-15 year site	3.3	4.7	0.013
Cannock Chase District Council – 6-15 year site	5.5	7.9	0.022
Total	**16.6**	**23.8**	**0.065**

5.3.5 Existing highway drains and public water sewers

There are no public surface water sewers in STWL records that align with the proposed canal route and therefore this is not considered to be a potential water supply for the Hatherton Canal.

There are thirteen existing highways that are located on the line of the Hatherton Canal (Table 5.3). Some of these have drains that would hard clash with the restored canal and thus have to be removed by diversion, while others do not clash with the canal restoration but are capable of diversion. It is assumed both hard clash and no clash drains have the potential to be used as an intermittent source of water supply. It has been confirmed by the EA that removal of water from piped drains and sewers is not legally deemed to be an abstraction. However, any diversion would need to be undertaken with the consent of the owner and take account of environmental impact.

It is anticipated there will only be limited interaction between the Hatherton Canal and road infrastructure, mainly at the tunnel crossing beneath the A5 east of Cannock and the tunnel crossing beneath the M6.

The planned A5 canal crossing appears on Highways Agency Drainage Data Management Systems (HADDMS) plans to cut through the highway drains, requiring them to be diverted into the canal. An

[4] It is prudent to expect that new housing will meet this standard even if it is not statutory. Guidance and best industry practice require that the first 5 mm are intercepted at the source and not drained to surface water bodies. The first 5 mm are therefore expected to be lost under some form of retention at the source.

existing canal culvert passes beneath the M6 approximately 750 m east of Hatherton Junction. The highway drains pass over the canal culvert in its current state and there is no discharge into the canal course. The canal culvert under the M6 will require modification to navigation dimensions, after which it is likely that there will be a clash with the highway drainage system and the motorway drainage catchment to the north will be diverted into the canal.

Table 5.3 Estimated run-off from highway catchments

Highway name	Approximate catchment length (km) *	Carriageway width	Run-Off (Ml/yr)	Run-Off (Ml/day)
M6 Motorway	0.6	13 m	5.0	0.014
A5 at Cannock	1.7	8 m	8.7	0.024
Kings Road	0.1	4 m	0.26	0.001
Straight Mile	0.4	4 m	1.0	0.003
Oak Lane	0.7	4 m	1.8	0.005
Four Crosses Lane	0.6	4 m	1.5	0.004
Catsbridge Lane	0.3	4 m	0.77	0.002
Wolverhampton Road	1.5	4 m	3.8	0.010
Walkmill Lane	0.06	4 m	0.15	0.000
M6 Toll Motorway	0.5	4 m	1.3	0.003
A5 Roundabout at M6 Toll	0.1	4 m	0.26	0.001
Gorsey Lane	0.2	4 m	0.51	0.001
Fishley Lane	0.15	4 m	0.38	0.001
Totals	**6.91**	**-**	**25.454**	**0.070**

* Calculated using LIDAR data (downloaded from DEFRA, 06/02/2020) to determine approximate roadway elevation gradients

Run-off estimates are based on the daily recorded rainfall at Rodbaston station between 1986 and 2019. Run-off from highway drains draining trunk roads is calculated to be 100% of the annual average rainfall minus a 2 mm per day interception rate[5] (see Table 5.3). The catchment area is calculated per km based on a single lane, dual or triple carriageway road having a width of 4 m, 8 m or 13 m, respectively (including the hard shoulder where applicable).

5.3.6 Backpumping

Water in the canal can be re-used by pumping from a topographically lower pound to a higher pound, where it can refill locks after use. Clearly this can reduce water requirements for lockage water but cannot make up for water losses through seepage and evaporation. It therefore offers a partial

[5] 2 mm is used to account for evaporation from the road surface. It is assumed no rainfall infiltrates on road surfaces as the surface is impermeable.

solution and one that could be used to reduce water need particularly in times of water stress. It is common practice in parts of the canal network which are particularly short of water resources.

Backpumping can be a temporary measure using mobile pumps, generators and temporary pipes laid along the canal bank or could be a more permanent arrangement built into the canal infrastructure. Either option involves operational costs related to the pumping, plus hire fees and regular inspection for the temporary backpumping solutions. It is therefore an option that is best used sparingly, either where no other feasible water supplies can be found for a particular pound or where short-term support is required.

Backpumping could also be of particular use during some of the early to middle restoration phases when the upper, restored, part of the canal may be connected to the Wyrley and Essington Canal (BCN) but isolated from the lower part of the Hatherton Canal.

5.3.7 Cannock STW

Cannock Sewage Treatment Works is located approximately 300 m north of the proposed canal route, close to derelict Lock 5. It currently discharges treated final effluent to the Ridings Brook using a discharge consent with a DWF of 17.6 Ml/d. Until the 1960s, the Ridings Brook flowed clear of the canal and discharged directly into Wyrley Brook (Figure 5.4). Following canal closure to navigation, the Ridings Brook now discharges into the original canal course approximately 500 m downstream of Cannock STW outfall, after which the watercourse merges with the planned canal restoration route (Figure 3.3 and Figure 3.4). It would therefore be technically feasible to use the STW discharge to direct and keep flows within the canal course.

Based on the preliminary enquiry to STWL regarding use of discharge from Burntwood STW for the Lichfield Canal, we assume STWL will take the same approach for Cannock STW discharge, which is that this is not a course of action they wish to pursue due to regulatory and financial concerns. However, it is the case that discharges from Barnhurst STW are made into the Staffordshire and Worcestershire Canal. Also, unlike the Burntwood Brook outfall, the Ridings Brook discharges into a section of the former canal. As a result, LHCRT will still need to liaise with STWL regarding an acceptable resolution of the interface between the canal, watercourses and STW outfall.. The location of a potential STW outfall crossing of the canal is shown in Figure 3.4, should STWL not wish to discharge into the restored canal.

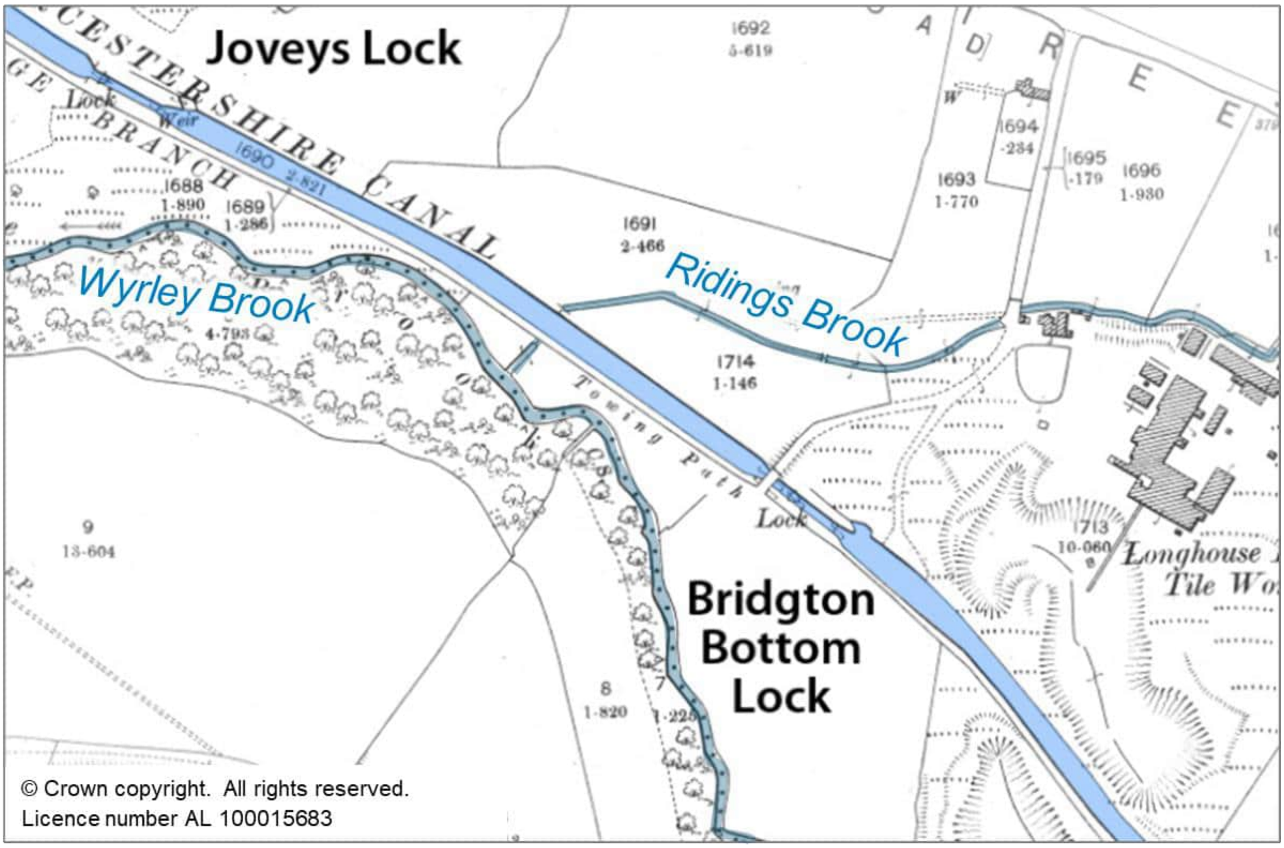

Figure 5.4 Ordnance Survey (1902) map showing relationship between Ridings Brook, Wyrley Brook and the canal

5.3.8 CRT, Birmingham Canal Navigations

The Hatherton Canal will link the Wyrley and Essington Canal (Wolverhampton Level of the BCN) in the east with the topographically lower Staffordshire and Worcestershire Canal in the west. This part of the BCN is supplied from Chasewater Reservoir, owned by SCC, and the Bradley borehole, which uses part of the old Wyrley and Essington Canal to feed the network. The outlet from the Reservoir is approximately 9 km from the proposed junction at Fishley and this, together with the Hatherton Reservoir, were the sources used to feed the Hatherton Canal prior to closure.

CRT has confirmed that there is generally an over-supply of water in the BCN and an under-supply in the Staffordshire and Worcestershire Canal (Appendix A). This is on the basis of provision of water from Fishley Junction. As the elevation of the Staffordshire and Worcestershire Canal is lower than the Wyrley and Essington Canal, supply from Hatherton Junction is not practical except through the use of backpumping. Although this would result in low losses of lockage water, backpumping would not be favoured as a source except possibly during initial restoration.

Whilst CRT modelling has confirmed some availability of water for restoration of both the Lichfield and Hatherton Canals, as stated in their report (Appendix A), additional demand on the wider network could not currently be met by CRT's network alone. It is also stated in the report conclusions that the content of the report should not be taken as a formal agreement that CRT will provide water for the Hatherton canal restoration. LHCRT will need to discuss the conclusions with CRT and reach an agreement for water supply.

CRT has stressed during liaison with both Stantec and LHCRT that even though some water is available without compromising the CRT canal network, CRT would prefer for LHCRT to obtain water from other sources where possible in order to minimise demand from CRT. It may also be possible to enhance supplies to the BCN, to free up more resource for the Hatherton Canal. The possibility of increasing the resource directly from Chasewater, either by physically increasing storage capacity or through changed management methods has been investigated but does not appear to be feasible (ESI, 2016). Other sources close to the BCN could also be investigated, such as pumping water from existing mine shafts at Wyrley Common (Section 5.3.3), that could compensate for an increased demand from the Chasewater resource for the Hatherton Canal.

5.3.9 Summary

A summary of potential water sources for the canal as detailed in the previous sections are summarised in Table 5.4 below.

Table 5.4 Summary of unconstrained options of potential water sources for the canal

Option Number	Description	Potential Volume (Ml/d)	Technical Feasibility
1	New abstractions from local watercourses (Section 5.3.1)	5.08	Feasible. Abstraction from surface watercourses in the Saredon Brook catchment will probably be licensed subject to a HOF restriction downstream (probably at Q_{75}). The potential volume would vary depending on the HOF restriction, but could provide the daily lockage volume provided storage for periods of low flow was implemented.
2	Licence Trading – CRT SW abstraction (03/28/03/0205).	0.82	Potentially feasible subject to licence holder agreement and licence conditions. WRGIS data suggest that this licence has 100% spare capacity (Section 3.5 and Section 5.3.2). Potential daily volume available for up to 14 days per year (licensed annual volume of 11.4 Ml).
3	Licence Trading – Great Saredon Farm SW abstraction (03/28/03/0225).	0.32	Potentially feasible subject to licence holder agreement and licence conditions. WRGIS data suggest that this licence has 100% spare capacity (Section 3.5 and Section 5.3.2). Potential daily volume available for up to 23 days per year (licensed annual volume of 7.37 Ml).
4	Licence Trading – Littlewood SPS discharge consent (T/03/20196/O)	Unknown	Potentially feasible subject to consent holder agreement and consent conditions. No recent actual discharge data were available so a volume available for diversion would have to be investigated. Potentially low discharge volume so costs may outweigh benefits.
5	Licence Trading – Longford House Pumping Station discharge consent (T/03/07950/O)	Unknown	Potentially feasible subject to consent holder agreement and consent conditions. No recent actual discharge data were available so a volume available for diversion would have to be investigated. Potentially low discharge volume so costs may outweigh benefits.

Option Number	Description	Potential Volume (Ml/d)	Technical Feasibility
6	Licence Trading – Latherford Lane SPS discharge consent (TSC3555)	Unknown	Potentially feasible subject to consent holder agreement and consent conditions. No recent actual discharge data were available so a volume available for diversion would have to be investigated. Potentially low discharge volume so costs may outweigh benefits.
7	Licence Trading – Calf Heath No 3 (Queens Road) discharge consent (T/03/12336/O)	Unknown	Potentially feasible subject to consent holder agreement and consent conditions. No recent actual discharge data were available so a volume available for diversion would have to be investigated. Potentially low discharge volume so costs may outweigh benefits.
8	Licence Trading – Woodlands Lane discharge consent (T/03/12304)	Unknown	Potentially feasible subject to consent holder agreement and consent conditions. No recent actual discharge data were available so a volume available for diversion would have to be investigated. Potentially low discharge volume so costs may outweigh benefits.
9	Licence Trading – Wellington Drive Pumping Station discharge consent (T/03/01489/O)	Unknown	Potentially feasible subject to consent holder agreement and consent conditions. No recent actual discharge data were available so a volume available for diversion would have to be investigated. Potentially low discharge volume so costs may outweigh benefits.
10	Licence Trading – New Bridgetown SPS discharge consent (T/03/12884/O)	Unknown	Potentially feasible subject to consent holder agreement and consent conditions. No recent actual discharge data were available so a volume available for diversion would have to be investigated. Potentially low discharge volume so costs may outweigh benefits.
11	Licence Trading – Wellington Drive SPS discharge consent (T/03/30249/O)	Unknown	Potentially feasible subject to consent holder agreement and consent conditions. No recent actual discharge data were available so a

Option Number	Description	Potential Volume (Ml/d)	Technical Feasibility
			volume available for diversion would have to be investigated. Potentially low discharge volume so costs may outweigh benefits.
12	Licence Trading – Cheslyn Hay/ Great Wyrley/Saredon discharge consent (T/03/00250/O)	Unknown	Potentially feasible subject to consent holder agreement and consent conditions. No recent actual discharge data were available so a volume available for diversion would have to be investigated. Potentially low discharge volume so costs may outweigh benefits.
13	Licence Trading – Station Road/103 Walsall Road CSO discharge consent (T/03/21311/O)	Unknown	Potentially feasible subject to consent holder agreement and consent conditions. No recent actual discharge data were available so a volume available for diversion would have to be investigated. Potentially low discharge volume so costs may outweigh benefits.
14	New groundwater abstraction from the Sherwood Sandstone Aquifer (Section 5.3.3)	5.08	Feasible. Abstraction of 5 Ml/d is at the upper end of the achievable yield for this source.
15	Drill a 100-150 m deep borehole at Fishley Junction into Carboniferous strata and pipe into existing canal (Section 5.3.3)	0.55	Feasible subject to an assessment of water quality and economic constraints.
16	Pump water from Carboniferous strata at Coal Authority's Wyrley Grove shaft and pipe for c.200 m to existing canal network (Section 5.3.3)	2.00	Feasible subject to an assessment of water quality and economic constraints. Although this may appear to be an attractive option there are several associated risks (Sections 3.5.3 and 5.3.3) that should be carefully considered prior to taking this option further.
17	Pump water from the Coal Authority's existing Wyrley Common boreholes	0.20	Unfeasible. Potential volume is likely to be less than 2% of the total fill volume and less than 4% of the average daily lockage estimate during

Option Number	Description	Potential Volume (Ml/d)	Technical Feasibility
	and pipe for c.700 m to existing canal network (Section 5.3.3)		a peak week. Costs to pipe the water will likely outweigh benefits as the distance is greater than 500 m.
18	Surface water from proposed residential development (Section 5.3.4)	0.065	Feasible. Other than discharge to ground via soakaway, the canal is the only outfall available However, it is noted that potential volume is less than 0.1% of the total fill volume required and 1.3% of the average daily lockage estimate during a peak week and is therefore not considered to be a reliable source of water for the canal.
19	Existing highway drains (Section 5.3.5)	0.07	Feasible. Based on run-off estimates from 13 highways that cut the proposed canal route. Catchment area has been calculated using LIDAR data to estimate roadside catchment boundaries. Potential volume is less than 0.1% of the total fill volume required and 1.4% of the average daily lockage estimate during a peak week. Although the volumes are small in comparison to canal demand, flows from highway drains and sewers that will have a hard clash with the canal as it is restored will have to be diverted to the canal regardless.
20	Backpumping (Section 5.3.6)	N/A	Feasible
21	Effluent from Cannock STW (Section 5.3.7)	N/A	Likely unfeasible due to regulatory and financial concerns from STWL (reported previously on Lichfield canal study). However, this may become feasible following LHCRT liaison with STWL as a precedent for this option exists at Barnhurst STW, where discharges are made into the Staffordshire and Worcestershire Canal.
22	Water from existing CRT network (Section 5.3.8)	N/A	Feasible subject to an assessment of available resource by CRT.

5.4 Constrained List of Supply Options for Full Restoration

A list of constrained options for the fully restored canal is provided in Table 5.5 and summarised in Figure 5.5. Options were constrained based on their potential to either fill the canal within 90 days or contribute to more than 10% of the average daily lockage estimate (during a peak week). It is acknowledged that it is unlikely that the canal will be fully restored in one single phase. Therefore the calculated fill time for the fully restored canal is used to highlight attractive options based on faster fill times.

Table 5.5 List of constrained options for full canal restoration

Option	Time to fill (days)	Daily lockage (peak week)	Notes
1 (New SW abstraction licence)	23	100%	Abstraction from the Saredon Brook (including upstream tributaries of the Wyrley Brook and Wash Brook) is available for approximately 75% of the time, subject to a HOF restriction downstream. Assuming an abstraction licence for 5.08 Ml/d was granted, this source could provide the full initial fill volume in 23 days and could contribute 100% of the daily lockage requirement. Abstraction volume would depend on flows due to the HOF restriction and the provision of storage for periods of low flow.
2 (SW licence trading with CRT, 03/28/03/0205)	143	16%	Licence is restricted to 0.82 Ml/d and 11.4 Ml/a so would not be able to meet the full initial fill volume (117.3 Ml). This source would provide 16% of the lockage estimate (average daily during a peak week) for up to 14 days per year (licensed annual volume of 11.4 Ml). This source is located within 25 m of the canal.
3 (SW licence trading with Great Saredon Farm, 03/28/03/0225)	367	6%	Licence is restricted to 0.32 Ml/d and 7.37 Ml/a so would not be able to meet the full initial fill volume (117.3 Ml). This source would provide 6% of the lockage estimate (average daily during a peak week) for up to 23 days per year (licensed annual volume of 7.37 Ml). This source is located within 140 m of the canal.
4-13 (Discharge consent acceptance)	-	-	Volume available for diversion from various discharge consents requires investigation with the licence holders. However, discharge consents are likely for low volumes, in which case costs are likely to outweigh benefits.

Option	Time to fill (days)	Daily lockage (peak week)	Notes
14 (New GW abstraction licence from Sherwood Sandstone aquifer)	23	100%	The EA is accepting licence applications for groundwater abstraction from Coven GWMU. However, Coven is located beneath the western, lower reaches of the canal near Hatherton Junction and would require backpumping to be in use throughout the length of the restored canal. There is a possibility that abstraction from Coven GWMU and discharge into the lower reaches of Hatherton Canal could partially resolve the potential issue of under-supply in the Staffordshire and Worcestershire Canal, should CRT agree to meet the demand following restoration of the Hatherton Canal (Section 5.3.8). Assuming an abstraction of 5.08 Ml/d could be demonstrated not to cause environmental deterioration and an abstraction licence was granted, this source could provide the full initial fill volume in 23 days and could contribute 100% of the daily lockage requirement. However, abstraction of 5 Ml/d is at the upper end of the achievable yield for this source.
15 (Deep borehole drilled into Carboniferous strata)	213	11%	The initial fill time is likely to be unacceptable although it could provide 11% of the daily lockage requirement and for this reason has been included in this list. This source would be subject to an assessment of water quality and economic constraints.
16 (Pumping from the Coal Authority's Wyrley Grove shaft)	59	39%	This source could provide the full initial fill volume in 59 days and could contribute to 39% of the daily lockage requirement. This source would be subject to an assessment of water quality and economic constraints as well as a strong backing from the Coal Authority (i.e. possible liabilities associated with mine subsidence, etc.).
22 (CRT network)	-	-	CRT has suggested that there would be a limited volume of available resource for the daily operation of the canal.

* infill times restricted by annual limit.

In addition those identified in the table above, discharges from the proposed new developments and highway drains/surface water sewers that will have a hard clash with the canal once restored will also contribute water to the canal. Options 18 and 19 could also be included in the constrained list.

However, the volume of water from these sources will be quite small[6] in comparison to the water supply demand of the canal and are unlikely to be reliable due to their sporadic nature (largely reliant on rainfall dependent events). That said, although the volumes are small, run-off from peak rainfall events could be stored in side pounds.

Whilst the estimated volume of water derived from surface water run-off is unlikely to provide a significant contribution to the estimated water demand requirements of the canal[7], it can offer sustainability benefits to the wider area by providing a point of discharge for surface water run-off, particularly when considering existing/new residential developments that can benefit from diverting run-off to a nearby surface water body like the restored canal. This will aid in the management and mitigation of surface water flooding issues currently experienced in the Cannock Area whilst also providing a use for the run-off rather than it simply being discharged to local water courses.

[6] Estimated total from all sources of 0.14 Ml/d, less than 1% of the total fill volume and 6% of the baseline average daily lockage estimate (2% of the peak daily).

[7]Whilst surface water run-off is unlikely to significantly contribute to the estimated water demand of the operational canal, it may be useful in initially filling sections of the canal as restoration proceeds and before full navigation commences.

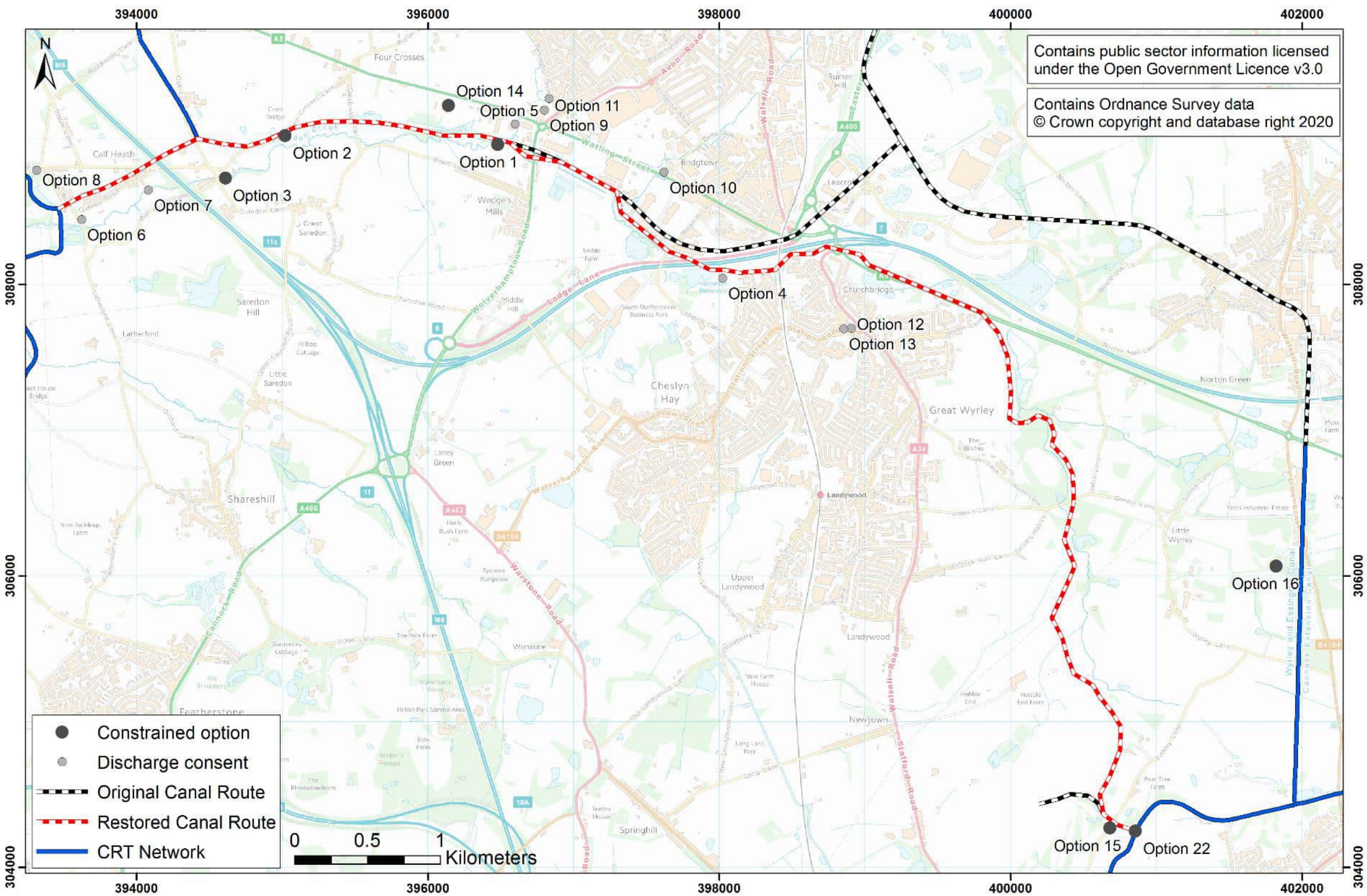

Figure 5.5 Constrained options for water source supply (WSS)

5.5 Water Source Reliability and Uncertainties

Once the restoration is complete and the canal operating normally, the simplest and most assured water supply would be to use the spare capacity in the CRT network (option 22). CRT has indicated that the available resource is present at the Fishley end, pumped from Chasewater Reservoir, and is in short supply at the Hatherton end, so this is likely to be acceptable, subject to detailed negotiation. Using this source would ensure that there is a reliable supply of water throughout the canal. However, ownership of the restored canal and the feasibility of supply from Chasewater Reservoir are currently unknown and require to be determined. If ownership of the Hatherton Canal was not to be taken over by CRT, then there may be issues with abstraction licenses that would need to be resolved. Regardless, another source or sources would be required to meet the balance of demand.

A new surface water abstraction licence (option 1) from the Saredon Brook or upstream tributaries would be anticipated to provide up to 100% of the daily lockage in a peak week. There is a reasonable likelihood of the EA granting an abstraction licence for surface water from the Saredon Brook, providing abstraction volumes do not result in exceedance of the HOF restriction downstream. The ability of a new surface water abstraction to provide 100% of daily lockage would be dependent on flows due to the HOF restriction and introduction of a storage solution to provide additional flow during lower flow periods. This source could easily be used for the initial infill requirement if the activity was timed for wetter periods.

Similarly, a new groundwater abstraction licence (option 14) could provide up to 100% of the daily lockage requirement, although abstraction of 5 Ml/d is at the upper end of the achievable yield for the groundwater source. There is a reasonable likelihood the EA would grant an abstraction licence for groundwater from Coven GWMU. However, the EA would require ongoing environmental monitoring to support the need for no environmental deterioration in the WFD status of the groundwater body. Additionally, Coven GWMU is located at the topographically lower end of the canal and backpumping would be required to enable use of the resource across the length of the canal.

The surface water licence trading options 2 and 3 and discharge consent acceptance options 4 to 13 could supplement the operational requirements of the canal to a small degree. The surface water abstraction of option 2 likely offers most water and has a medium potential for a trade, but the reliability of this source in dry weather conditions is questionable. It is recommended that relevant discharge consent holders are contacted to clarify their consent conditions and willingness to trade. However, it is anticipated this would result in most of the discharge consents being discounted due to low discharge volumes.

Surface water sources are also likely to be vulnerable to climate change as overall drier summers, but with more variability, are expected over the next 50 years in the West Midlands. An increase in rainfall intensity is also expected, which would make the surface water runoff sources more difficult to manage. These are likely to produce more water but less frequently and unless large storage capacities can be provided most of the runoff from intense rainfalls is likely to be lost.

The Coal Measures groundwater source at Wyrley Grove (option 16) is likely to be reliable, but there is considerable uncertainty regarding the quantity, the cost of supply and its quality. This option requires further assessment and discussions with the Coal Authority to reduce the current uncertainties, but most of all to clarify potential future liabilities arising from pumping water from mine shafts. This source is unlikely to supply the full requirement of operating the canal at peak times, although it could potentially replace some CRT water at lower cost and has the advantage of supplying water at the top pound of the canal.

Providing a new groundwater source from the Carboniferous strata (option 15) is likely to be expensive (high drilling and pumping costs) and the potential long term quality provides further uncertainty. Since this source is likely only to supply around 11% of operational need it is unlikely to be a practical solution.

Groundwater sources are less prone to climate change, but the increased risk of long term drought may also affect these in later years.

The CRT source (option 22) from Chasewater Reservoir therefore offers the easiest and most reliable source for operation of the canal when fully restored. However, CRT supply would not cover total demand and is only practically available when the full length of canal from Fishley Junction to Hatherton Junction is complete. Water sources during the various phases of restoration may differ as the canal would not be available to transport water throughout its length (Section 6).

Whilst CRT have indicated the potential availability of water from the BCN Wolverhampton Level, additional demand on the wider network could not currently be met by CRT's network alone. CRT require the Hatherton Canal to use other sources of water where readily available, in order to minimise demand on CRT sources.

6 Water Requirement for Restoration Phases

6.1 Proposed Restoration Phases

It will not be possible to fund and build the whole canal in one single phase, so restoration will be completed in several phases. Based on discussions with LHCRT, it has been initially assumed that restoration would start at the upstream end at Fishley Junction and work downhill until reaching Hatherton Junction. There are two variations on this sequence that LHCRT has proposed (Table 6.1 and Figure 6.1). These phasing approaches depend on the timing of construction of the tunnel beneath the M6 motorway. There are seventeen planned locks between the two junctions (Figure 6.1), of which three are derelict and one is currently constructed and in use, however this lock arrangement is yet to be confirmed. This phasing approach is likely to change as the restoration is still in the early stages of feasibility and planning.

Table 6.1 Proposed restoration phases

Scenario	Phase	Approx. length	Activity	Description
1	1	5440 m	Construction	Fishley Junction to Cannock (A5 roundabout)
	2	3290 m	Construction	Cannock (A5 roundabout) to Meadow Lock
	3	2540 m	Construction	Meadow Lock to Hatherton Junction
	4	90 m	Construction	M6 tunnel
	2 (cont.)	3290 m	Construction	Cannock (A5 roundabout) to Meadow Lock (continued)
	3 (cont.)	2540 m	Restoration	Meadow Lock to Hatherton Junction (continued)
2	1	5440 m	Construction	Fishley Junction to Cannock (A5 roundabout)
	2	3290 m	Construction	Cannock (A5 roundabout) to Meadow Lock
	3	2540 m	Restoration	Meadow Lock to Hatherton Junction
	4	90 m	Construction	M6 tunnel

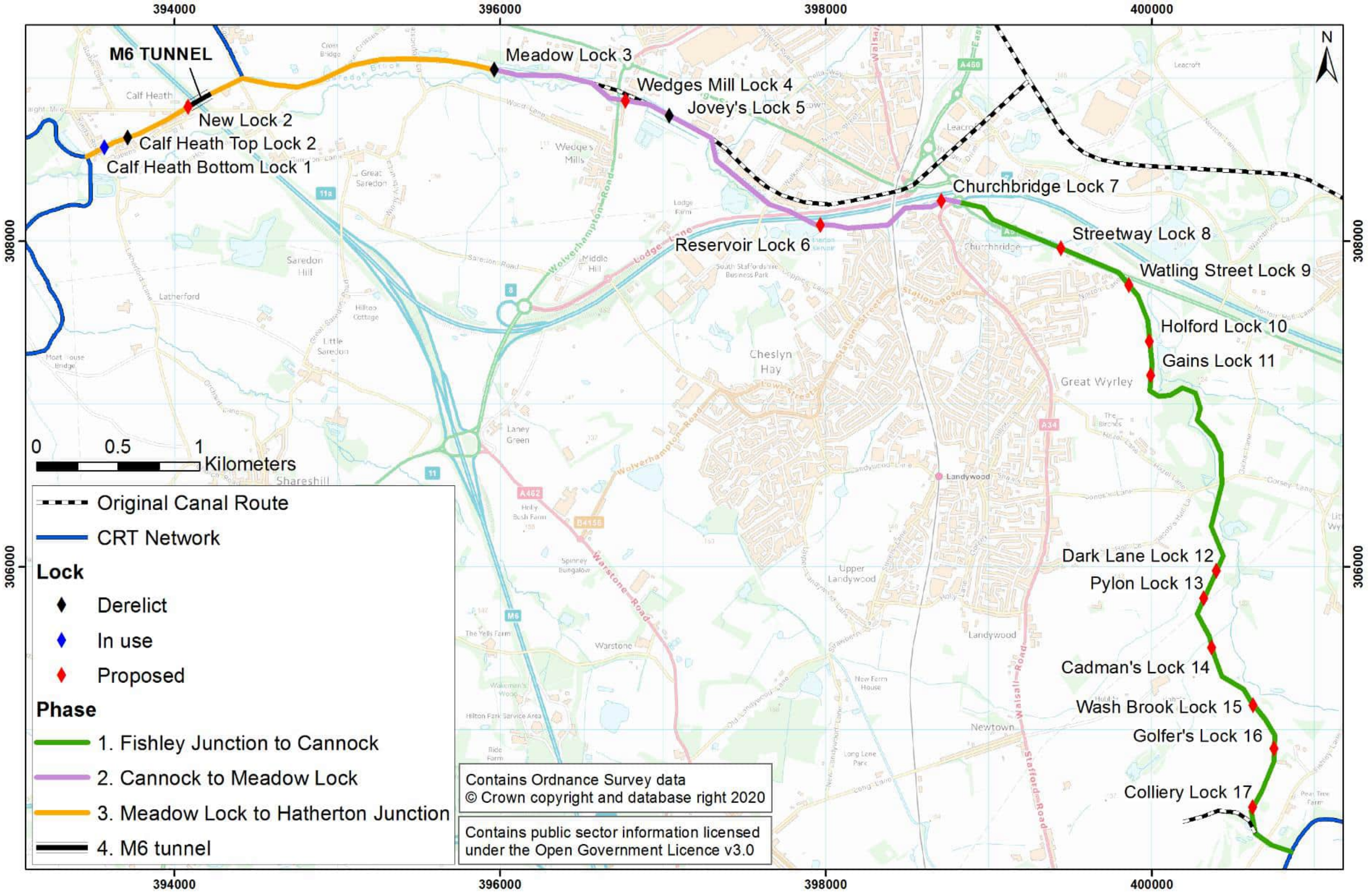

Figure 6.1 Potential restoration sections

6.2 Constrained list of Supply Options for Partial Restoration

The following sections provide a list of constrained options for each of the restoration scenario sequences. Licence trading options have been constrained based on proximity to each section. If an abstraction/discharge location is greater than 500 m away from the named section then it is considered unfeasible as costs to acquire land or a wayleave to pipe the water are likely to be prohibitive.

6.2.1 Scenario 1

This scenario comprises construction from Fishley Junction to Cannock in the first phase, followed in various order by construction activities of the Cannock to Meadow Lock phase, the M6 tunnel phase and the Meadow Lock to Hatherton Junction restoration phase.

During the first two phases of construction, options 15 (deep borehole), 16 (Wyrley Grove mineshaft) and 22 (CRT network) are the most feasible due to their proximity to Fishley Junction. Supply from the CRT network would be sufficient for initial infill and operational requirements when combined with water pumped from Wyrley Grove or the deep Carboniferous (secondary A) aquifer. Option 15 would require a groundwater investigation to determine sustainable yield; assuming this is sufficient for demand, this would be followed by construction of a deep borehole and installation of pumping infrastructure. The Wyrley Grove source would require a water quality assessment and an abstraction licence, the latter which could potentially include water treatment within the licence conditions.

Several discharge consents south of the proposed canal route in Great Wyrley could be used to supplement supply during the first two phases, with option 4 (Littlewood SPS discharge consent) located within 60 m of the canal and requiring least effort to divert. However, this would depend upon successful negotiation, and the likely low volume of all discharge consents may preclude the installation of necessary infrastructure for diversion into the canal.

Phases 3 and 4 of construction could be supplied using resource from the CRT network and substantially augmented by supply from a new surface water (option 1) or groundwater (option 14) abstraction licence. These options have been discussed in detail in Sections 5.4 and 5.5 and due to their topographic location could most conveniently supply the canal from Meadow Lock westwards.

Due to the potential in Scenario 1 for construction of various sections of the Hatherton Canal in Phases 2, 3 and 4 in a non-sequential order, it is likely that certain sections of the canal may be out of water until they can be connected to the main supply coming down from Fishley Junction. Given that construction is planned to mostly follow an east-to-west direction, it could be planned that this period out of water is minimised and construction is not extended too far westwards beyond the state of current water supply.

Four locks are planned between Cannock A5 roundabout and Meadow Lock so there is a possibility of surplus water accumulating in Phase 2 but, if this occurs, discharge to the Wyrley Brook or Saredon Brook could be viable options, subject to any necessary consents. It is unlikely surplus water will accumulate west of Meadow Lock as the current state of the canal allows hydraulic connection of surface water within the canal course to the Staffordshire and Worcestershire Canal.

6.2.2 Scenario 2

Similar to the scenario above, this scenario comprises construction first from Fishley Junction to Cannock, however then follows sequentially downhill along the canal to Hatherton Junction, with construction of the M6 tunnel as the final undertaking to link the two canal junctions.

Initial demand for Phases 1, 2 and 3 can be met for Scenario 2 in the same way as outlined above for scenario 1. Supply from the CRT network (option 22), combined with water pumped from Wyrley Grove mineshaft (option 16) or the deep Carboniferous aquifer (option 15), would be sufficient for initial infill and operational requirements during phase 1 and 2. When construction reaches Phase 3, west of Meadow Lock, the increasing demand on the CRT network could be reduced by substituting CRT supply with surface water (option 1) or groundwater (option 14) from the Saredon Brook or Coven GWMU, respectively.

During Phase 3, a 750 m reach of canal immediately east of Hatherton Junction and west of the M6 tunnel will remain cut off from the main canal supply until the final phase of construction (the M6 tunnel) in Scenario 2. Three locks are present in this stretch of canal and supply could be maintained above Calf Heath Bottom Lock 1 by backpumping. Similarly, it is anticipated that water accumulating on the eastern side of the M6 could be backpumped in order to keep this canal stretch in full water. Discharge of excess water into the Saredon Brook is another alternative, subject to the necessary consent.

7 Conclusions and Recommendations

7.1 Conclusions

This water supply study has identified several options for the initial infilling and operation of the restored canal. Available options have been assessed and summarised in an unconstrained list. The technical feasibility of each option and the proportional contribution to the initial infill and operational volumes has been assessed and a constrained list has been produced. The constrained list identifies the most attractive options although this could be better refined once remaining uncertainties have been clarified.

The existing CRT network has also been considered as an option in the constrained list. CRT has undertaken modelling work on its existing network which suggests that the impact of demand, including lockage and losses, on both of the fully restored canals could potentially be met from the CRT network. However, the impact of additional demand on the wider CRT network could not currently be met by CRT's network alone.

The local surface water and groundwater systems are subject to some restriction but further abstraction licensing should be possible provided there is no environmental deterioration due to new abstraction. Surface water abstraction from the Saredon Brook catchment is the most likely to achieve a sufficiently high yield to supply the maximum operational requirements of the canal. There are potentially several other options that could be considered, including groundwater from abandoned mine workings, a supply borehole drilled into Carboniferous strata and licence trading with local abstraction licence or discharge consent owners.

The option of supplying the water from future proposed residential developments in Cannock and Great Wyrley, although attractive from a sustainability point of view, is unlikely to provide a continuous and reliable source of water for the canal (<1% of total fill volume). The sporadic nature of such sources (dependant on rainfall events) would make them very unreliable particularly considering that most of the canal water demand is in the summer when rainfall is lower. A similar conclusion applies to re-routing surface water drainage from major roads in the Cannock area, though it is noted that flows from some of these sources will flow into the canal regardless due to hard clashes with the canal following restoration. Although discharges from these sources do not provide a significant volume of water in comparison to the total demand, the canal can still accept these flows providing a sustainable alternative for the discharge of surface water.

Amongst all the options identified, the CRT source combined with either a new surface water abstraction or mine water abstraction offers the easiest and most reliable source for operating the canal when fully restored.

7.2 Recommendations

A series of recommendations have been provided below.

- Negotiations should be held with CRT regarding the quantity of bulk water that may be available to contribute towards ongoing operation of Hatherton canal.
- Further discussions should be undertaken with the Coal Authority and CRT with the aim of collating further data and information to reduce the uncertainty of obtaining infill and operational water from the Carboniferous strata (whether via existing shafts or newly drilled boreholes).

- If mines water were to be introduced to Hatherton Canal, CRT would need to be assured that this water would not cause a deterioration to the WFD classification assigned to the Staffordshire and Worcester canal (due to potential high metal content in mines water). To do this, work would need to be undertaken to assess the current water quality of both the mines water and canal to determine the potential impact.
- A cost/benefit analysis should be undertaken for the constrained list of options, focusing on mine water supply and new abstraction of either groundwater or surface water.
- LHCRT should liaise with STWL regarding Cannock STW as the pipe runs across the proposed canal route.
- Initiate discussions with existing abstraction/discharge licence holders and investigate the potential for licence transfer of spare capacity or, alternatively, purchase the water from these licence holders.
- CRT has requested to be made aware of any response or advice from the EA to the LHCRT, especially regarding water quality issues from mine water pumping.

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Appendices

Appendix A

Canal and River Trust Modelling Report

Report Reference: 67142 R1

Report Status: Final

Canal & River Trust

Making life better by water

Hatherton Canal Restoration

Water Supply Study Support

Kathryn Maye

8 January 2020

Demands – Lockage and Losses on the Restored Hatherton Canal

<u>Annual Lockage:</u>

Baseline annual lockage/potential boat traffic on the restored Hatherton Canal has been estimated using existing annual lockage totals, as published in the Trust's Annual Lockage Reports, 2000 onwards at the following locations (please see Figure 1 below).

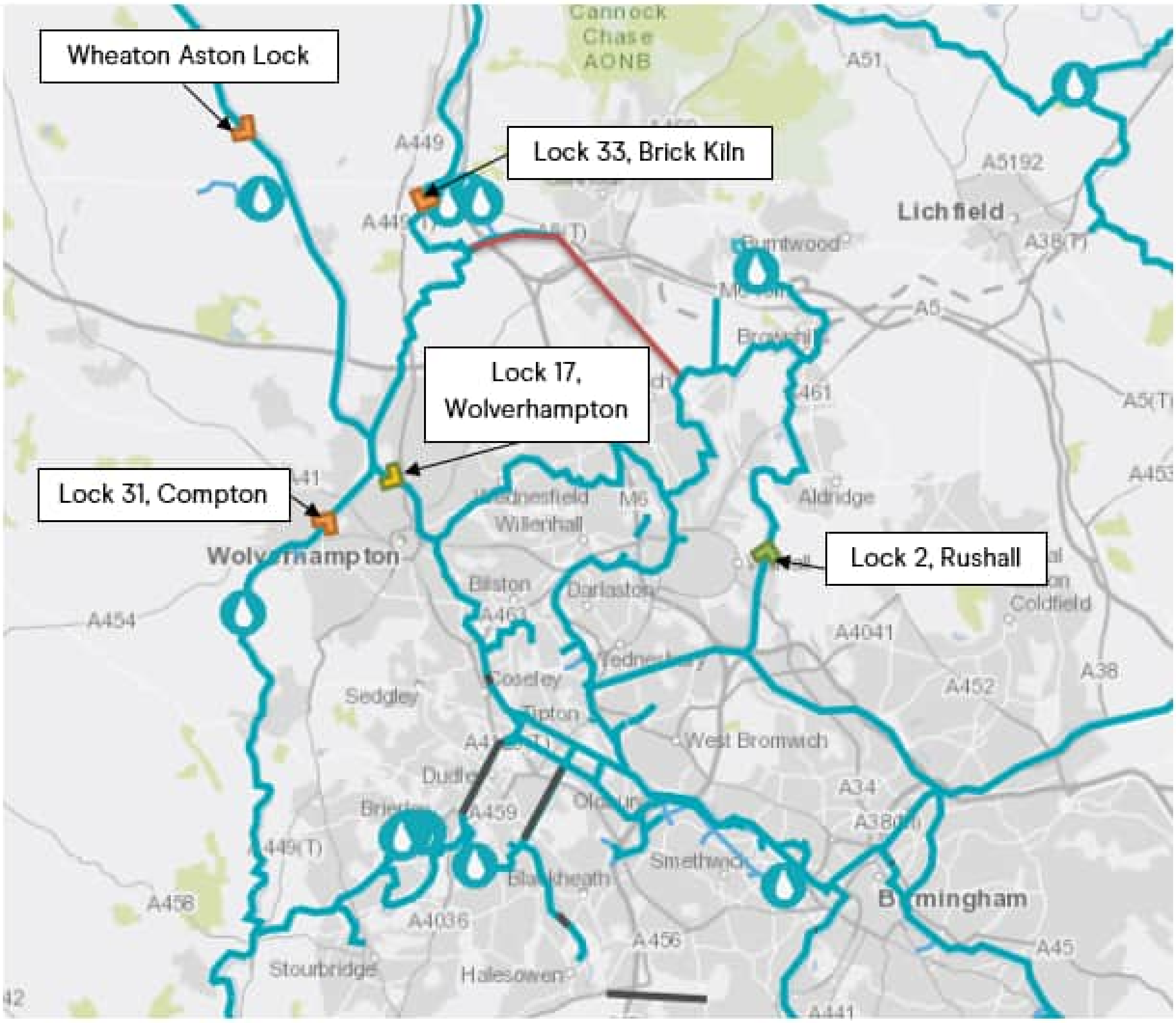

Figure 1: Approximate location of proposed restoration (red line) and lockage data available.

Figure 1 above shows the approximate line of the restored canal in red. The locations of the nearest locks to the proposed network connections at Fishley Junction and Hatherton Junction, where lockage data are recorded (lock symbols in green, orange and yellow) are also shown. Table 1 below includes the annual lockage data recorded at each location.

Fully Restored Canal:

Assuming that:

1. all boat movements from the above locations are in the direction of the nearest proposed junction with the restored canal (shortest distance chosen if more than one option); and
2. at each junction on route the direction of travel is split 50/50 in each direction (based on the proportionate split used in the Trust's, now obsolete, Boat Traffic Model)

the estimated number of lockages on the restored canal from each of the recorded lockage locations above would be:

Table 1: Recorded annual **l**ockage data (LTA: Based on last 3 years data where available)

Lock	Min	Max	Latest	LTA	Period
Lock 2, Rushall	143	356	155	**253**	2009-18, 14 missing
Lock 17, Wolverhampton	1350	2819	1754	**1809**	2000-18, 07 missing
Lock 31, Compton	3468	4661	3468	**3497**	2002-17
Lock 33, Brick Kiln	4982	7044	5182	**5128**	2002-18, 06 missing
Wheaton Aston Lock	5486	8630	5558	**5625**	2000-18, 06-08 missing

Onto the restored canal at Fishley Junction:

Lock 2, Rushall: 253 LTA annual lockage recorded

Junction 1 with Anglesey Branch: 127

Junction 2 with Cannock Extension Canal 64

Junction 3 **onto restored canal:** **32**

Total number of lockages on the restored canal at Fishley Junction: 32 lockages per year

Onto the restored canal at the junction with the Hatherton Canal:

Lock 17, Wolverhampton: 1809 LTA annual lockage recorded

Junction 1 with S&W 905

Junction 2 with Autherley Junction: 453

Junction 3 **onto restored canal:** **227**

Lock 31, Compton 3497 LTA annual lockage recorded

Junction 1 with Old Main Line, Wolverhampton 1749

Junction 2 with Autherley Junction 875

Junction 3 onto restored canal: 438

Wheaton Aston Lock 5625 LTA annual lockage recorded

Junction 1 with Autherley Junction 2813

Junction 2 onto restored canal: 1407

Lock 33, Brick Kiln 5128 LTA annual lockage recorded

Junction 1 onto restored canal: 2564

Total number of lockages on the restored canal at Hatherton Junction: 4636 lockages per year

The total estimated annual lockage on the Hatherton Canal from both Junctions is therefore 4668

Partially Restored Canal:

Restoration of the canal is likely to be undertaken in phases. These are not yet confirmed. The estimated lockage at each stage of the restoration will therefore need to be determined by Stantec once the phasing has been confirmed, based on the estimated annual lockage on the fully restored canal of 4668.

Lockage Demand

Fully Restored Canal:

Information provided by Ove Arup & Partners Ltd 2006 Feasibility Report (Ove Arup & Partners Ltd, 2006) suggests that locks on the restored canal will be constructed to dimensions equivalent to that of a standard narrow lock, at 26.3m in length, 2.3m in width. Depths will vary between 1.3m and 2.7m depending on location. Based on this information, the deepest lock chamber will have a volume of 163m^3 or 0.163Ml.

Based on an annual lockage of 4668 and deepest lock volume of 0.163Ml therefore, the **annual lockage demand** is equivalent to **761Ml/yr**.

To estimate the weekly and daily lockage demand based on the annual demand, the following standard assumptions have been applied:

1) peak weekly lockage is equivalent to 4.5% of the annual total; and
2) peak daily lockage is equivalent to 25% of the peak weekly

The estimated peak weekly lockage is 210 lockages, equivalent to a demand of 34.2Ml/wk, the estimated average daily lockage in a peak week is 30 lockage, equivalent to a demand of 4.9Ml/d and the estimated **peak daily lockage is 53 lockages, equivalent to a demand of 8.6Ml/d.**

A weekly lockage profile has also been produced from the estimated annual lockage total by applying a standard weekly lockage distribution for the Midlands Region. This has been inputted into the Trust's Water Resources Model to assess the impacts of the restoration on the Trust's network (see below for further details).

Partially Restored Canal:

As with the estimates of lockage in section 1.1 above, the lockage demands required at each stage of the restoration will need to be determined by Stantec once the phasing has been confirmed, based on the estimated annual lockage demand on the fully restored canal of 761Ml/yr.

Future Lockage

Estimates of future lockage have been calculated based on annual lockage totals, 2000 onwards, applying a non-compounded percentage increase, per year.

If we assume an increase per year in boat movements/lockage of 1.5% (the national growth in boat numbers (British Waterways, 2011) used in the demand analysis undertaken to assess the impacts of the Lichfield Restoration in 2015, the annual lockage total on the fully restored canal increases to:

4738 in Year 1 ~ 772Ml/yr, 213 lockages/wk or 35Ml/wk, 30 lockages/d or 5.0M/d average and 53 lockages/d or 8.7Ml/d peak

5018 in Year 5 ~ 829Ml/yr, 229 lockages/wk or 37Ml/wk, 32 lockages/d or 5.3Ml/d average and 56 lockages/d or 9.2Ml/d peak

5368 in Year 10 ~ 875Ml/yr, 242 lockages/wk or 39Ml/wk, 35 lockages/d or 5.6Ml/d average and 60 lockages/d or 9.8Ml/d peak.

Loss Estimates

Fully Restored Canal:

Losses have been estimated using the existing bespoke loss model produced for ESI to assess the impacts of the Lichfield Canal Restoration in 2015. This model includes the same climatic inputs as those applied to the Lichfield Canal Restoration as the Hatherton Canal is within 5-18km from the Lichfield Canal. The soil permeability and landscape codes have been updated to reflect the differences in soil type, underlying geology and terrain between the two planned routes.

Losses have been estimated based on four potential lining scenarios as follows:

1) Best case – Geomembrane (e.g. Bentomat) – whole canal;
2) Very Low Density Polyethylene (VLDP) or new puddle clay;
3) New concrete; and
4) Worst case – lining in just a few selected areas.

NB. The worst case option – no lining over deep course sand/gravel – has not been modelled as this scenario was considered unlikely.

Average Loss Rates

The results of the modelling to estimate loss rates on the fully restored canal are shown below in Table 2:

Table 2 Estimated loss rates for a range of lining types

Lining Scenario	Average Summer Loss Rate Ml/km/wk	Summer Range Ml/km/wk
Geomembrane (e.g. Bentomat)	0.50	0.20-0.80
Very Low Density Polyethylene (VLDP) or new puddle clay	1.11	0.45-1.78
New concrete	1.25	0.50-2.00
Lining in just a few selected areas	1.70	0.68-2.73

Weekly Loss Profile

A weekly loss profile has also been derived for the best and worst-case lining scenario based on the average summer loss rates shown in Table 2. This weekly profile is a trapezoidal annually repeated sequence, as required for input into the Trust's Water Resources Model.

Loss Demands

Based on the assumption that the restored canal will be 8.7km (between Fishley Junction and Meadow Lock i.e. not including the section already constructed and in water), the average summer weekly loss rate is estimated to range from **4.4Ml/wk** to **14.8Ml/wk** depending on the lining type chosen. On a daily basis, this is equivalent to an average loss demand of between **0.6Ml/d** and **2.1Ml/d**.

Partially Restored Canal:

Restoration of the canal is likely to be undertaken in phases. These are not yet confirmed. The estimated losses at each stage of the restoration will therefore need to be determined by Stantec once the phasing has been confirmed, based on the estimated summer loss rates shown in Table 2 above.

The Trust's Water Resources Model has been used to determine the potential impacts of the full restoration of the Hatherton Canal on the Trust's network using six scenarios, as agreed with Stantec, as follows:

Scenario 1: Best Case - 100% of demand at Hatherton Junction, SU and S&W

Scenario 2: Worst Case - 100% of demand at Hatherton Junction, SU and S&W

Scenario 3: Best Case – 100% of demand at Fishley Junction, Wolverhampton, BCN

Scenario 4: Worst Case – 100% of demand at Fishley Junction, Wolverhampton, BCN

Scenario 5: Best Case – 50% of demand at Hatherton Junction, SU and S&W and 50% at Fishley Junction, Wolverhampton, BCN

Scenario 6: Worst Case – 50% of demand at Hatherton Junction, SU and S&W and 50% at Fishley Junction, Wolverhampton, BCN

Two further scenarios were run to assess the impact of both the Hatherton and Lichfield Canal Restorations together on the Trust's network as follows:

Scenario 7: Hatherton Canal Worst Case with Lichfield Canal Worst Case – based on Hatherton Run 2 (100% at Hatherton Junction) and Lichfield Run 4 (50% demand at Ogley Junction, BCN and 50% at Huddlesford Junction, Ox&GU)

Scenario 8: Hatherton Canal Best Case with Lichfield Canal Best Case – based on Hatherton Run 3 (100% at Fishley Junction) and Lichfield Run 1 (100% at Ogley Junction, BCN)

The best case scenarios include the estimated demands assuming the canal is lined with a geomembrane (e.g. Bentomat) along the whole of the canal and the lowest annual lockage estimate (baseline lockage – please see above).

The worst case scenarios include the estimated demands assuming the canal is lined in only a few selected areas, and the highest annual lockage estimate (year 10 lockage – please see above).

Results

Hatherton Restoration – Scenarios 1 to 6:

The results show that under scenarios 3 and 4, with 100% of the demand at Fishley Junction i.e. for the Wolverhampton Level, the fully restored canal would have no net impact on the level of service of the BCN Hydrological Unit, nor any other hydrological unit on the wider canal network.

Under all other scenarios: with 100% of the demand at Hatherton Junction i.e. from the Staffordshire & Worcestershire Canal; and with 50% of the demand at Hatherton Junction and 50% at Fishley Junction, the results show that the fully restored canal would have a net impact on the level of service of the Staffordshire & Worcestershire and Shropshire Union Canals Hydrological Unit.

Hatherton and Lichfield Canals Restoration – Scenarios 7 & 8:

The results show that under scenario 8, with 100% of the Hatherton demand at Fishley Junction and 100% of the Lichfield demand at Ogley Junction i.e. both from the Wolverhampton Level, the fully restored canals, in combination, would have no net impact on the level of service of the BCN Hydrological Unit, nor any other hydrological unit on the wider canal network.

Under scenario 7: with 100% of the Hatherton demand at Hatherton Junction; and with 50% of the Lichfield demand at Ogley Junction and 50% at Huddlesford Junction, the fully restored canals, in combination, would have a net impact on the level of service of the Staffordshire & Worcestershire and Shropshire Union Canals Hydrological Unit.

Conclusions

The results showed that for the full restoration of the Hatherton Canal alone, there is no net impact on the level of service of the BCN or any neighbouring hydrological unit on the Trust's network providing 100% of the demands are met from the BCN Hydrological Unit i.e. the demands on the fully restored canal could potentially be met from the Trust's network.

The results showed that for the full restoration of the both the Hatherton Canal and Lichfield Canals in combination, there is no net impact on the level of service of the BCN or any neighbouring hydrological unit on the Trust's network, again, providing 100% of the demands are met from BCN Hydrological Unit i.e. the demands on both of the fully restored canals could potentially be met from the Trust's network.

Please note however, this should not be taken as formal agreement from the Trust that it will provide the water for this restoration.

Demands – Additional Lockage on Wider Trust Network following Restoration of the Hatherton Canal

The impacts of the full restoration of the Hatherton Canal, and of both the Hatherton and Lichfield Canals in combination, on the Trust's network have been assessed using the Trust's Water Resources Model. This modelling assessed the impacts of estimated demands on the Hatherton and Lichfield Canals as a result of their full restoration. In order to assess the impacts of additional boat traffic and lockage on the wider connected Trust network, as a result of the restorations, further estimates of additional demand were made.

Additional demand on wider Trust network as a result of restoration

In 2000, work was undertaken by the Trust (then British Waterways) to estimate boat movements in association with the restoration of the Droitwich Canal. This work included running the Trust's now obsolete Boat Traffic Model to estimate the impact of the restoration on the wider canal network. This work suggested that an increase in annual boat movements of 50% could be expected in the immediate vicinity of the restored canal. This percentage increase has been applied to estimate the additional boat movements, from the current baseline, within 5 km of either end of the restored canal. A decay rate has then been applied up to a distance of 50 km from each junction of the restored canal, reducing the number of expected boat movements with increasing distance from the canal. Please see Table 3 below for details:

Table 3 – Percentage increase in boat movements with increasing distance from restoration

Distance from Junction of restored canal	Percentage increase in boat movements
<5 km	50%
<10 km	40%
<20 km	25%
<30 km	15%
<40 km	7.5%
<50 km	3.75%

The above decay rate is in line with that applied in the screening methodology currently used by the Trust to estimate the number of additional boat movements as a result of marina developments.

Using the above methodology, an increase in annual boat movements has been estimated at strategic locks, within 5 Hydrological Units, within 50 km of the restored canal. In order to assess the impact of these additional boat movements on the CRT network, boat movements have been converted to lockages using a boat to lockage ratio of 1.4:1 for narrow locks and 2.6:1 for broad locks. These lockages have then been converted to lockage demand using a lock volume of 0.1 Ml and 0.2 Ml for narrow and broad locks, respectively. As with the decay rate above, this is in line with the screening methodology currently used by the Trust to estimate the number of additional boat movements as a result of marina developments.

Further applying this methodology, this additional lockage demand was added to the current demand for each hydrological unit and the impacts on the current level of service for each was determined.

Results

Table 4 below shows the additional lockage demands estimated for each hydrological unit within 50 km of the Hatherton Canal Restoration.

Table 4 – Additional lockage demand on wider Trust network as result of restoration

Hydrological Unit	Additional Annual Lockage Demand Ml/yr
BCN	287
Oxford & GU	0
10 Mile	14
Peak & Potteries	321
Shropshire Union/S&W	771

Based on these estimates, the results show that there is *no net impact* on the level of service of the BCN, Oxford & GU, 10 Mile or Peak & Potteries Hydrological Units. However, there *is a net impact* on the level service of the Shropshire Union and Staffordshire & Worcestershire Canals Hydrological Unit. The additional demands resulting from the full restoration of the Lichfield Canal could not currently be met by the Trust's network alone.

Conclusions

The results showed that for the full restoration of the Hatherton Canal, there is a net impact on the level of service of the Shropshire Union & Staffordshire & Worcestershire Canals Hydrological Unit i.e. the additional demands on the wider Trust network resulting from the restoration cannot currently be fully met by the Trust's network alone.

Alternative sources of supply to meet the estimated demands on the Trust's wider network as a result of the restoration of the Hatherton Canal will therefore need to be investigated by Stantec/L&HCRT.

References

Ove Arup & Partners Ltd (2006) Hatherton Canal Restoration – Final Feasibility Report September 2006, 130pp