Lichfield Canal Water Supply Study – Stage B

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Prepared for

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Lichfield Canal Water Supply Study – Stage B

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1 INTRODUCTION

1.1 Background

The Lichfield and Hatherton Canals Restoration Trust (LHCRT) is restoring the former Lichfield branch (Ogley Lock Section) of the Wyrley and Essington Canal. The former canal ran in a downhill direction, approximately for 7 miles, from Ogley Junction at Brownhills on the northern Birmingham Canal Navigations (BCN), to the Coventry Canal at Huddlesford Junction (Figure 1.1).

The purpose of this restoration, which will be undertaken over seven distinct phases (Section 6.1), is to restore it back to full use for navigation and to maintain land drainage functions. The majority of the restoration is to take place along the original route of the canal with some off-line restoration in some of the eastern sections (Figure 1.1). Once restored, the canal will join the existing national canal network at these junctions, both of which are owned by the Canals and Rivers Trust (CRT).

In July 2015, ESI Ltd was commissioned by Pleydell Smithyman Ltd (PSL), on behalf of Walsall Concrete Limited (WCL), to undertake a formal Water Supply Study. WCL currently operate Cranebrook Quarry and submitted a mineral planning application in September 2015, supported by PSL, for the eastwards extension of Cranebrook Quarry.

As part of the mineral planning application, a quarry restoration plan was proposed which includes a physical landform for the future development of a marina subject to a separate planning application. A preliminary report, Stage A report, was produced to support the mineral application in respect of its restoration scheme (ESI, 2015). As part of the report, an outline baseline water demand and water supply was provided for the restoration of the eastern extension area of Cranebrook Quarry where a void containing a waterbody is being considered.

The proposed marina will be connected to Section B of the restored Lichfield Canal which runs along the southern boundary of Cranebrook Quarry (Section 2.1). WCL and PSL are therefore working closely with LHCRT so that a technically robust solution is implemented with the potential to provide benefit to the wider community in the area. The detailed brief for the works being agreed between LHCRT and ESI.

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 Lichfield canal to be used for navigation.

The following needs to be addressed for the WSD:

1. the water volume required to fill the canal upon completion and at different phases of the restoration;
2. water losses due to evaporation, leakage through canal base and lock gates;
3. water required to operate the canal (lockage water);
4. changes in WSD due to climate change scenarios, deterioration of infrastructure and changes in canal traffic. The subjectivity of assumptions and the subsequent impacts of these scenarios will be addressed through sensitivity analysis;
5. consideration needs to be given to the development of the marina at Tamworth Road and Cranebrook Quarry in terms of water supply demand within the context of the overall canal restoration plans (Cranebrook Quarry has mostly been addressed in the Stage A report).

Once the WSD has been determined, a WSS assessment will be required in order to determine the location and potential of the sources of water needed to fill and operate both the marina and the canal.

The objective and scope summarised above were laid out in LHCRT's "*Lichfield Canal Restoration: Water Supply Study Requirements and Scope*" (LCRWSSR&S) document which was circulated to CRT and EA for comments. CRT comments were incorporated into a version circulated prior to the start-up meeting on 10/08/2015. EA comments were later incorporated into the final version of the LHCRT scoping document (circulated to ESI on 31/08/2015), the meeting minutes[1] and subsequent discussions with PSL and LHCRT.

1.3 Previous Reports

1.3.1 Sharkey Associates

A report was issued in February 2000 by Ed Sharkey Associates who had been commissioned by the LHCRT to prepare an environmental report outlining the potential impacts and environmental benefits and disbenefits of a restoration of the Lichfield Canal. The report has recognised the importance of arranging for an existing licence holder to get a variation to an abstraction licence that allows water to be supplied to a third party or for a different purpose than originally abstracted (i.e. transferring licence rights to CRT who would then supply the Lichfield Canal). At the time, the EA agreed, in principle, that the canal could be supplied with water from the BCN using water supplied to the Wolverhampton Level which is fed by Chasewater Reservoir and the Bradley borehole, although the impacts of the canal construction on this borehole licence would have to be quantified.

1.3.2 Atkins

In 2009 LHCRT commissioned a Restoration Feasibility Study which was undertaken by consultant Atkins (Atkins, 2009). This demonstrated the technical feasibility of restoration and included some considerations of water supply required for a restored and navigable canal. However it did not confirm availability of water or likelihood of obtaining abstraction licenses for the required water. One of the report's recommendations was to undertake a formal Water Supply Study (WSS).

1.3.3 PSL

In July 2015, PSL commissioned BCL Consultant Hydrogeologists Ltd (BCL), on behalf of WCL, to undertake a hydrological and hydrogeological assessment in support of a mineral planning application for Cranebrook Quarry (BCL, 2015). The report provides a detailed insight into the geology, hydrology and hydrogeology of the western area of the Lichfield Canal route.

1.3.4 ESI

In July 2015.ESI Ltd was commissioned by PSL to undertake a formal Water Supply Study for Cranebrook Quarry (ESI, 2015). This report was issued as a Stage A report in September 2015. The report identified several feasible options for the initial infilling of the void that will be created as part of the WCL restoration of the eastern part of Cranebrook Quarry. The constrained list of options identified in the Stage A report indicated that the Cranebrook Quarry site would be self-sustaining. Rainfall alone would be able to support the initial infill of the void within 2.5 years. The onsite 20 m^3/d borehole would be able to reduce the infill time to 1.5 years.

1.4 This Report

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

[1] Comments received from Derek Lord (LHCRT) on 27/08/2015 and CRT on 21/09/2015.

The assessment includes two proposed marinas that will eventually be connected to the canal (Section 2). One of the marinas will be the restored quarry waterbody at Cranebrook Quarry. The Canal and River Trust (CRT) has supported this study by undertaking modelling work for water losses arising from the operation of the canal and leakage through the canal base. They have provided water demand estimates for the operation of the canal through their internal models used on their own canal network. The estimates have been provided for both the fully restored scenario and various partially restored scenarios.

Support has also been provided through LHCRT[2] for the identification of future residential estates that are part of the Lichfield Development Plans. LHCRT has undertaken liaison with Severn Trent Water Ltd (STWL), Staffordshire County Council (SCC) and Highways England (HE).

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.

[2] Various email correspondence with Derek Lord, including a summary document provided on 16/11/2015

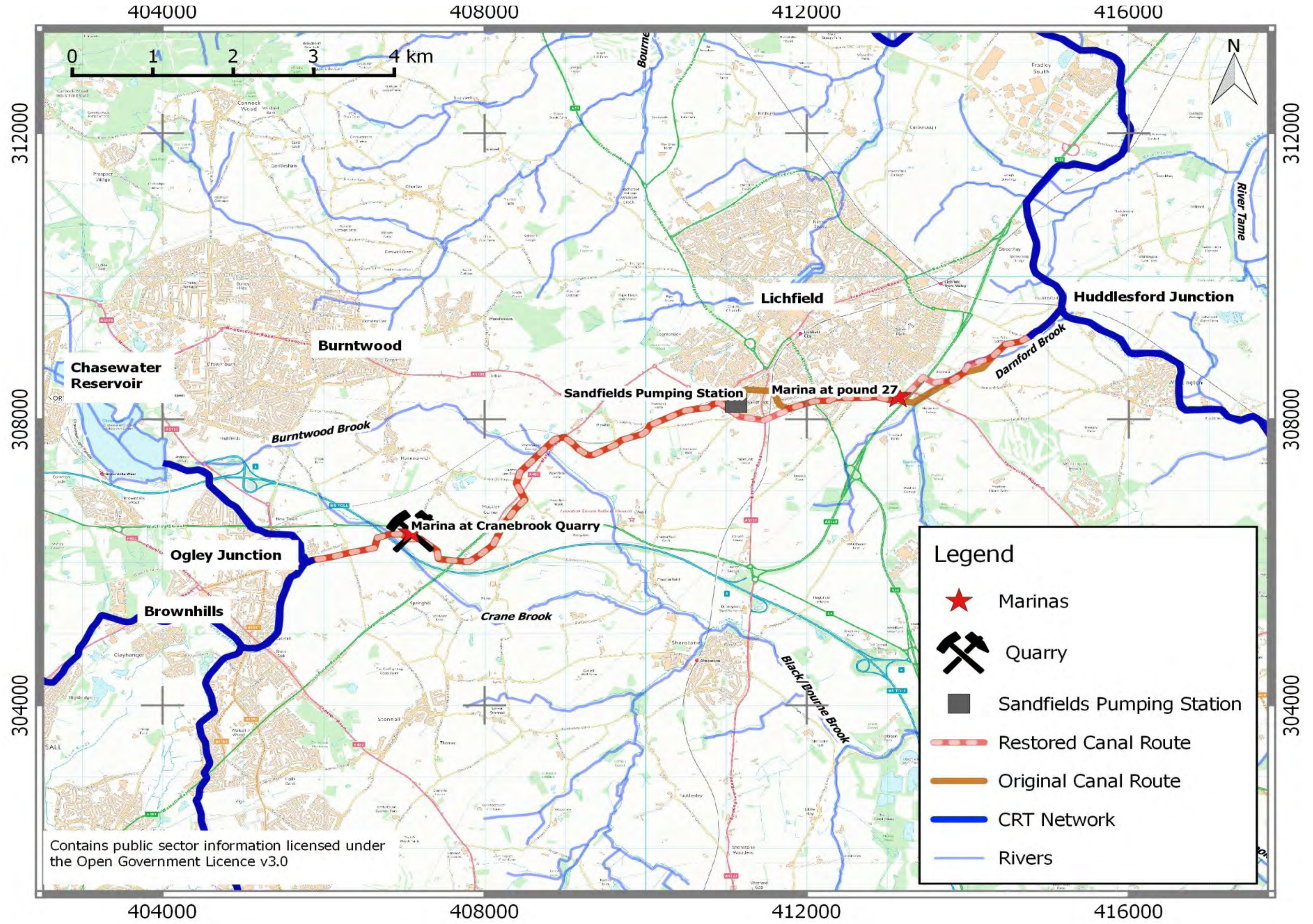

Figure 1.1 Site Location

2 LICHFIELD CANAL

2.1 Background to the Proposed Restoration

LHCRT has outlined in its scoping document that there will be several benefits as a result of the proposed restoration, particularly in giving direct access to the underused BCN network, relieving overcrowding of the local Trent and Mersey/Coventry canals and also in supporting economic regeneration of the area. As a result, the restoration is supported by CRT, Lichfield City Council, Lichfield District Council and SCC. Restoration to date has, in part, been funded by public sector grants, including funding from the European Regional Development Fund (ERDF).

The proposed canal restoration will include two marinas (see Figure 1.1):

1. The marina at the restored quarry waterbody at Cranebrook Quarry;
2. The marina at Pound 27, south of A51 Tamworth Road and west of the A38. Lichfield canal runs along the south side of the marina (see Appendix B).

2.2 History of the Canal

Construction of the canal started in 1792 and was completed in 1797 when the entire length was opened (Wikipedia, 2015). Prior to the abandonment of navigation in 1954 (by Act), the primary source of water for the canal was the British Canal Navigation (BCN), Wolverhampton Level, which is fed from Chasewater Reservoir, located to the north west of Ogley Junction. This was supplemented by discharges from Sandfields Pumping Station at Lichfield. It is understood that flows from Sandfields Pumping Station are no longer available, but Chasewater Reservoir still remains in use and supplies the existing canal network to the west of Ogley Junction[3].

Plans to restore the Lichfield Canal were first raised in 1975, when area planning authorities were required to produce county structure plans (Wikipedia, 2015). Since these initial plans, several external events have influenced the restoration, including the construction of an aqueduct over the M6 Toll road in 2003. The proposed construction of the Lichfield Southern Bypass has also led to the provision of the canal tunnel under the Birmingham Road Roundabout and will result in a combined crossing for both road and canal beneath the Lichfield to Birmingham Railway

The section of the canal between Lock 25 and 26 was the first part of the canal to have been filled with water in April 2011 (Figure 6.1).

2.3 Current State

Much of the canal bed has been filled in or drained down since closure to navigation in 1955, although a short section at Huddlesford Junction remains in water and use.

The section upstream of Ogley Junction to Sandfields Pumping Station has been abandoned whilst the section from Ogley Junction to the M6 Toll Road has been removed.

The former Lichfield branch was abandoned for navigation purposes in 1954 but was kept open to provide a land drainage function. However, over time parts of the canal have since been removed or culverted, particularly the section south of Lichfield which acts as a surface water drainage system for those areas of the town.

Many of the historical locks are in good condition and, although some restorations works will be required, these locks will be included as part of the full canal restoration (Atkins, 2009).

Since the initial plans for the restoration of the canal, the LHCRT has had to adjust the plans to meet the requirements of external events and opportunities that have manifested over recent years.

[3] CRT has indicated a preference to identify other sources of water, in order to limit the requirement to supply from their existing network.

3 PHYSICAL SETTING

3.1 Geology

The outcrop geology in the area is dominated by Triassic sandstone, notably formations of the Sherwood Sandstone Group, which rests unconformably on the Carboniferous Coal Measures.

The Coal Measures crop out to the west of Ogley Junction, in the Brownhills area where there is a history of coal mining (Section 3.4.4) and to the south of Cranebrook Quarry (Figure 3.1). These include the red marls and sandstones of the Enville Member (formerly the Hamsted Group) which crop out approximately 1 km to the south of Cranebrook Quarry and similar lithologies belonging to the Alveley Member (formerly the Keele Group) which crops out in the Brownhills area.

The Permian aged Bridgnorth Sandstone Formation is not present at outcrop. The western section (Sections A, B and C in Figure 6.1) of the Canal is underlain by the older Wildmoor Sandstone Formation which is composed of fine to medium grained sandstones (Allen *et al.,* 1997). The majority of the canal route is underlain by the Bromsgrove Sandstone Formation, stratigraphically above the Wildmoor Sandstone. The Bromsgrove Sandstone is a lithologically variable sequence of fine to medium grained sandstones with interbedded mudstones. This layering can result in steep vertical hydraulic gradients within the sandstone.

Superficial deposits are absent along most of the canal route. Alluvium deposits associated with Darnford Brook are present beneath the western section of the proposed canal route, south east of Lichfield. Glaciofluvial deposits are present over a 300 m section near Lichfield Road (end of Phase D section) while a 200 m section of Phase B crosses Sandy Till deposits near Tamworth Road (Figure 3.2).

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

Table 3.1 Summary of the geological succession (BGS, 2015).

Stratigraphy	Unit/ Formation	Lithology	Thickness from geological map (m)	Thickness along route of canal (m)
Quaternary (Pleistocene-Holocene)	Alluvium	Brown silly clay with sand and gravel lenses	Not provided	3-4[4]
	Glaciofluvial Sheet Deposits	Undifferentiated (mainly ice-contact): sand, pebbly sand and gravel with silty clay layers	Not provided	2-3[5]
	Till	Red-brown, silty, clay-sand diamict with Triassic and Carboniferous clasts and granitoid erratics	Not provided	Not present
	Sandy Till	Heterogeneous pebbly, silty sand and silt with locally-derived rock fragments	Not provided	3-4[6]
Triassic	Mercia Mudstone	Mudstone, red-brown, with indurated beds of dolomitic siltstone and sandstone	0-175	Not present at outcrop
	Bromsgrove Sandstone Formation	Sandstone, brown and reddish brown, micaceous, locally pebbly; interbedded with mudstone	30-140	30-140
	Wildmoor Sandstone Formation	Sandstone, red with grey-green mottling, silty, micaceous, very weakly cemented; minor interbedded mudstone.	20-240	100-140
	Kidderminster Formation	Pebble conglomerates and reddish brown sandstones. The sandstones are cross-bedded and pebbly	50-154	100-120[7]
Permian	Bridgnorth Sandstone Formation	Sandstone, red, poorly cemented, with large-scale Aeolian dune-bedding	0-236	Not present at outcrop
Upper Carboniferous	Salop Formation (comprising the Alveley and Enville Members)	Interbedded mudstone and sandstone, reddish brown with minor conglomerate and limestone bands	200-360	200-360

[4] Estimated thickness from BGS map for the areas underlying the section from Tamworth Road to Huddlesford Junction as no BGS logs available.
[5] From BGS borehole logs in the areas to the south of Lichfield Road although logs identify these as River Terrace deposits.
[6] This lithology underlies the last 200 m of the section from Toll Road to Tamworth Road and thicknesses are from BGS borehole logs are from the area near Tamworth Road
[7] Assuming a 5 degree dip of strata as indicated by BGS

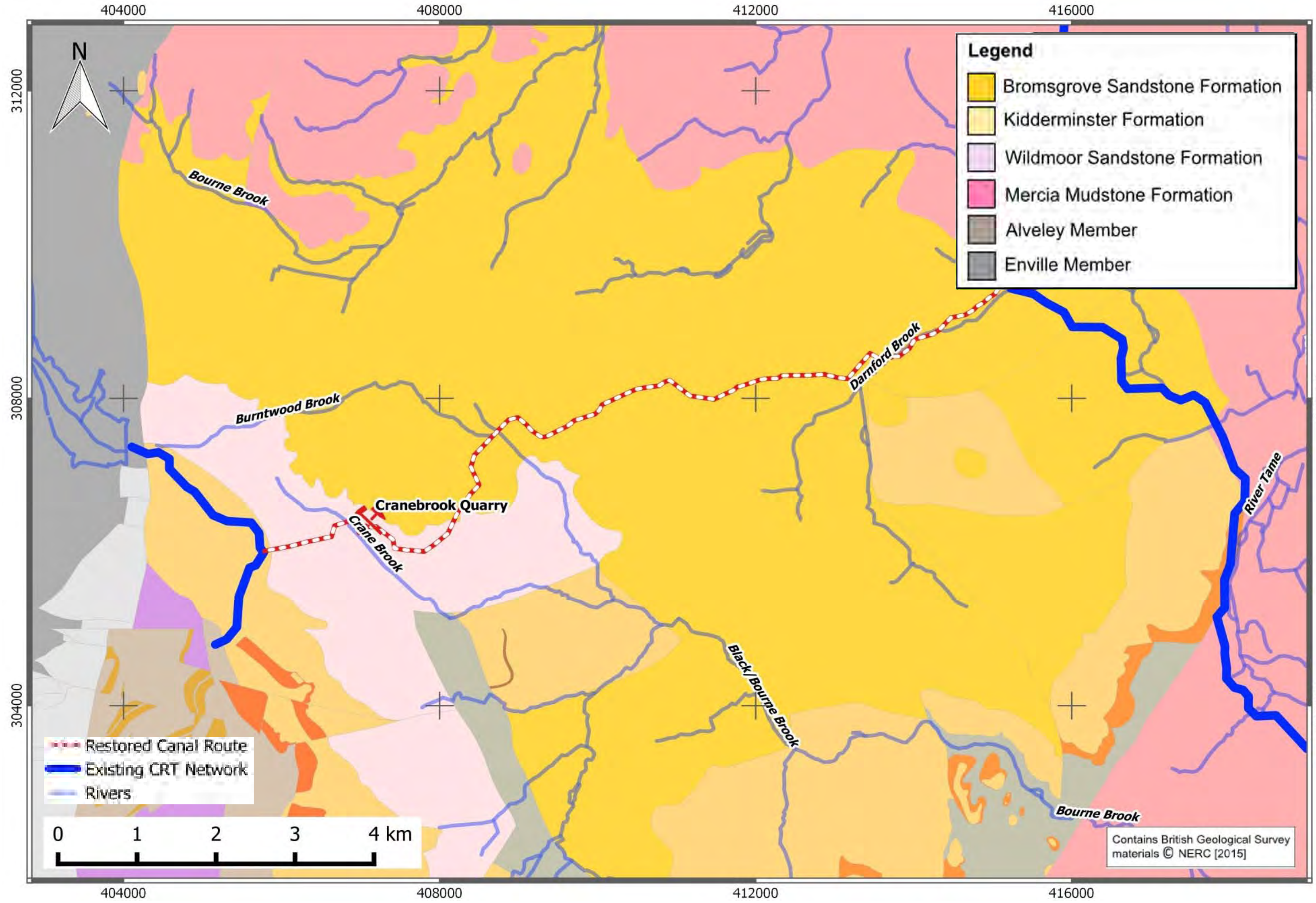

Figure 3.1 Bedrock geology.

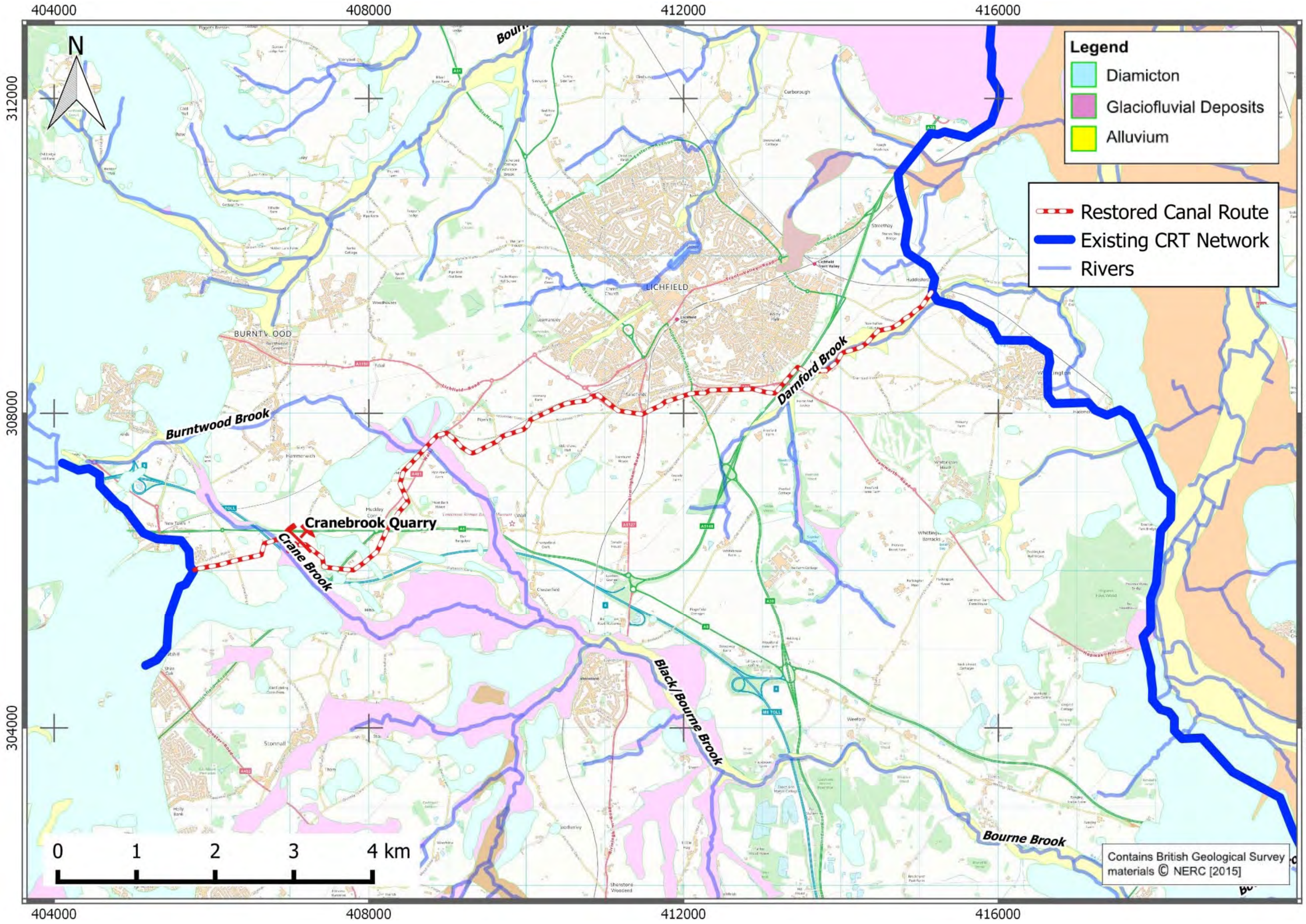

Figure 3.2 Superficial geology.

3.2 Hydrology

There are a number of surface water features present in the area. The Crane Brook and the Burntwood Brook cross the western section of the canal route. These are both tributaries to the larger Black/Bourne Brook (Figure 3.3).

The Crane Brook is impounded by Chasewater Reservoir which was constructed in 1797 to feed the Wyrley and Essington Canal via the Anglesey Branch. At present there is no requirement for the reservoir to augment the Crane Brook and it only receives inflows from the reservoir if excess water is discharged from the spillway via a gravity fed pipeline. As such, this brook is designated as a Heavily Modified Water Body (HMWB) and is effectively dry, especially during summer months (EA, 2013). Flows in the lower reaches of the Burntwood Brook are largely sustained by discharges from Burntwood Sewage Treatment Works (STW) (see Figure 3.6).

There are a number of smaller surface water bodies in the area including Burntwood Pools which are located c. 170 m north of Burntwood Brook, adjacent to Walsall Road (Figure 3.3).

In the east, Darnford Brook flows adjacent to the canal towards Huddlesford and continues to flow north eastwards where it joins the River Tame.

3.3 Hydrogeology

3.3.1 Aquifer units and properties

The Permo-Triassic Sherwood Sandstone aquifer underlying the study area is classified as a principal aquifer (orange colour in Table 3.1). The EA has split the aquifer into two Groundwater Management Units (GWMU), the Lichfield GWMU and the Shenstone GWMU (Figure 3.3) for groundwater management purposes. From a hydrogeological point of view, the two units can be treated regionally as a single hydrogeological unit. However, on a local scale it may represent a multiple aquifer system due to the interbedded mudstone layers, particularly in the upper sequence of the Bromsgrove Formation where marl horizons become thicker (ESI, 2015).

Permeability in the Permo-Triassic Sandstones is understood to be governed by both intergranular flow and flow through small-scale fractures (ESI, 2008).

The Alveley and Enville Members are considered minor aquifers and are normally considered largely hydraulically detached from the overlying sandstone aquifer.

3.3.2 Groundwater levels

The Environment Agency has provided groundwater levels for twelve boreholes located within the sandstone underlying the study area (Figure 3.3). Summary statistics and time series data are presented in Table 3.2 and Figure 3.4 respectively.

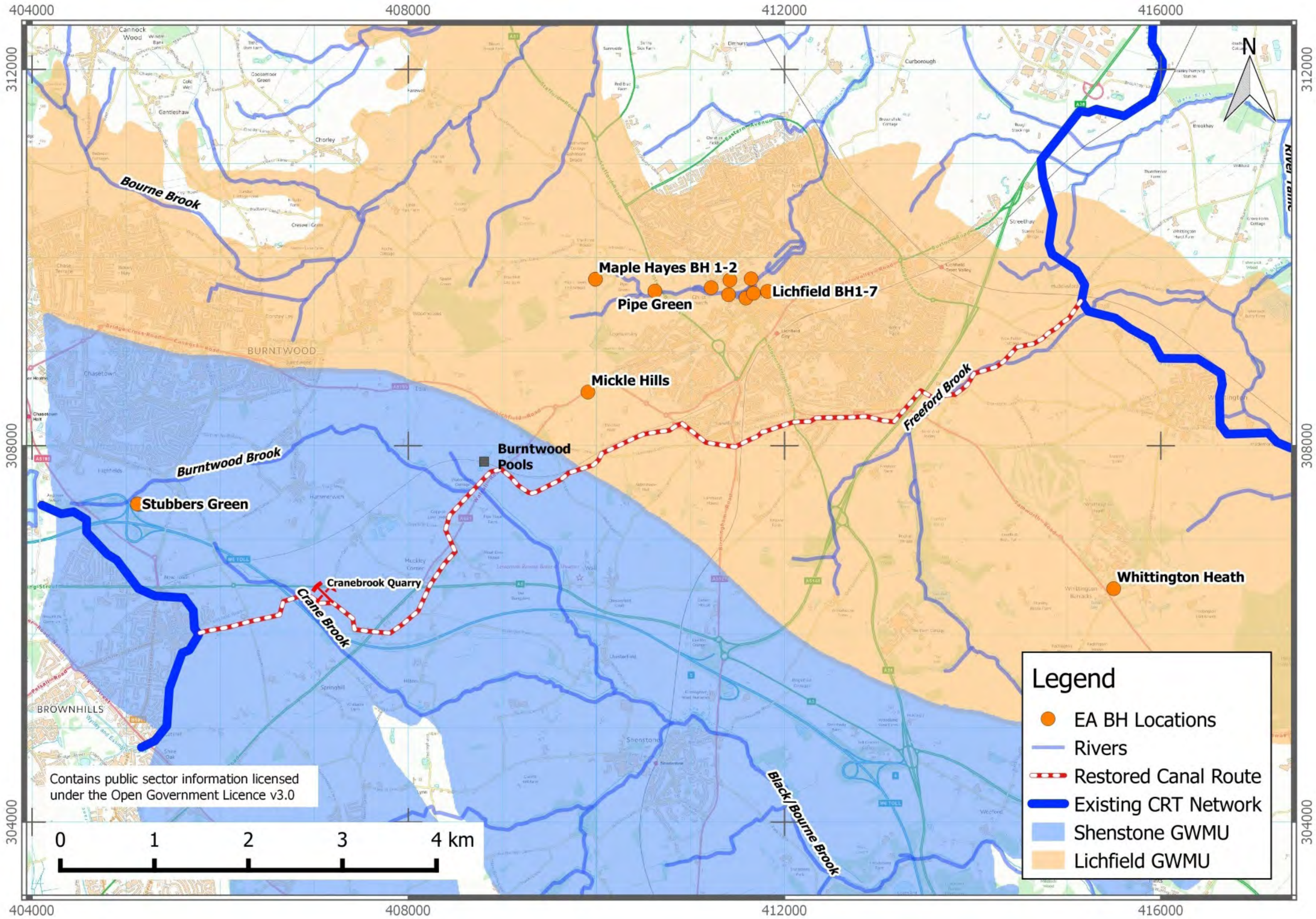

Figure 3.3 Hydrology and Hydrogeology

Table 3.2 Summary groundwater level statistics

Name	Date Range	Groundwater Level (maOD)		
		Min	Mean	Max
Lichfield 1	Jun 99 – Apr 10	76.95	77.38	78.08
Lichfield 2	Jun 99 – Apr 10	69.16	69.88	70.83
Lichfield 3	Jun 99 – Apr 10	76.13	76.52	77.11
Lichfield 4	Jun 99 – Apr 10	74.89	75.39	76.53
Lichfield 5	Jun 99 – Apr 10	74.45	75.02	76.30
Lichfield 6	Jun 99 – Apr 10	73.66	74.54	76.92
Lichfield 7	Jun 99 – Jul 15	67.99	72.09	73.48
Maple Hayes	Oct 91 – Mar 11	83.11	84.62	85.59
Mickle Hills	Jan 07 – Jul 14	87.00	88.69	90.00
Pipe Green	Mar 92 – Jul 15	78.98	80.87	81.81
Stubbers Green	Sep 76 – Jul 15	105.91	109.54	111.06
Whittington Heath	May 81 – Jul 15	88.09	90.58	91.98

Groundwater levels at Stubbers Green are at approximately 10 m below ground level in the western areas of the canal route (likely to be representative for the sections of Phases A, B, C and D). Groundwater levels at Mickle Hills are approximately 12 m below ground level (likely representative of the entire section of Phases E and the western section of Phase F). 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.

The section along Phase G is mostly running along the alluvial deposits of the Darnford Brook and it is expected that there may be some connection of the canal to groundwater along this section. It is unclear whether the Darnford Brook is losing water to the underlying bedrock aquifer. Groundwater levels at Whittington Heath are unlikely to be representative of groundwater levels along the section of Phase G, as several faults may be controlling groundwater levels at Whittington Heath. If the canal cuts through the alluvial deposits and the bedrock water table is greater than 2-3 m deep, the canal may end up losing water along this section too.

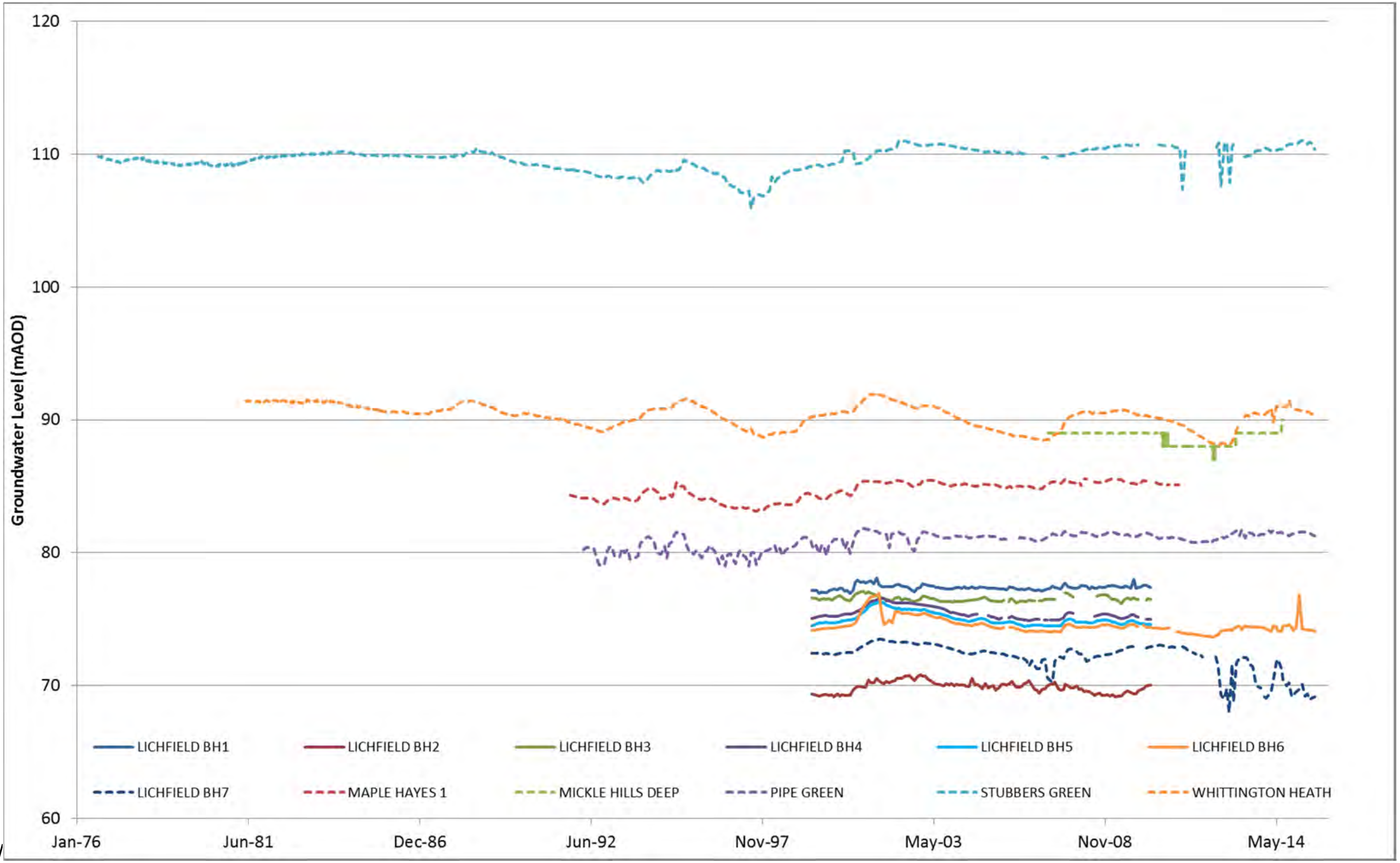

Figure 3.4 Groundwater level in the area.

3.4 Anthropogenic Influences

3.4.1 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 3.3 and surface water abstraction in Table 3.4 and shown in Figure 3.5.

Both the surface water and groundwater catchments within the area are closed to new abstractions due to the EA defining the Lichfield and Shenstone GWMUs as being 'over abstracted'. Over abstraction has lowered the groundwater table resulting in a depletion of base flow to hydraulically connected surface water bodies, namely the Black/Bourne Brook (EA, 2013).

The EA confirmed during the start-up meeting that water resources in the area are stressed and therefore there is no opportunity for granting new abstraction licences.

Table 3.3 indicates that there are four licensed groundwater abstractions (highlighted in grey) that are within 500 m of the proposed canal route. Three of the abstractions (the furthest from the canal route) have only small licensed daily and annual quantities. The fourth (Pipe Hill) is a public water supply (PWS), operated by South Staffordshire Water (SSW), that has a recent average annual abstraction (2011 to 2014) that is approximately 25% of the licensed annual amount, indicating that the licence is currently being under used. The Pipe Hill PWS borehole is only 80 m from the proposed canal route.

The EA has identified several SSW groundwater sources as potentially impacting groundwater and surface water resources in the area under their National Environmental Programme (NEP). Environmental monitoring began under the fifth Asset Management Programme (AMP5) investigation cycle and is continuing under the current AMP6 programme. Table 3.4 indicates that there are four licensed surface water abstractions (highlighted in grey) that are located within 500 m from the proposed canal route. While three sources have relatively small licensed daily (<0.73 Ml/d) and annual quantities (<16 Ml/a), the fourth (Manor Farm at Burntwood Pools) has a relatively large licensed daily and annual abstraction. Over the recent four years this source has been used at 14% on average, leaving significant spare capacity on the licence.

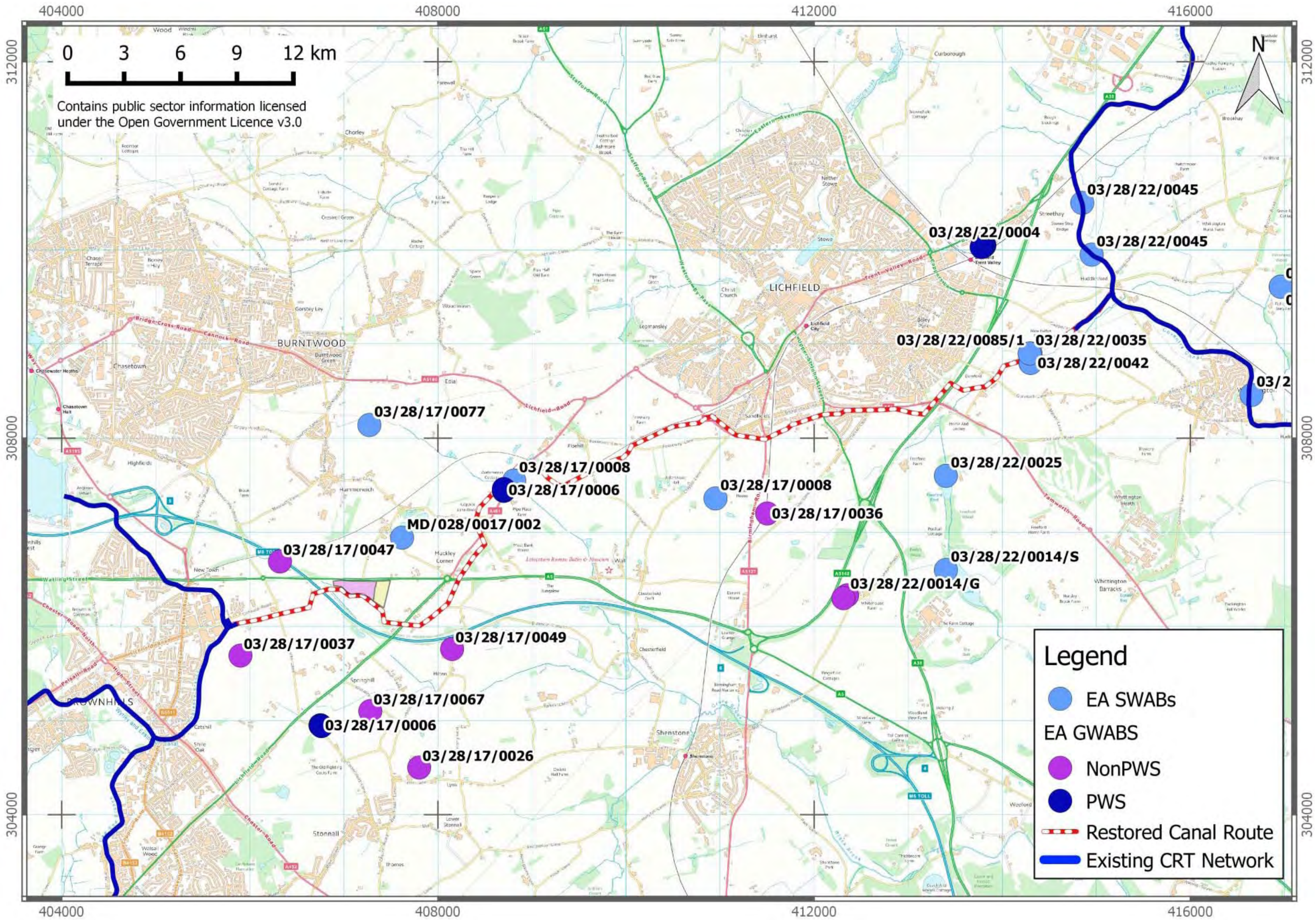

Figure 3.5 Groundwater and surface water abstractions

Table 3.3 Licensed groundwater abstractions within a 2 km buffer of the canal route (EA data).

Site Name	Licence No.	Source	Sector	Distance to Canal (m)	Licensed Daily Volume (Ml/d)	Licensed Annual Volume (Ml/a)	Recent Actual (Ml/a)*			
							2011	2012	2013	2014
Pipe Hill*	03/28/17/0006	Borehole	Public Water Supply	80	45.46	13,665.60	4186.86	4097.43	4028.20	1897.62
Sandhills*	03/28/17/0006	Borehole	Public Water Supply	>500			-	-	-	-
Trent Valley Pumping Station	03/28/22/0004	Borehole	Public Water Supply	>500	20.00	5,000.00	-	-	-	-
Whitehouse Farm	03/28/22/0014/G	-	Other Potable Uses	>500	6.82	45.46	-	-	-	-
Warren Bridge House	03/28/17/0037	Borehole	Agriculture	330	1.68	68.19	-	-	-	-
Semi Bungalow Farm	03/28/17/0047	Borehole	Agriculture	500	0.32	9.09	-	-	-	-
Barn Farm	03/28/17/0049	Borehole	Agriculture	400	0.45	20.00	-	-	-	-
Sandhills	03/28/17/0067	Borehole	Agriculture	>500	1.19	40.00	-	-	-	-
Lynn Farm	03/28/17/0026	Borehole	Agriculture	>500	0.34	10.23	-	-	-	-
Knowle Farm	03/27/17/0036	Borehole	Agriculture	>500	0.34	10.23	-	-	-	-

*Recent Actual data was only provided for licenses within 200 m of the restored canal route

Table 3.4 Licensed surface water abstractions within a 2 km buffer of the canal route (EA data).

Site Name	Licence No.	Source	Sector	Distance to Canal (m)	Licensed Daily Volume (Ml/d)	Licensed Annual Volume (Ml/d)	Recent Actual (Ml/a)*			
							2011	2012	2013	2014
Manor Farm	03/28/17/0008	Burntwood Pool	Agriculture	90	4.36	136.36	39.87	0.18	12.16	25.38
The Old Farm	03/28/17/0077	Burntwood Brook	Agriculture	>500	0.52	34.00	-	-	-	-
Whitehouse Farm	03/28/22/0014/S	Land Drains	Other Potable Uses	>500	0.27	4.55	-	-	-	-
Freeford Farm	03/28/22/025	Packington Brook	Agriculture	>500	0.55	40.28	-	-	-	-
Marsh Farm	03/28/22/0035	Trib of River Tame	Agriculture	20	0.73	15.91	0.00	0.00	0.00	0.00
Mill Farm	03/28/22/0042	Darnford Brook	Agriculture	450	0.41	12.73	12.73	0.00	3.48	1.07
Whittington Farms	03/28/22/0045	Coventry Canal	Agriculture	>500	0.82	15.00	-	-	-	-
Sheepwash Farm	03/28/22/0061	Fisherwick Brook	Agriculture	>500	2.62	109.10	-	-	-	-
Whittington	03/28/22/0063	Fisherwick Brook	Agriculture	>500	1.31	73.00	-	-	-	-
Darnford Lane	03/28/22/0085/1	Darnford Brook	Industry	10	0.30	6.00	0.00	0.00	0.00	0.00
Coppice Lane	MD/028/0017/002	Spring	Agriculture	>500	0.00	0.00	-	-	-	-

**Recent Actual data was only provided for licenses within 200 m of the restored canal route

3.4.2 Discharges

Permitted discharges falling within a 2 km buffer around the proposed canal route are listed in Table 3.5 and shown on Figure 3.6.

Table 3.5 Discharge consents (EA data).

Consent Name/Number	Details	DWF (Ml/d)	Mean Daily Flow (Ml/d)	Max Rate (l/s)
EPRFP3421GM	STP and Soakaway		0.0036	
T/22/35984/TG	Sewage & trade		0.004	
T/17/02813/T	Water Treatment Works	18.18		227.3
NPSWQD008140	Domestic Property		0.0036	
T/07/36455/TG	Trade (Unknown/Other)		0.0044	
T/22/30085/O	Sewerage Network - Pumping Station			
T/22/35662/T	Recreational and Cultural		0.0031	
EPRJP3327XF	Domestic Property		0.011	

All discharges listed in Table 3.5 are at most 300 m from the proposed route of the Canal. Discharges from permit number T/17/02813/T are likely to be associated with Burntwood Sewage Treatment Works (see Figure 3.6). None of the remaining discharge consents have substantial permitted discharges.

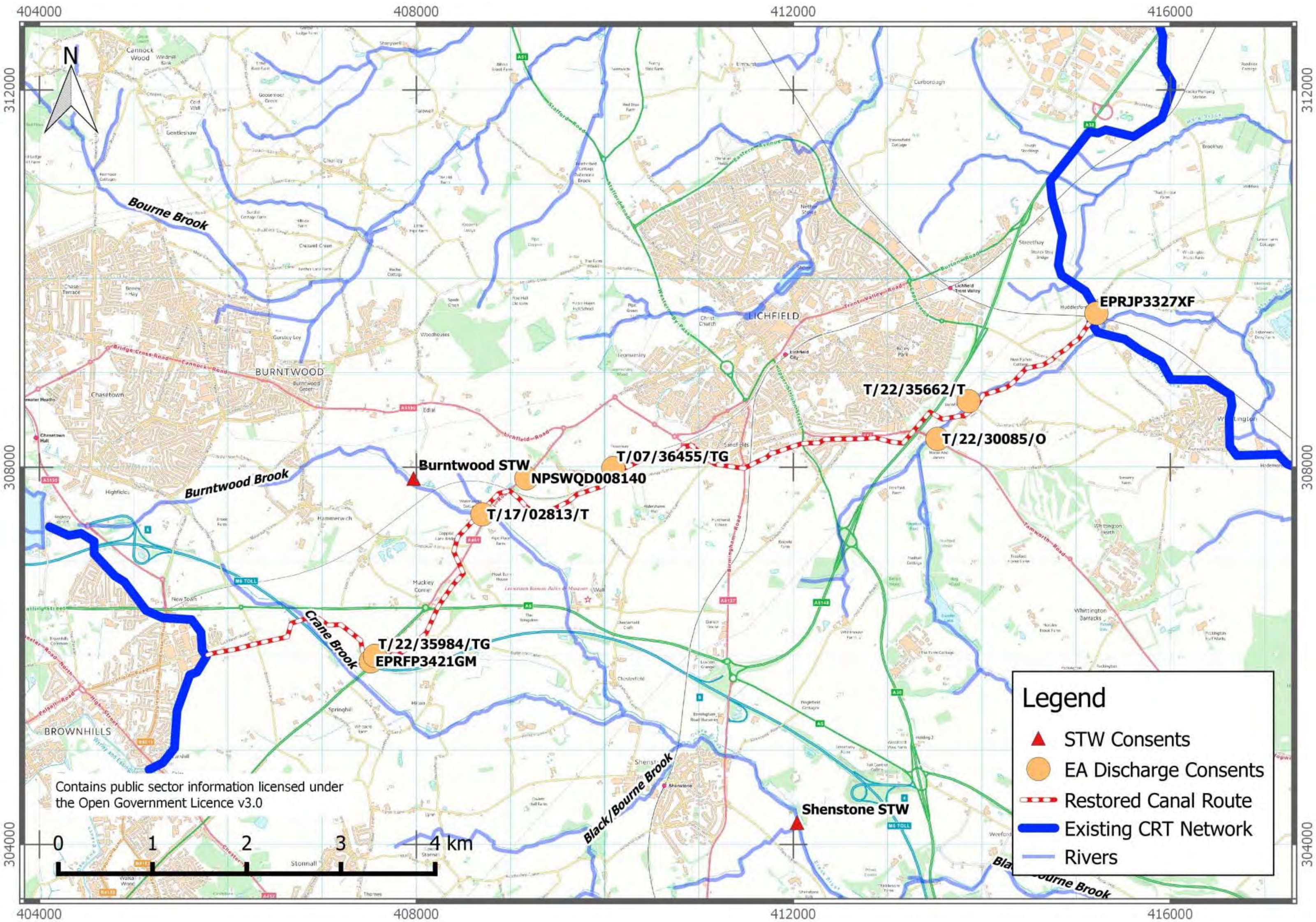

Figure 3.6 Discharge Consents

3.4.3 Quarries

Two operational quarries were identified within a 2 km buffer from the proposed canal route (Table 3.6).

Table 3.6 Quarries within 1 km from the canal route.

Name	Easting	Northing	Distance from the canal route (m)	Status
Cranebrook Quarry	407100	306435	100	Active
Shireoak	406100	304260	1,600	Active*

* Quarry is assumed active based on inspection of Google Maps aerial imagery.

As outlined in Section 1, Cranebrook Quarry is owned by WCL Quarries Ltd and situated adjacent to the proposed line of the Canal in Section B, below Lock 7. It is located along the northern side of the canal with the A5 running along its northern boundary, the Crane Brook and the M6 Toll road on its western boundary and Muckley Corner just 800 m to the east of the quarry.

The current extension of the quarry (purple in Figure 3.7) is currently being worked to a maximum depth of 112 maOD. The proposed extension (yellow in Figure 3.7) will proceed eastwards with the maximum depth at the same elevation. The base of the quarry is c. 1 m above the maximum groundwater level at Stubbers Green and workings are therefore being undertaken in dry condition (no dewatering occurring). A borehole is used on site for dust suppression. Abstractions from the borehole do not exceed 20 m^3/d (0.02 Ml/d) and a licence is therefore not required.

At restoration phase, the western half of the quarry will be filled with inert waste to an elevation of 122 maOD. The eastern half of the quarry will be filled with inert waste to an elevation of 119 maOD. It will then be capped with a 1.2 m thick, low permeability (10^{-9} m/s) material. The lowest point of the brim of the void space will be at an elevation of 125 maOD, creating a void space of 106,000 m^3 (BCL, 2015). The void will host a water body that will be, in the interim, gradually filled with water, the source of which was part of the Stage A report.

The water body's future use (subject to a future separate planning application that will be accompanied by this report) will be that of a marina once the restored Phase 1 of the Lichfield canal reaches the quarry. The estimated timescales for the restoration, subject to a predicted mineral extraction rate of 75,000 tonnes/year, is ten years, which is similar to the estimated timescale for the restoration of Section B of the canal.

The proposed marina will extend over an area of 22,000 m^2 and will have a minimum depth of 1.5 m. The total volume of water within the marina will be 33,000 m^3 and it will allow the mooring of 70 boats, 63 private and 7 rented.

Shireoak quarry is located c. 1.6 km to the south of the restored canal route (see Figure 3.7). Based on inspection of Google Earth aerial imagery, there appears to be one surface water body within the quarry. The elevation of the current base of the quarry is approximately 130 maOD[8], c. 20 m above the observed groundwater levels observed at the nearby Stubbers Green borehole (see Figure 3.3 and Figure 3.4). Therefore, unless the working depth of the quarry is more than 20 m, it is unlikely that this quarry is dewatered as part of the site operation.

[8] Based on the elevation of the existing surface water body shown on Google Earth.

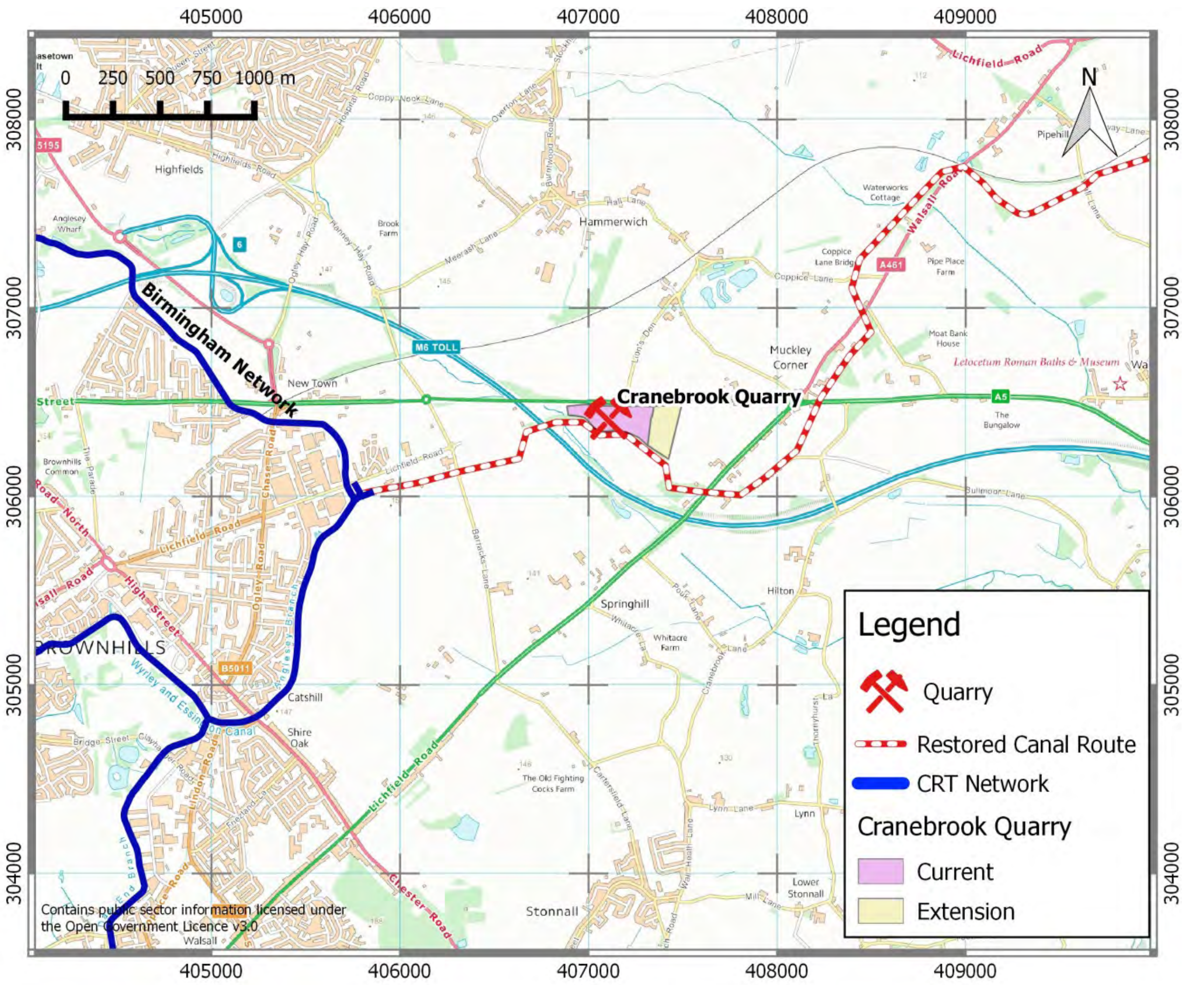

Figure 3.7 Location of Cranebrook and Shireoak Quarry[9].

3.4.4 Mining

Brownhills, to the west of Ogley Junction, has a history of coal mining. Coal was extracted from the Upper Coal Measures. Several historical coal mining pits were located in the area, including Wyrley Grove Pit which is located in Wyrley Common) (pers. comm. Lee Wyatt, Coal Authority, 25/11/2015). This location of this pit and two Coal Authority boreholes, School Lane and Cathedral Pit, are shown on Figure 3.8. 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 does not hold water quality records for this location.

The Coal Authority's reporting boundary falls 800 m to the west of Cranebrook Quarry and Ogley Junction falls within this area (Figure 3.8). Any underground works that are undertaken within this area require permits from the Coal Authority.

The Canal route does not cross any historical mine working areas and is therefore not likely to suffer from mining induced land subsidence which occurs in the nearby Cannock Chase areas.

[9] Extents of quarry areas digitised from PSL quarry restoration plan.

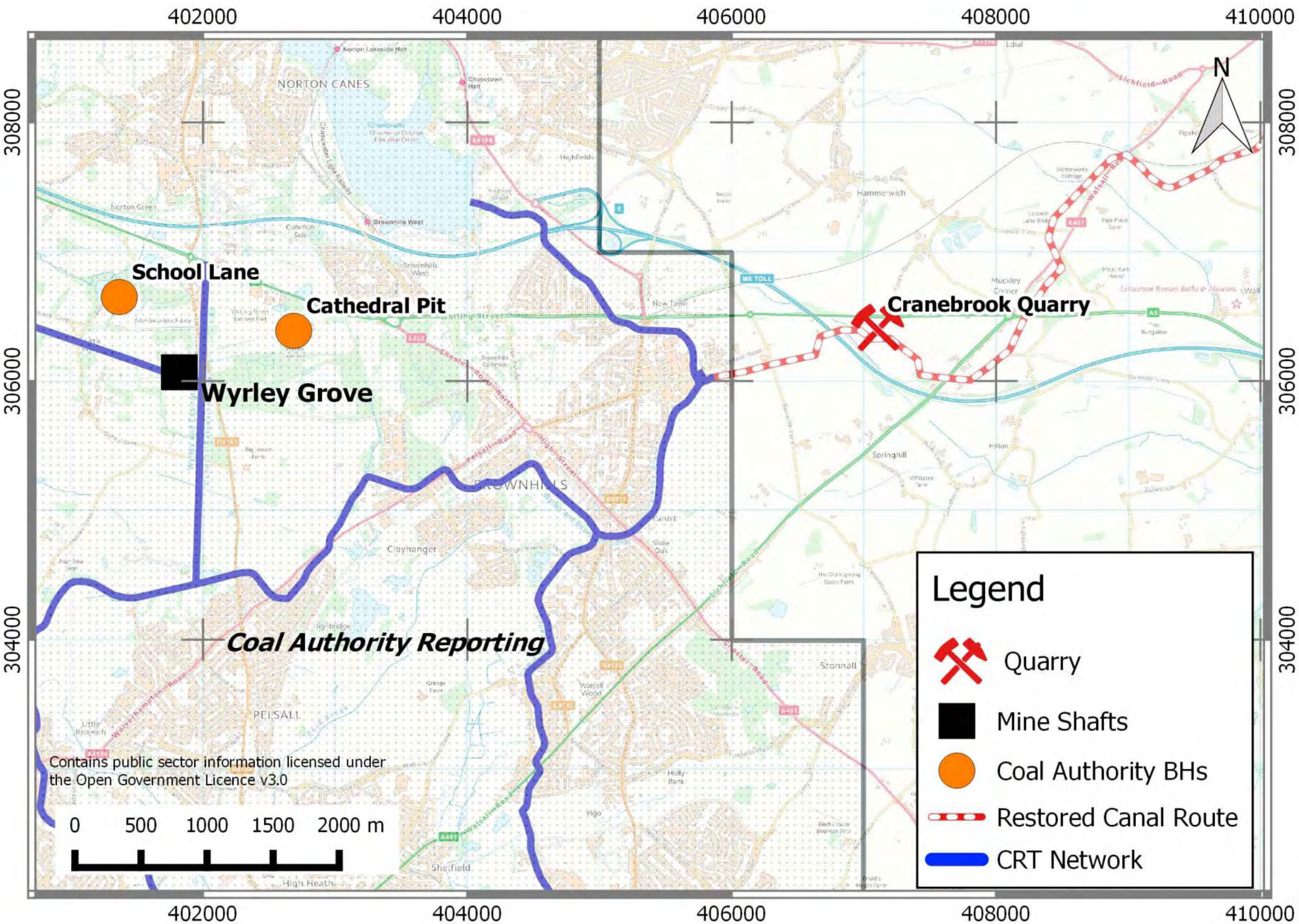

Figure 3.8 Coal mining areas in relation to Cranebrook quarry.

4 WATER SUPPLY DEMAND (WSD) ASSESSMENT

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 ESI for its leakage models, lockage models and the 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 full 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 C). The operational water demand of the fully restored canal is presented in Section 6.1 and 4.2.3.

It was initially agreed with CRT at the start up meeting that lockage water would be estimated based on the CRT Boat Traffic Model. Lockage water was initially assessed using existing lockage data from CRT records and assuming that a virtual customer would exist at each end of the proposed restored route. However, CRT has subsequently confirmed that the model setup would have been prohibitively time consuming. CRT adopted an alternative approach based on radial decay functions that take into account the distance of the proposed restored canal to the existing canal network (Appendix C). This method was used to account for the increase in boat traffic resulting from the restoration of the Lichfield canal. A similar approach has been used by CRT to estimate water demands resulting from increased boat traffic due to the presence of the two proposed marinas.

The results for the fully restored canal 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 in the initial restoration. It has been assumed from the Atkins feasibility report (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	Length (m)	Volume Ml
A	1,109	14.97
B	1,056	14.26
C	837	11.30
D	1,648	22.25
E	2,207	29.80
F	2,637	35.60
G	2,411	32.55
Total	**11,905**	**160.72**

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 CRT loss model, based on four lining scenarios (Table 4.2). A summary of their findings is presented below.

Table 4.2 Lining scenarios considered in CRT modelling.

Lining Scenario no.	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 – 1.00' 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 better than no lining for instance – and include factors other than permeability.

The loss model includes evaporation and is derived from loss profile records derived in the period 1918 – 2003.

The results of the modelling to estimates 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/d	Summer Range (Ml/km/d)
Geomembrane (eg Bentomat)	0.09	0.04-0.14
VLDP* or new Puddle Clay	0.20	0.08-0.31
New Concrete	0.22	0.09-0.35
Lining in just a few selected places	0.30	0.12-0.48

* VLDP = Very low density polyethylene

Based on the assumption that the canal is 11.7 km in length and fully restored, the average weekly loss rate is estimated to range from 7.3 Ml/wk to 24.6 Ml/wk, depending on the lining type chosen. On a daily basis, this is equivalent to an average loss demand of between 1.04 Ml/d and 3.5 Ml/d.

CRT also modelled the loss rate expected from each section during the restoration which are shown in Table 4.4. The loss rates, being expressed by CRT as average loss rates, will have accounted for infrastructure deterioration. In fact, the canal would lose less water in the initial years and gradually lose more water as the infrastructure deteriorates.

Table 4.4 Restoration Section Losses

Section	Length (m)	*Best case average summer loss rate (Ml/d)*	Worst case average summer loss rate (Ml/d)
A	1,100	0.10	0.33
B	1,100	0.10	0.33
C	900	0.09	0.27
D	1,600	0.14	0.49
E	2,900	0.26	0.87
F	1,900	0.17	0.57
G	2,200	0.20	0.66
Total	**11,700**	**1.06**	**3.51**

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 (taken from CRT, 2015 – Appendix C) shows the approximate line of the restored canal in red and the locations of annual lockage totals available from CRT, represented by stars. Those represented in green have been used in the estimate of lockage, assuming lockage totals at all other locations will be taken into account within the lockage totals of those used in the estimation.

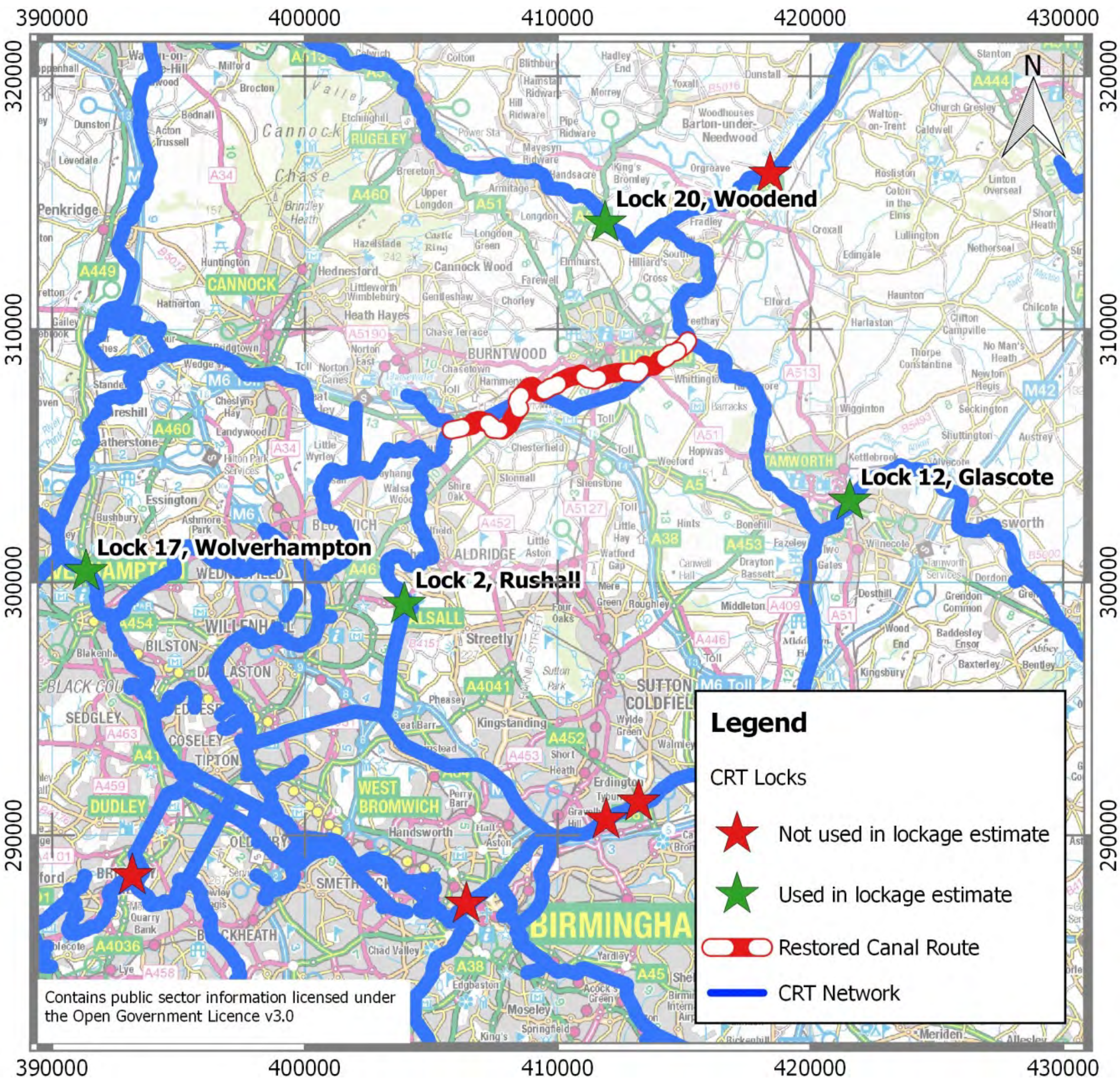

Figure 4.1 Location of CRT Lockage data

The CRT boat traffic model assumes traffic flows in the new network will divide equally at a junction, with half the traffic at each junction going in each direction. Summating the boat traffic that will approach the Canal from all available routes provides an estimate of total lockage in the restored Canal. The total number of lockages has been estimated to be 3,721 at current rates, with a corresponding annual water demand of 781 Ml (Table 4.5).

Table 4.5 Estimated annual lockage

Year	Total No. 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	3721	*781*	35.2	5.0	8.8
1	3777	793	35.7	5.1	8.9
5	4000	840	37.8	5.4	9.5
10	4279	899	40.4	5.8	10.1

The volume required per lock is based on the assumption made by Atkins in their 2009 Feasibility Report (Atkins, 2009)[10], where the deepest lock chamber had a volume of 0.21 Ml (3.5m deep, 25m long, 2.4m wide). The peak weekly lockage is then based on the assumption that it is equivalent to 4.5% of the annual total and that the peak daily is 25% of that. 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)[11]).

4.3 Impact of Full Restoration on the Existing CRT Network

CRT assessed the impact of the full restoration of the Lichfield Canal on the existing CRT network. This was assessed using the CRT Water Resources Model which 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 Lichfield Canal or the demands of the two proposed marinas (Appendix C).

A total of four scenarios were run. These are detailed in Table 4.6 along with the results of the modelling.

Best case scenarios include the estimate 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 on the existing CRT Network

Scenario	Description	Result
1	Best Case – 100% of demand at Ogley Junction, Wolverhampton Level, BCN	No net impact on the level of service of the BCN Hydrological Unit, nor the wider canal network.
2	Worst Case – 100% of demand at Ogley Junction, Wolverhampton Level, BCN	No net impact on the level of service of the BCN Hydrological Unit, nor the wider canal network.
3	Best Case – 50% of demand at Ogley Junction, Wolverhampton Level, BCN, 50% of demands at Huddlesford Junction, Coventry Canal, Ex & GU	There would be a net impact on the level of service of a neighbouring hydrological unit.
4	Worst Case – 50% of demand at Ogley Junction, Wolverhampton Level, BCN, 50% of demands at Huddlesford Junction, Coventry Canal, Ex & GU	There would be a net impact on the level of service of a neighbouring hydrological unit.

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

No Marinas:

Additional boat movements, from current baseline, within 5 km of the either end restored canal have been estimated based on a percentage increase. A decay rate was the applied up to a distance of 50 km from each junction of the restored canal to reduce boat

[10] Atkins (2009) Lichfield Canal – Restoration Feasibility Study – Final Report, July 2009, 131pp
[11] British Waterways (2011) National Water Resource Plan - Summary, 24pp

movements with distance from Lichfield Canal (see Table 4.7). This methodology is based on work undertaken by CRT in 2000 to estimate boat movements in association with the restoration of Droitwich Canal.

Table 4.7 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

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. Additional lockage demand was then added to the current demand for each hydrological unit. Results of the modelling are shown in Table 4.8.

Table 4.8 Additional lockage demand on the wider CRT network as a result of restoration

Hydrological Unit	Additional Annual Lockage Demand (Ml/yr)
BCN	215
Oxford & GU	163
10 Mile	43
Peak & Potteries	111
Shropshire Union Way/S&W	95

The results of this modelling show that there is no net impact on the level of service on any of the hydrological units listed in Table 4.8. This suggests that the additional demands resulting from the full restoration could potentially be met by the CRT network.

The methods used to estimate these values are in line with the screening methodology currently used by CRT to estimate the number of additional boat movements as a results of marina developments.

Traffic growth due to marinas:

The above estimates of traffic growth on the canal do not take into account the potential growth which may arise from construction of marinas on the canal. Marinas will increase traffic due to the increased number of boats moored on the canal, and the requirement for each boat trip to use at least part of the canal at the start and end of the trip. Access to marinas may also stimulate a local growth in boast ownership.

The CRT approach to modelling the impact of marinas is to assume a 50% increase in traffic over a 5 km section either side of the marina, which decays with distance (see Table 4.9). There are two marinas planned for the canal, roughly one towards each end, so increase in lockage through the canal of between a 50% and 100% is possible due to the marinas.

The impact of these marinas on the CRT network is considered below.

Table 4.9 Percentage increase in boat movements with distance from the Marinas

Distance from Marina (km)	Percentage Increase in Boat Movements (%)
< 5	100
< 10	80
< 20	50
< 30	25
< 40	15
< 50	7.5

Boat movements at strategic locks within a 50 km radius for each marina development (Cranebrook Quarry and Pound 27) were estimated. The results of this modelling are shown in Table 4.10 and presented in full in Appendix C.

Table 4.10 Additional lockage demand on the wider CRT network as a result of the proposed marinas

Hydrological Unit	Marina 1 - Additional Annual Lockage Demand (Ml/yr)	Marina 2 - Additional Annual Lockage Demand (Ml/yr)
BCN	158	94
Oxford & GU	9.8	21
10 Mile	25	7.4
Peak & Potteries	28	17
Shropshire Union Way/S&W	9.8	7.4

CRT have indicated that the additional demands resulting from both marinas could potentially be met by the CRT network.

4.4 Summary of 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 marinas.

These uncertainties are summarised in Table 4.11, 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 4.11 suggests that the average daily water demand is most likely to be around 13 Ml/d, but could peak at 23.7 Ml/d in periods of high demand if both marinas are completed.

The following assumptions have been made to calculate the water demand shown in Table 4.11:

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 down to an average loss similar to that in Table 4.11.
2. Good lining installed along the whole length (bentonite over most of the canals route which runs over Permo-Triassic sandstone where groundwater is largely depressed, see Figure 3.1 and Figure 3.2);

3. Traffic volumes between average and peak rates;
4. Annual growth between historic 1.5% per year and no growth;
5. No marinas, or one or two marinas constructed.

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 4.11 Summary of Water Demand Uncertainties*

	Loss Rate (Ml/d)	**Traffic (Ml/d)**	**10 years Annual Growth (Ml/d)**	**Marinas (Ml/d)**	**Total (Ml/d)**
High	3.50	8.80	1.30	10.10	23.7
Low	1.04	3.00	0.00	0.00	4.04
Most Probable	2.25	5.00	0.80	5.00	13.05

5 WATER SUPPLY SOURCE (WSS) ASSESSMENT

5.1 Availability of Water

The Lichfield Canal is located in a relatively high area near a watershed. There are no major watercourses in the area, and the few watercourses that are in the vicinity are small headwater tributaries. Groundwater resources in the area are also heavily exploited for public water supply and the groundwater table in the underlying sandstone aquifer 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 local water resource in the area. The EA has advised that all surface watercourses are already over-abstracted and there is generally no spare capacity for further abstraction for the Canal.

Nevertheless there are 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 Canal route crosses the watershed between the south easterly flowing Bourne Brook catchment, and the north easterly flowing River Tame catchment. The tributaries Cranebrook and Burntwood Brook are in the former, whist the Darnford Brook is a tributary of the latter.

The Tame, Anker and Mease Abstraction Licensing Strategy[12] (CAMS) provides information on the availability of surface water for abstraction in these catchments. As noted above, this is generally very limited.

For the Bourne Brook (Craneford and Burntwood Brooks) the CAMS states:

> "*Environmental flows in the Bourne/Black Brook have been assessed to be at risk for a large proportion of the time. For over a quarter of the time, at lower flows, the water needed by the environment has actually been removed due to abstraction. The majority of the abstraction is from groundwater, which then depletes the brook of base flow. For this reason we have closed the catchment to both groundwater and surface water abstraction.*"

For the Tame catchment the CAMS states:

> "*The River Bourne will remain closed to new consumptive abstractions due to the need to protect water required by existing abstractions. Darnford Brook will be closed to further abstraction as it is over licensed and abstracted throughout the flow range.*"

Abstraction from any of the local watercourses thus appears to be unavailable, even if storage could be provided for abstraction in higher flows. This possibility has therefore not been investigated further in the Study.

[12] Tame, Anker and Mease Abstraction Licensing Strategy. Environment Agency, February 2013.

5.3.2 Licence Trading

Several options for purchasing/trading water from existing abstractors and discharge consent licence holders (excluding PWS/STW licences) within 500 m of the proposed canal route have been identified for the initial infill and operation of the canal (see Section 3.4, Figure 3.5 and Figure 3.6). These are listed in Table 5.5 table below.

It is assumed that for locations over 500 m away the cost to acquire land ownership to pipe water to the canal would be prohibitive.

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

Type	Name	Licence Number	Licensed Daily Volume (Ml/d)	% of licensed annual volume used between 2011-2014
SW abstraction	Manor Farm	03/28/17/0008	4.36	30%
SW abstraction	Marsh Farm	03/28/22/0035	0.73	0%
SW abstraction	Darnford Lane	03/28/22/0085/1	0.3	0%
GW abstraction	Warren Bridge House	03/28/17/0037	1.68	Not available
GW abstraction	Semi-Bungalow Farm	03/28/17/0047	0.32	Not available
GW abstraction	Barn Farm	03/28/17/0049	0.45	Not available

5.3.3 Groundwater

The area is underlain by a major aquifer that is heavily abstracted for public water supply (Section 3.3). This aquifer would not be available for abstraction into the canal.

Below the aquifer, however, lie deeper Carboniferous rocks that have been worked for coal in the past and represent another water resource, independent of the abstracted strata, which might potentially be available.

Good yields can be obtained from the red marls and sandstones of the Enville Member (formerly Hamstead Group) and/or the Alveley Member (Keele Group). This preliminary advice is based upon data presented in Table 8.8 of Jones et al., (2000) which is reproduced in Figure 5.1 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 5.1 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.

These strata rise to the west of the Canal and are not too deep at Ogley junction. The Coal Authority (pers. comm. Lee Wyatt, Coal Authority, 15/09/2015) has confirmed that they are not actively pumping in the immediate vicinity and that piezometric heads in the Carboniferous[13] are not far from ground level (c. 130 maOD) at their boreholes at Wyrley Common (3 km west of Ogley, Figure 5.2). Water could be abstracted from these boreholes however, rates are likely to be limited (pers. comm. Lee Wyatt, Coal Authority, 25/11/2015).

A mine shaft has also been identified within the Wyrley Common area, Wyrley Grove, which is located in close proximity to the existing CRT network. The Coal Authority have indicated that there may be potential to pump water from this shaft into the existing network, as the CRT are currently doing for the Wolverhampton Canal Network from mineshafts at Bradley, Bilston (email Kathryn Maye, CRT, 16/09/2015). If sufficient yields were available, pumping costs would not be prohibitive.

It should be noted that 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 unless a the Coal Authority provided significant backing of the option.

Concerns over water quality (mostly iron and high salinity water) could also make this solution impractical although water quality 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, which could be in the range 0.1 to 4 Ml/d. The availability of this water would be less susceptible to short-term droughts 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 Canal in Section A, close to Ogley junction.

Costs of providing a borehole to exploit this source, and the likely quality of the water abstracted will have to be investigated further.

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

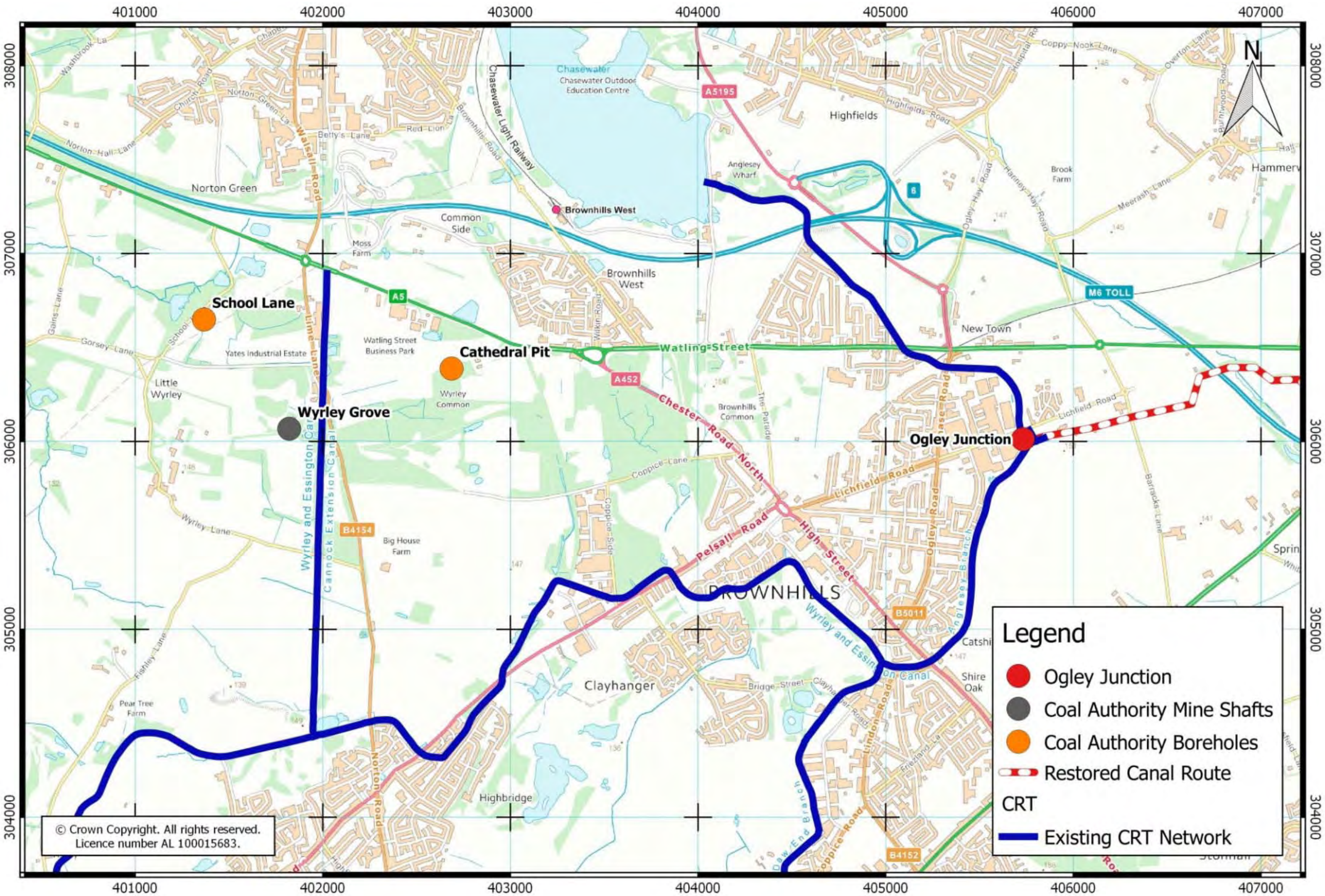

Figure 5.2 Wyrley Common[14]

[14] Borehole locations are approximate

5.3.4 Surface Water from Residential Development

There are three known proposals for residential development of greenfield sites in the Lichfield area. The locations are at Berryhill, Cricket Lane and Deanslade Farm which are shown in Figure 5.3.

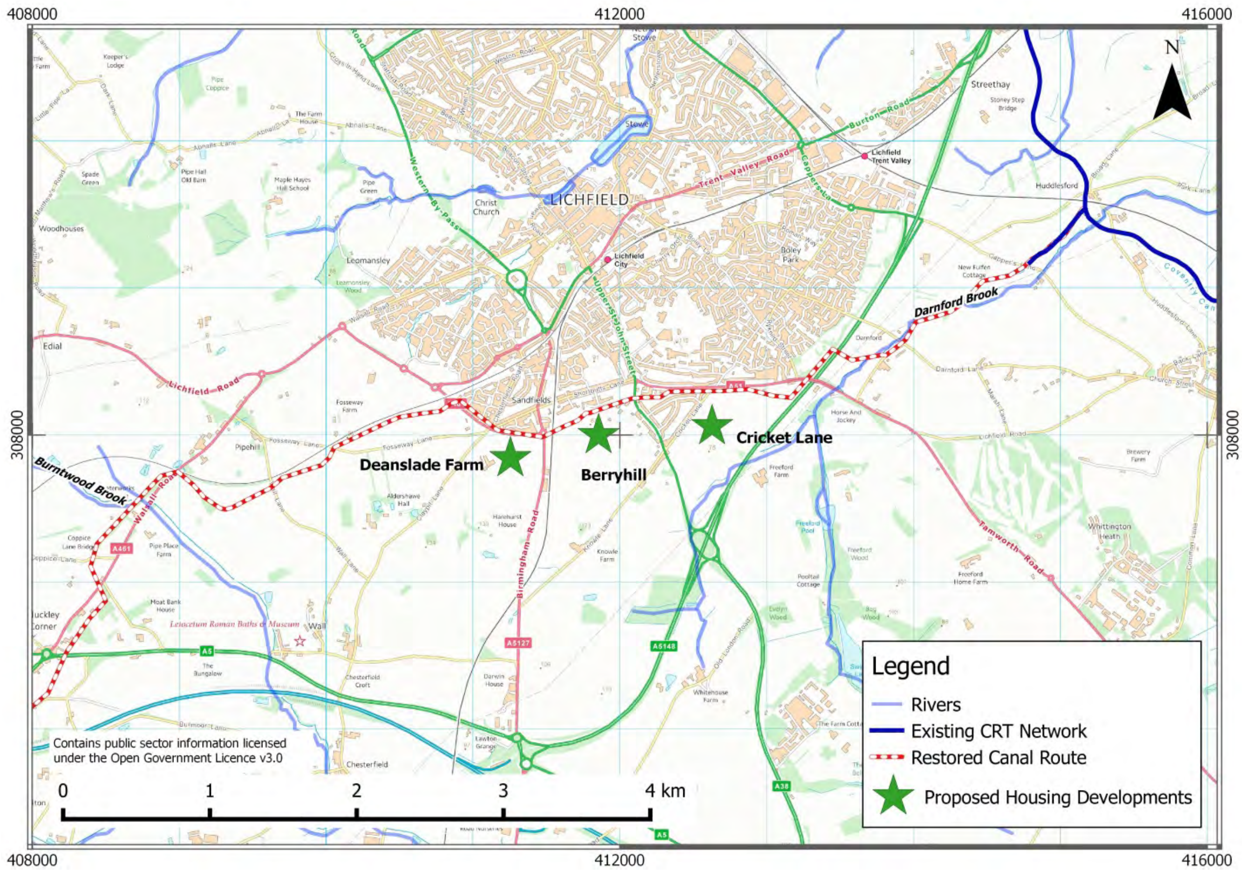

Figure 5.3 Proposed Housing Developments

The topography of the Berryhill site falls naturally to the line of the canal and there is a connection into the pipe located in the base of the canal. This is the only available drainage outfall. The Berryhill site has been the subject of discussion between developer Persimmon Homes, Lichfield District Council and LHCRT with regard to potential discharge into the canal. The development FRA identifies use of the canal as a sustainable drainage option with the canal providing storage and attenuation of runoff.

Deanslade Farm is a relatively new proposal and has not been the subject of discussion between developer and LHCRT. The topography of the Deanslade site falls naturally to the line of the canal on its proposed diversion route. SCC as Lead Local Flood Authority has noted that the canal would be ideally located to provide an outfall for this development (pers. com Derek Lord, LHCRT, 16/11/2015).

The topography of the Cricket Lane site falls naturally from Cricket Lane east towards the A38 and south away from the restored section of canal. As a result there is limited scope to drain this site by gravity into the canal and no allowance for runoff into the canal is considered in this study. However it is noted that Persimmon Homes consultant RPS has recently approached LHCRT with regard to interface with the canal and some discharge to the restored canal may result from these discussions.

Table 5.2 shows the estimated size of each development[15] 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 is not formally drained.

Estimates are based on the daily recorded rainfall at Nottingham Weather Station between 1999 and 2015. 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[16].

Table 5.2 Estimated run-off from proposed residential developments

Name	Total Size (Ha)	Run-Off (Ml/yr)	Run-Off (Ml/d)
Berryhill	23	29	0.08
Deanslade Farm	15	19	0.05
Cricket Lane	33	40	0.11
Total	**71**	**88**	**0.24**

5.3.5 Existing Highway Drains and Public Surface Water Sewers

There are many existing highway drains and public surface water sewers which are located in proximity to or on the line of the Lichfield Canal. Some of these would hard clash with the restored canal and thus have to be removed by diversion, such as part of the Big Pipe which is currently located in the bed of the canal and is the main surface water outfall for a large part of Southern Lichfield (Figure 5.4). Removal of the Big Pipe would not alter the size of the catchment draining towards the restored canal and it can therefore be assumed that surface water drainage currently flowing to the Big Pipe would continue to flow towards the restored canal. The presence of the restored canal would act as an obvious drainage point for existing and future residential developments whereby the local council and developers would find themselves with an “easy option” for implementing sustainable drainage solutions as part of the developments. Side pounds that store the runoff from peak events would have to be considered in order to maximise the benefits.

As well as the Big Pipe, which is one of the main surface water drainage features in the area, there are others that do not clash with the canal restoration but are capable of diversion. 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.

The owners are Severn Trent Water for surface water sewers and SCC/HE for highway drains. Each organisation has been contacted with support from LHCRT, to establish their position with regard to diversion of flow into the canal.

Severn Trent Water has confirmed (original correspondence in Appendix D) that they would in principle be prepared to consider a request to divert a surface water sewer into the Lichfield canal. However they would have to be satisfied that there is no detriment if this is to be permitted. Issues to be addressed would include:

- no adverse impact on the hydraulic performance of the surface water sewer resulting in increased flood risk;
- long term guarantee of the canals existence such that security of discharge is secured in perpetuity;

[15] Catchment size for Berryhill and Deanslade Farm is based on information provided by LHCRT. The catchment size for Cricket Lane was based on estimations using the field boundary in the vicinity of the proposed development from an OS map.
[16] It is prudent to expect that new housing will meet this standard even if it is not statutory. In fact, 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.

- formal legal agreement guaranteeing the right of discharge into the canal at no cost to Severn Trent Water, irrespective of future ownership of the canal;
- all costs of diversion to be met by others with no cost to Severn Trent Water.

SCC has confirmed (original correspondence in Appendix D that in principle they would consider the request to divert highway drainage assets under the control of SCC into the new canal, providing that, as a minimum, the following issues were addressed:

1. no adverse impact on the hydraulic performance of the highway drain resulting in increased flood risk;
2. long term guarantee of the canals existence such that security of discharge is secured in perpetuity;
3. formal legal agreement guaranteeing the right of discharge into the canal at no cost to SCC, irrespective of future ownership of the canal;
4. all costs of diversion to be met by others with no cost to SCC;
5. notwithstanding any wider water resource implications;
6. any connection should not increase flood risk to any third party.

With regards to item 3, SCC would require a guarantee that this couldn't be renegotiated in the future.

Although similar discussions have taken place with HE no definitive statement of their position has been obtained within the timescale of this study but it is understood that their position would be similar.

Full details of all highway drains and surface water sewers identified as part of this study by LHCRT are provided in Appendix E. The estimated run-off from highway drains and surface water sewers is presented in Table 5.3 and respectively, along with examples of the total run-off generated from some of the key features identified (see Figure 5.4).

Table 5.3 Estimated run-off from highway drains

Name	**Catchment Area (Ha)**	**Run-off (Ml/yr)**	**Run-off (Ml/day)**
Highway Drain (single lane road) per km	1	4.31	0.012
Highway Drain (dual carriageway) per km	2	8.62	0.024
Examples			
A5 Highway Drain (single lane road) [HC4]	0.65	2.8	0.008
A461 Walsall Road from Muckley Corner (single lane road) D7	0.6	2.6	0.007

Table 5.4 Estimated run-off from surface water sewers

Name	Catchment Area (Ha)	Run-off (Ml/yr)	Run-off (Ml/day)
Big Pipe*	125.0	157.2	0.43**
Darnford Park SW sewer [HC1]	14.5	18.2	0.05
Pound 27 SW Sewer (Tamworth Road) [HC3 in Figure 5.4]	3.3	4.2	0.01
Total	**141.8**	**179.6**	**0.49**

*a culvert within the invert of the former canal (see Appendix D). Estimate of the catchment boundary was provided by LHCRT. **in addition to the run-off there is a continuous dry weather flow which runs from the Big Pipe into the restored canal at Tamworth Road. This flow rate is typically between 0.05 to 0.1 Ml/d (pers. comm. Derek Lord, LHCRT).

Run-off estimates are based on the daily recorded rainfall at Nottingham Weather Station between 1999 and 2015. 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[17] (see Table 5.3). The catchment area is calculated per km based on a single lane, dual carriageway road having a width of 10 m (including the hard shoulder).

Run-off from surface water sewers (see Table 5.4) draining present housing developments, such as the Big Pipe, was calculated using the same method as that used for the proposed housing developments (see Section 5.3.4).

[17] 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.

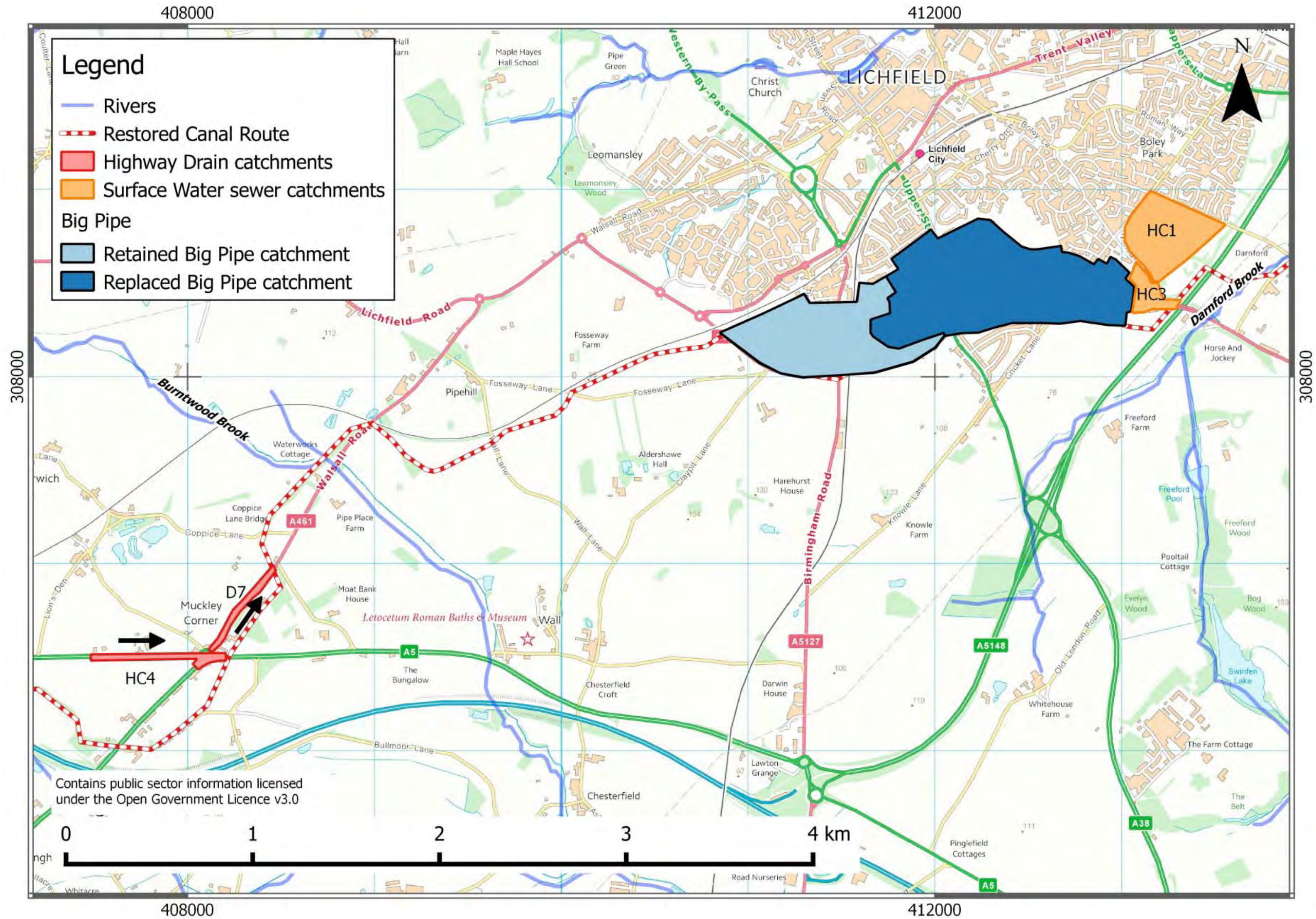

Figure 5.4 Highway drains and surface water sewers

(For sample catchments shown in Table 5.3 and Table 5.4

5.3.6 LHCRT Licensed Abstraction

LHCRT currently holds a licence to abstract surface water from the Darnford Brook (licence number 03/28/22/0042) at Mill Farm (NGR SK 14313 08901, see Figure 3.5). Licence details and recent actual abstractions are shown in Table 3.4.

Recent actual data shows that this licence has been underused between 2012 and 2014 suggesting that there could be spare capacity on the licence to provide a source of water to the canal. However, abstraction can only take place when flow in the Darnford Brook immediately downstream of the abstraction point is greater than 1.64 Ml/d.

5.3.7 Backpumping

Water in the canal can be re-used by pumping from a topographically lower pound to 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 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 and 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 used to abstract water from the Coventry Canal at Huddlesford junction. This may be of particular use during some of the early restoration phases when the lower part of the canal may be connected to the Coventry Canal but isolated from the rest of the Lichfield Canal and its other water sources. An arrangement would be required with CRT in order to do this, and since the Coventry Canal is generally in water deficit it may not be permitted, particularly when water resources are under stress.

5.3.8 Burntwood STW

Burntwood Sewage Treatment Works is located within about 800 m of the canal. It currently discharges treated final effluent to the Burntwood brook. The Burntwood Brook passes under the line of canal in an existing culvert. Based on relative levels it would be possible to direct flows to the canal. A preliminary enquiry was made to Severn Trent Water to establish their view on the possibility of diversion of flow. Severn Trent Water have confirmed that they don't think using final effluent from the sewage treatment works would be something that they would want to pursue, due to regulatory and financial concerns.

5.3.9 Marina at Cranebrook Quarry

A marina has been proposed as part of the proposed restoration plan for Cranebrook Quarry (see Section 3.4.3). Should this be developed and connected to the canal, water levels in the marina will have to equilibrate to 122.2 mAOD, the design level of the canal. This would result in the marina water level being lower that the western half of the restored quarry, and surface water from this part could be directed into the marina or the canal instead of the Crane Brook (ESI, 2015). This could then supply an additional source of water to the canal. However, based on calculations undertaken in support of the planning application (ESI, 2015), it is estimated that this would contribute approximately 0.008 Ml/d to the canal. This may increase to 0.052 Ml/d should the retailed section of the site be developed.

5.3.10 CRT, Birmingham Canal Navigation

The Canal will link the BCN in the west with the topographically lower Coventry Canal in the east. 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 2 km from the proposed junction at Ogley and this was the source used to feed the Lichfield 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 Coventry Canal (Appendix C). This is on the basis of provision of water from Ogley junction. There are potential restrictions with supply from Huddlesford junction but since this would involve back pumping this would not be favoured as a source except possibly during initial restoration. Whilst CRT modelling has confirmed availability as stated in their report which is shown in Appendix C, it is 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 Lichfield canal restoration. LHCRT will need to discuss the conclusions with CRT and reach an agreement for water supply.

CRT have stressed during liaison with both ESI and LHCRT that even though 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 Lichfield 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. 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 Lichfield Canal.

5.3.11 Summary of the Unconstrained list of Potential Water Sources for the Canal

A summary of potential water sources for the canal as detailed in the previous sections are summarised in Table 5.5 and Figure 5.5 below.

Table 5.5 Summary of unconstrained options of potential water sources for the canal

Option Number	Description	Potential Volume (Ml/d)	Technical Feasibility
C1	New abstractions from local watercourses (Section 5.3.1)	N/A	Unfeasible due to CAMS
C2	Licence Trading – Manor Farm SW abstraction (03/28/17/0008). Recent Actuals suggest that this licence has 70% spare capacity (Section 3.4.1 and Section 5.3.2)	3.05	Feasible subject to licence holder agreement and licence conditions.
C3	Licence Trading – Marsh Farm SW abstraction (03/28/22/0035). Recent Actuals suggest that this licence has 100% spare capacity (Section 3.4.1 and Section 5.3.2)	0.73	Feasible subject to licence holder agreement and licence conditions.
C4	Licence Trading – Darnford Lane SW abstraction (03/28/22/0085/1). Recent Actuals suggest that this licence has 100% spare capacity (Section 3.4.1 and Section 5.3.2)	0.3	Potentially feasible subject to licence holder agreement and licence conditions. Relatively small volume of water so costs may outweigh benefits.
C5	Licence Trading – Warren Bridge Farm GW abstraction (03/28/17/0037) (Section 3.4.1 and Section 5.3.2).	1.68	Feasible subject to licence holder agreement and licence conditions. No recent actual data was available so any spare capacity on the licence would have to be investigated through negotiation with the licence holder.
C6	Licence Trading – Semi-Bungalow Farm GW abstraction (03/28/17/0047) (Section 3.4.1 and Section 5.3.2).	0.32	Potentially feasible subject to licence holder agreement and licence conditions. No recent actual data was available so any spare capacity on the licence would have to be investigated through negotiation with the licence holder. Relatively small volume of water so costs may outweigh benefits.
C7	Licence Trading – Barn Farm GW abstraction (03/28/17/0049) (Section 3.4.1 and Section 5.3.2).	0.45	Potentially feasible subject to licence holder agreement and licence conditions. No recent actual data was available so any spare capacity on the licence would have to be investigated through negotiation with the licence holder. Relatively small volume of water so costs may

Option Number	Description	Potential Volume (Ml/d)	Technical Feasibility
			outweigh benefits.
C8	Abstraction from the Triassic Sandstone Aquifer (Section 5.3.3)	N/A	Unfeasible due to CAMS
C9	Drill a 100-150 m deep borehole at Ogley 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.
C10	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 (Section 3.4.4) that should be carefully considered prior to taking this option further.
C11	Pump water from the coal authorities existing boreholes and pipe for c. 700 m to existing canal network (Section 5.3.3)	0.20	Unfeasible. Potential volume is likely to be less than 2% of the total fill volume. Costs to pipe the water will likely outweigh benefits as the distance is greater than 500 m.
C12	Surface water from proposed residential development (Table 5.2)	0.24	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 1% of the total fill volume required and 5% 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.
C13	Existing Big Pipe (Table 5.4)	0.43	Feasible. LHCRT confirms a minimum continuous base flow through the Big Pipe into Lock 25 of 0.6 l/s which equates to 0.05 Ml/day. Volume due to rainfall is additional to this base flow. However it is noted that, potential volume is less than 1% of the total fill volume required and less than 9% of the baseline average daily lockage estimate during a peak week. Though provision of storage would increase the volume available for use, total discharge will be small in comparison to canal demand. However, flows from the Big Pipe will discharge into the restored canal regardless as it is currently located within the canal bed and will be

Option Number	**Description**	**Potential Volume (Ml/d)**	**Technical Feasibility**
			replaced by the canal once restored.
C14	Existing other (not including the Big Pipe) Surface Water Sewers (Table 5.4)	0.06	Feasible. Based on 60% run-off from the total catchment area (22.4 Ha) of the 2 surface water sewers identified in Section 5.3.5. Potential volume is less than 1% of the total fill volume required and 1.2% of the average daily lockage estimate during a peak week. Although the volumes are small in comparison to canal demand, flows from these surface water sewers will have to be diverted to the canal as they will hard clash with the canal as it is restored.
C15	Existing highway drains (Table 5.3)	0.1	Feasible. Based on run-off estimates from 17 highway drains that have been identified (Appendix E). Each is assumed to have a catchment of 5000 m^2*. Potential volume is less than 1% of the total fill volume required and 2% 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.
C16	Utilisation of existing SW abstraction licence on Darnford Brook (Section 5.3.6)	0.41	Feasible subject to licence conditions.
C17	Backpumping (Section 5.3.7)	N/A	Feasible
C18	Effluent from Burntwood STW (Section 5.3.8)	N/A	Unfeasible due to regulatory and financial concerns.
C19	Discharge from Cranebrook Quarry Marina	0.008 to 0.052	Feasible. However, the volume of water is small in comparison to the canal demand and as such is not considered to be a reliable water source for the canal.
C20	Water from existing CRT network (Section 5.3.9)	N/A	Feasible subject to an assessment of available resource by CRT.

*based on a single lane road with an estimated length of 500 m per drain. See Section 5.3.5 for methodology used to calculate run-off.

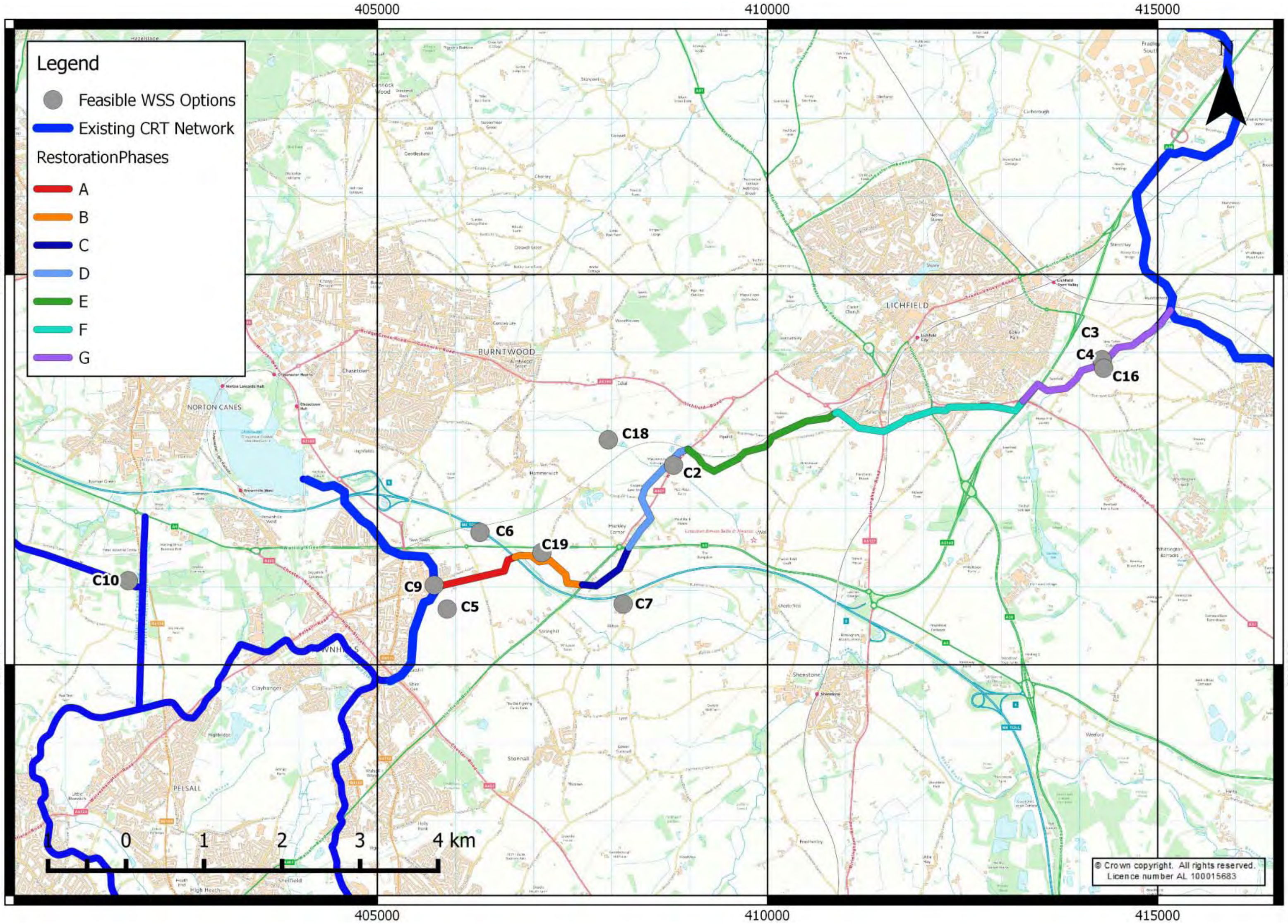

Figure 5.5 Feasible Water Source Supply (WSS) options

(See Appendix D for options C12 to C15. Options C17 and C20 are not shown as they have no fixed location)

5.4 Constrained list of Supply Options for Full Restoration

A list of constrained options for the fully restored canal is provided in Table 5.6. 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 5.6 List of constrained options for full canal restoration

Option	Time to Fill (days)	Notes
C2 (Manor Farm SW Licence)	31.3*	Licence is restricted to 136.36 Ml/d (95.45 Ml/d spare capacity) so would not be able to meet the full initial fill volume. Over a period of 31.3 days it could provide 59% of the initial fill volume assuming 70% spare capacity on the licence. This source would provide 61% of the lockage estimate (average daily during a peak week) and is located c.90 m from the canal.
C5 (Warren Bridge Farm GW licence)	40.6*	Licence is restricted to 68.19 Ml/d so would not be able to meet the full initial fill volume. Over a period of 40.6 days it could provide 42% of the initial fill volume assuming 100% spare capacity on the licence. This source would provide 33.6% of the lockage estimate (average daily during a peak week). It is located c.330 m from the canal so the feasibility of this source would be subject to economic assessment.
C9 (Deep borehole)	292	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.
C10 (Coal Authority's Wyrley Grove shaft)	80.35	This source could provide the full initial fill volume in 80.35 days and could contribute to 40% 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.).
C20 (CRT network)		CRT has suggested that there would be available resource for the daily operation of the canal.

*infill times restricted by annual licence limit.

In addition those identified in the table above, discharges from the proposed new developments, the Big Pipe 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 C12 to C15 could also be included in the constrained list. However, the volume of water from these sources will be quite small[18] 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[19], 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 Lichfield Area (Royal Haskoning, 2010) whilst also providing a use for the run-off rather than it simply being discharged to local water courses.

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 (C20). CRT has indicated that resource is available at the Ogley end and is in short supply at the Huddlesford end, so this is likely to be acceptable, subject to detailed negotiation[20]. Using this source would ensure that there is a reliable supply of water throughout the canal. CRT have also indicated that sufficient water exists to operate the canal for the foreseeable future, so this source is likely to remain reliable even with the traffic growth and climate change forecasts.

No other single source can supply the estimated operational requirements of the canal alone. However, the two licence trading options, C2 and C5, together could very nearly do so (see Figure 5.5). The surface water abstraction at C2 offers most water, but the reliability of this source in dry weather conditions is questionable. It would not be advisable to rely on water from this surface source without a backup. However, if the water can be accessed at modest cost it might form a useful main source, with or without the groundwater C5 source, provided CRT water can be used if C2 fails in dry conditions.

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 groundwater source at Wyrley Grove (C10) 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 C9) is likely to be expensive (high drilling and pumping costs) and the potential long term quality provides

[18] Estimated total from all sources of 0.88 Ml/d, less than 1% of the total fill volume and c.18% of the baseline average daily lockage estimate (10% of the peak daily). This assumes that flow from all sources identified in Appendix E are diverted to the canal, either through a hard clash or intentional diversion and includes the dry weather flow from the Big Pipe.

[19] 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.

[20] CRT would also be able to transfer flow from Ogley to Huddlesford if required.

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 (C20) therefore offers the easiest and most reliable source for operation of the canal when fully restored. However CRT supply is only practically available when the full length of canal to Ogley 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 they expect the Lichfield 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 have to be done in several phases. It was initially assumed that restoration would start at the downstream end at Huddlesford Junction and then work upstream until reaching Ogley Junction and the Atkins report split the restoration into five phases to achieve this. The logic of this was that there would always be an outfall for water, though there would be a need to pump water up from the Huddlesford Junction to maintain the canal in water until it reached Ogley Junction.

In more recent years, whilst seeking to work in this logical sequence, the LHCRT has had to take account of external events and opportunities (M6 Toll, Lichfield Southern Bypass), which impact on the restoration phasing, and also the availability of land on which to build the canal.

The more recent restoration plans take into account these externalities and indicate that the Canal is more likely to be initially restored part-way from the Ogley end, in parallel with some central sections and that the Huddlesford end may actually be restored last. This presents potential problems with sourcing water in the central section and in discharging excess water if the lower pound does not connect to Huddlesford Junction, and these are considered below.

The canal has been divided into 7 sections for the purposes of considering restoration (Table 6.1 and Figure 6.1). Phases A and B once restored, will provide an access from the marina, which may already be in existence in the form of a restored quarry waterbody (restored eastern area of Cranebrook Quarry), to the national canal network at Ogley Junction.

Table 6.1 Proposed restoration phases and corresponding sections.

Phase	Name	Length (m)		NGR x	NGR y
A	Ogley Junction to Toll Road	1109	Start	405780	306000
			End	406760	306380
B	Toll Road to Walsall Road	1056	Start	406760	306380
			End	407620	306020
C	Walsall Road to Watling Street	837	Start	407620	306020
			End	408220	306500
D	Watling Street to Lichfield Road	1648	Start	408220	306500
			End	408980	307760
E	Lichfield Road to Fosseway	2207	Start	408980	307760
			End	410870	308220
F	Fosseway to Tamworth Road	2637	Start	410870	308220
			End	413270	308380
G	Tamworth Road to Huddlesford Junction	2411*	Start	413270	308380
			End	415160	309530

A number of locks and side pounds are to be restored in each of these phases and a total of eight new locks are proposed. Details are shown in Figure 6.1 and Table 6.2.

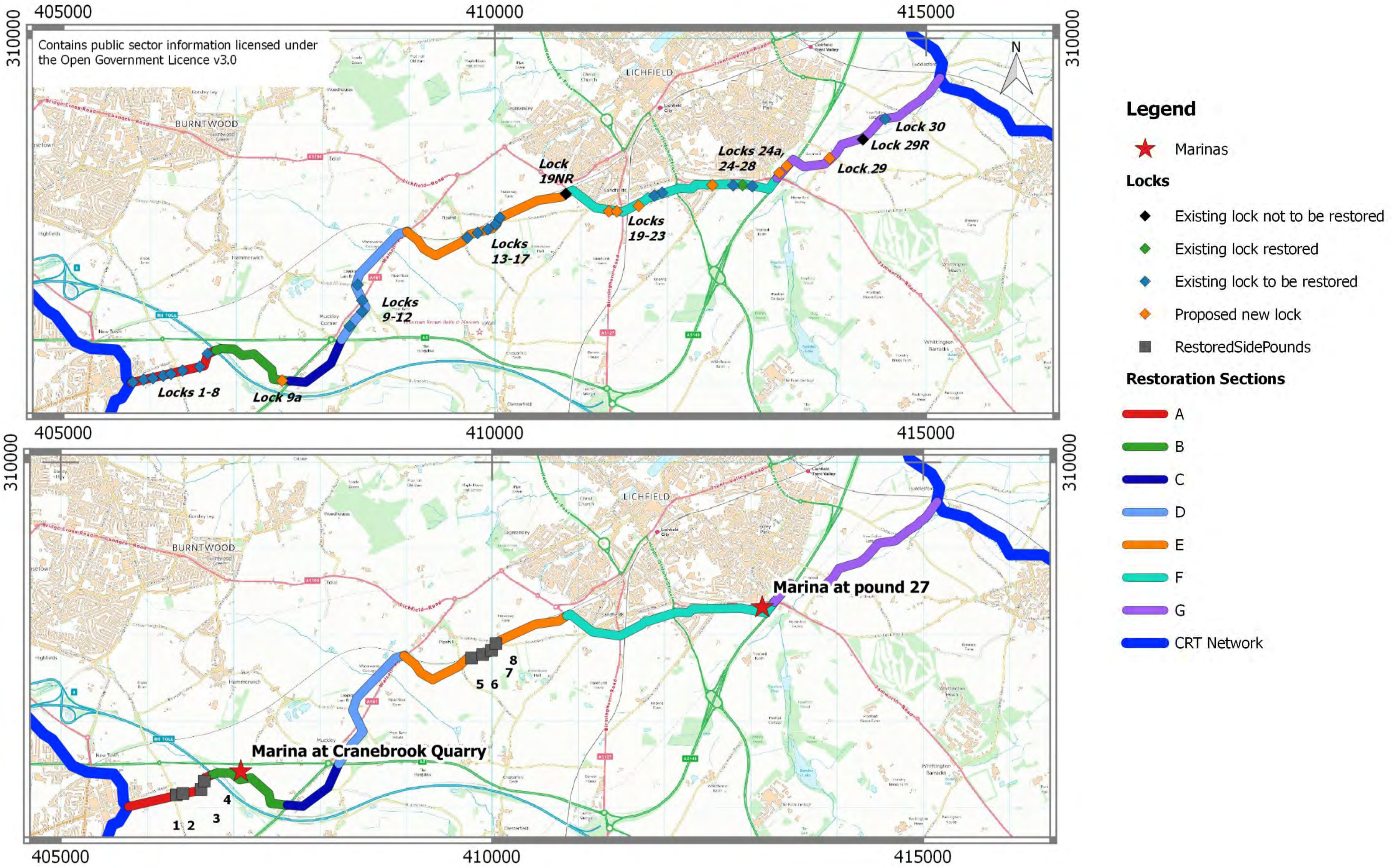

Figure 6.1 Potential Restoration Sections

Table 6.2 List of proposed locks and side pounds

Lock Number/Side Pound	Phase	Status
Locks 1-8	A	Existing lock to be restored.
Lock 9a	B	Proposed new lock.
Locks 9-12	D	Existing lock to be restored.
Locks 13-17	E	Existing lock to be restored.
Lock 19NR	E/F	Existing lock not to be restored.
Locks 19-21	F	Proposed new locks.
Locks 22-23	F	Existing lock to be restored.
Lock 24a	F	Proposed new lock.
Lock 24 and 26	F	Existing lock to be restored.
Lock 25	F	Existing lock already restored.
Lock 27-29	G	Proposed new locks.
Lock 29NR	G	Existing lock not to be restored.
Lock 30	G	Existing lock to be restored.
Side Pound 1	A	Side pound above lock 6 to be restored.
Side Pound 2*	A	
Side Pound 3*	A	Part of the "Wides" below lock 6 to be restored.
Side Pound 4*	A	
Side Pound 5	E	Side pound above lock 14 to the north of the canal to be restored.
Side Pound 6	E	Side pound above lock 15 to the north of the canal to be restored.
Side Pound 7	E	The "Wide" pound above lock 16 to be restored.
Side Pound 8	E	The "Wide" pound (but not the original side pound) above lock 17 to be restored.

*Location on Figure 6.1 mark estimated start, middle and end positions of the side pound.

A number of phasing scenarios have been developed with potentially different sequencing of section restoration. These are shown in Table 6.3.

Table 6.3 Phasing Scenarios

Scenario Combination	Section						
	A	**B**	**C**	**D**	**E**	**F**	**G**
1						■	
2		■					
3	■	■				■	
4	■	■			■	■	
5	■	■		■	■	■	
6	■	■	■	■	■	■	
7	■	■	■	■	■	■	■
8	■	■				■	■
9	■	■				■	■
10	■	■			■	■	■
11	■	■		■	■	■	■
12	■	■	■	■	■	■	■

*Red shading indicates restoration of the section is complete

LHCRT owns Section B (Toll Road to Walsall Road) and leases parts of Section F (Fosseway to Tamworth Road) with a right to construct the canal. They expect these two sections to be completed in isolation and would want to have them in water. LHCRT anticipates that Section F could be used for boating in advance of completion of the Canal to Huddlesford. Similarly it may be possible to bring Section B (Toll Road to Walsall Road) into use although this is less certain. These are shown as Scenarios 1 and 2.

Given partial ownership of Section A (Ogley Junction to Toll Road) and the WCL marina proposal (Section 3.4.3), dependent on procurement of land and funding LHCRT would like to consider construction of Section A which would link to Section B and create a continuous section of navigable canal from Walsall Road to the national CRT network. This is shown as Scenario 3.

Scenarios 3 – 7 and 8 – 12 are essentially the same sequence with the important difference that the final section to Huddlesford junction (Section G [Tamworth Road to Huddlesford Junction]) is completed last in the former sequence and first in the latter sequence.

This is because there is currently an area of uncertainty with Section G (Tamworth Road to Huddlesford Junction) downstream from the existing constructed section at Darnford Lane to the east of Cappers Lane, where the existing canal is in water and used by Lichfield Cruising Club. This is due to the High Speed 2 (HS2) railway line proposal. If HS2 does not proceed, then the Canal would follow the current proposed route and Section G could be completed. However, if HS2 does proceed as currently planned, this route would not be viable.

An alternative route, which does allow construction of HS2 and restoration of the Canal, has been identified (pers. comm. Derek Lord, LHCRT, 06/09/2015). Until such time, as the situation becomes clear, it is not practical to commence on restoration along either route. Accordingly Scenarios 4, 5 and 6 show the situation in which the canal restoration extends upstream from Section F (Fosseway to Tamworth Road) to Section B (Toll Road to Walsall Road). This would provide a navigable canal from Ogley to Lichfield terminating at Tamworth Road, with a pass forward base flow to Darnford Brook. Section G would be left until the situation with HS2 becomes clear and one of the routes can physically be constructed.

Each of these scenarios would require a water supply in the upstream (westward) section to fill and operate and a feasible route for water to be discharged at the downstream section until the Canal is open to Huddlesford. These are considered below.

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 - Section B (Toll Road to Walsall Road) only

Licence Trading at the Semi-Bungalow Farm GW abstraction (C6) could be used to fill Section B (Toll Road to Walsall Road) if it is available and can be negotiated successfully. Based on a fill volume of 14.26 Ml/d and assuming 100% spare capacity on the licence, time to fill would be 45 days. If this source is not available, then the best option would be to pipe water from the CRT network at Ogley Junction (C20), provided a wayleave over Section A (Ogley Junction to Toll Road) can be obtained. This would require negotiating the M6 Toll aqueduct, which is currently raised above the level of the land on the other side, which may be expensive to achieve.

The Semi-Bungalow Farm GW abstraction (C6) is unlikely to be a viable option to meet the operational requirement due to the volume of water required to maintain Section B (Toll Road to Walsall Road), although a restraint on usage may not be unacceptable if only this section is complete. The CRT source, if a pipeline is available from the filling operation could maintain the Section.

The proposed marina at Cranebrook Quarry (ESI, 2015) could also be an additional source of water from this section if it has been constructed prior to this restoration phase. However, the estimated volume of water is small (0.008-0.052 Ml/d) in comparison to canal demand. Therefore it is not considered to be a reliable source of water for the canal.

The only lock in Section B (Toll Road to Walsall Road) is lock 9A, which is at the downstream end. It is therefore unlikely that there will be surplus water accumulating in Section B but, if this occurs, discharge to the Crane Brook or indirectly via the Highway Drain at Walsall Road could be viable options, subject to any necessary consents.

6.2.2 Scenario 2 - Section F (Fosseway to Tamworth Road) only

Section F (Fosseway to Tamworth Road) skirts round the southern edge of Lichfield and includes five locks. Although it would be isolated it is likely to attract considerable usage as it is near the built-up area and use of the locks will create a substantial demand.

The only sources identified in this section are the highway drains and public surface water sewers (C12 – C15), including the Big Pipe. The canal will have to accept flows from those which will have a hard clash with the canal upon restoration. Whilst the Big Pipe alone is expected to provide a minimum of 0.05 Ml/d dry weather flow to the canal, the volume of water from these sources combined is likely to be limited in comparison to overall canal demand. Such sources will not provide a constant baseflow for the operation of the canal unless side pounds are considered in the restoration plans (Section 5.3.11 and Table 5.5).

The LHCRT abstraction point at Darnford could be used, though this would require pumping and a pipeline.

The other option available for Section F (Fosseway to Tamworth Road) would be to pump water from the existing CRT network at Huddlesford (c. 2.5 km) (C20). This would be subject to acquiring wayleave over Section G (Tamworth Road to Huddlesford Junction) and permission from CRT, which may not be possible given the deficit in the Coventry Canal.

Backpumping, probably over several of the locks, is also likely to be required to maintain water in the top pound of this section.

It is unlikely that there will be surplus of water to discharge in this scenario as any water accumulating in the bottom pound would be best back-pumped up to the top. However, the EA require a continuation of flow in order to maintain minimum flow in Darnford Brook. LHCRT have constructed an overflow weir and baseflow structure which will pass an agreed minimum flow towards Darnford Brook. Additional flow will discharge to Darnford Brook via the overflow when the canal pound is full.

6.2.3 Scenario 3 - Sections A, B (Ogley Junction to Walsall Road) and F (Fosseway to Tamworth Road)

Completion of Section A (Ogley Junction to Toll Road) will link Section B (Toll Road to Walsall Road) to the CRT network at Ogley. The long-term operational water supplies will then become available for these sections, as discussed above. Water accumulation in Section B will increase along with usage and discharge to the waterbody in Cranebrook Quarry should be viable. Alternatively, backpumping could be used to reduce the usage of CRT water if this proves economic.

The issues with water supply in Section F (Fosseway to Tamworth Road) would continue as in Scenario 2.

6.2.4 Scenario 4 - Sections A, B (Ogley Junction to Walsall Road) and E, F (Lichfield Road to Tamworth Road)

Sections A and B will function as in the previous Scenario. Section F (Fosseway to Tamworth Road) now extends up through Section E (Lichfield Road to Fosseway), taking the canal up to the Lichfield Road. The Manor Farm surface water licence (C2) could be used to fill Section E if it can be negotiated and would be adequate to maintain both Sections E (Lichfield Road to Fosseway) and F (Fosseway to Tamworth Road). Assuming all of the water to fill Section B (Toll Road to Walsall Road) had already been sourced, the time to fill Section E (Lichfield Road to Fosseway) would be 10 days (assuming 70% spare capacity on the licence). This source would also be adequate for the operational needs of Section F (Fosseway to Tamworth Road), which would ease the supply issues there.

If this source is not available, the CRT water from Ogley Junction or the groundwater sources (C9 and C10, if these are found to be feasible) would be the only viable option to fill Section E and a wayleave would be required to pipe water from Section B (Toll Road to Walsall Road) across to Section E (Lichfield Road to Fosseway).

The likelihood of water accumulation at the end of Section F (Fosseway to Tamworth Road) would increase with the access to better water sources. However, excess water would be controlled via the overflow weir and baseflow structure that discharge to Darnford Brook (Section 6.2.2).

6.2.5 Scenario 5 - (Sections A, B Ogley Junction to Walsall Road and D, E, F Watling Street to Tamworth Road)

The source for filling section E could be used to fill Section D (Watling Street to Lichfield Road). Based on a fill volume of 22.5 Ml/d and assuming 70% spare capacity on the licence, time to fill would be 7.4 days. Sections D, E and F would then be maintained by this source.

A highway drain (HC4, see Appendix E) which will have a hard clash with the canal will also discharge into the upstream end of Section D (Watling Street to Lichfield Road). However, the potential volume from this is low and as such it is not considered to be a reliable water source.

Other sections would remain as in previous scenarios.

6.2.6 Scenario 6 - Sections A – F (Ogley Junction to Tamworth Road)

Barn Farm GW abstraction (C7) could be used to provide additional water required to fill Section C (Walsall Road to Watling Street). Based on an additional infill volume of 11.3 Ml/d and 100% spare capacity on the licence time to fill would be 25 days. The other sources considered for Section A and B could also be used to fill Section C (Walsall Road to Watling Street) as the canal would now be connected through to Ogley Junction.

A highway drain (HC5, see Appendix E) which will have a hard clash with the canal will also discharge into the upstream end of Section C (Walsall Road to Watling Street) However, the potential volume from this is low and as such it is not considered to be a reliable water source.

Usage of the canal could be expected to increase as a route from Lichfield through to the national canal network would be established. The long term operational water sources should thus be in place and a large volume of water will have to be either back-pumped or discharged to Darnford Brook.

6.2.7 Scenario 7 - Sections A – G (Ogley Junction to Huddlesford Junction)

Section G (Tamworth Road to Huddlesford Junction) would complete the restoration. It could be filled via Sections A – F of the canal, using whichever sources have been adopted for the fully restored canal supplemented, if necessary, by the smaller traded licences for a limited period - the combined annual abstraction limits on these licences could provide 34.64 Ml/d, 2.09 Ml/d more than the required fill volume (assuming 100% spare capacity on all licences).

Removal of surplus water is unlikely to be a problem as it can discharge to the Coventry Canal. Though this would be subject to discussions with CRT who would need to consider the impact of this surplus flow on water levels in the Coventry Canal.

6.2.8 Scenarios 8 – 12

These scenarios duplicate the sequence of restoration for Scenarios 3 – 7 but with Section G (Tamworth Road to Huddlesford Junction) completed, providing a link to the Coventry Canal at Huddlesford Junction.

This relieves some of the issues in the previous scenarios as disposal of water from Sections C (Walsall Road to Watling Street) through to F (Fosseway to Tamworth Road) can be achieved through Section G (Tamworth Road to Huddlesford Junction), as these sections are progressively restored up through the canal. Filling and operation of each section as it is completed would remain as with the previous Scenarios, although backpumping from the Coventry Canal, if permitted, would be made easier to achieve by having the canal connected.

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 and the planned marinas. 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 it 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 as CRT has undertaken modelling work on its existing network which suggests that the restoration and operation of the Lichfield Canal would not have any adverse effects on the existing CRT network.

Although the local groundwater and surface water systems are subject to restriction to further abstraction licensing, there are potentially several options that could be considered to support the operation of the restored canal, including groundwater from abandoned mine workings, ad hoc boreholes drilled into Carboniferous strata and water from the BCN.

The option of supplying the water from future proposed residential developments in south Lichfield, 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)although this can be mitigated to some extent with side pounds. 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 less. A similar conclusion applies to re-routing surface water drainage from major roads in the South Lichfield 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. This is likely to relieve some of the surface water flooding issues in the area, as outlined in the SWMP (Royal Haskoning, 2010).

Amongst all the options identified, the CRT source offers the easiest and most reliable source for operating the canal when fully restored.

7.2 Recommendation

A series of recommendations have been provided below.

- Negotiations should be held with CRT regarding the supply of bulk water to operate the canal. This is the most viable and reliable source.
- Further discussions should be undertaken with the Coal Authority 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).
- Initiate discussions with existing licence holders and investigate the potential for licence transfer of spare capacity or, alternatively, purchase the water from these licence holders.
- A cost/benefit analysis has to be undertaken for the options identified in the constrained list of options. As CRT have indicated that activating the Lichfield Canal would not impact their existing network, the cost/benefit assessment should be undertaken against the base case “CRT Option”.

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APPENDICES

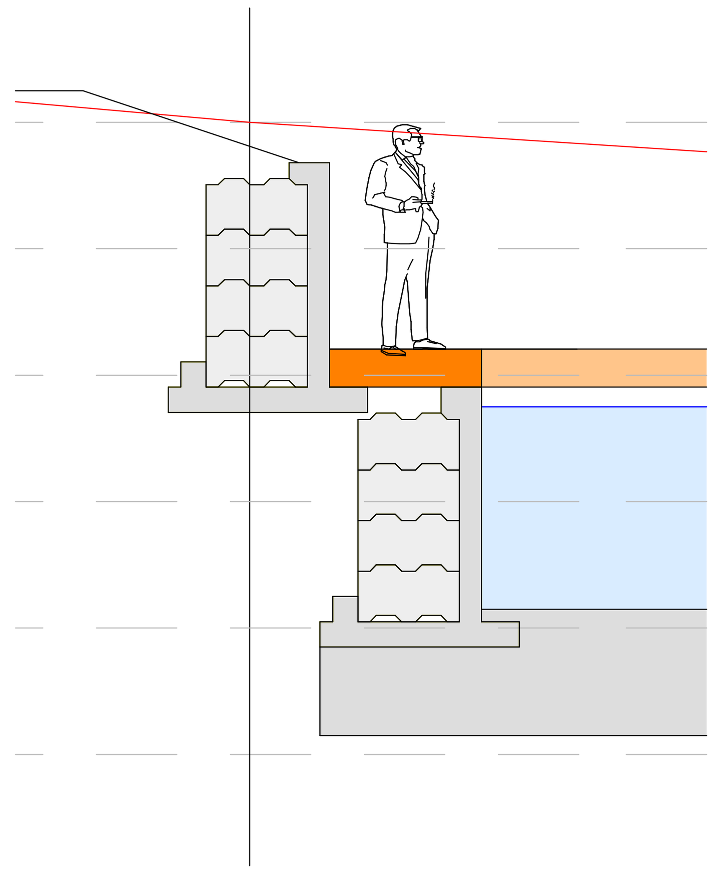
APPENDIX A

Data Sources

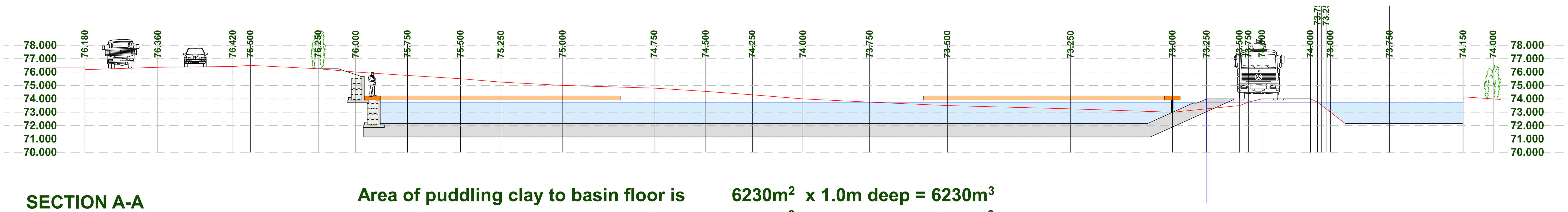
Data Description	Data Provider	Status	Date Obtained	Comments
Final scoping document	Derek Lord - LHCRT	Complete	31/08/2015	ESI has compared this to the oringal and compariso notes are in a file within the same folder
Lockage demand data	Kathryn Maye - CRT	Actioned		KM agreed to provide by 7th September (meeting minues with Bob)
Required input parameters for canal models	Kathryn Maye - CRT	Complete	01/09/2015	Bob obtained more info through meeting with Kathyrn on 01/09/2015
Confirmation of likely phases to be used for scenarios	Derek Lord/Peter Buck - LHCRT	Complete		Derek Lord to provide on 7th September (see Email from D Lord on 06/09/2015)
Standard for canal construction	Kathryn Maye - CRT	Complete	18/08/2015	Draft version (pre CRT review) received on 18/08/2015
Lock positioning	Peter Buck - LHCRT	Actioned		
Drawing of side pounds	Peter Buck - LHCRT	Actioned		
Phase I report for quarry extension	Rob Price - Pleydell Smithyman	Not urgent		Relevant information received through other documents provided by Robin on 24/08/2015
Information relating to potential sources of water and points of contact	Derek Lord - LHCRT	Complete	12/08/2015	Based on past experience at STWL
Lichfield Canal Restoration Feasibility Study Final Report 2009	Derek Lord - LHCRT	Complete	12/08/2015	
Hydraulic Asessment for Proposed Restoration of the Lichfield Canal	Derek Lord - LHCRT	Complete	12/08/2015	
License to abstarct water at Darnford Lane Lichfield	David Dixon	Complete	18/08/2015	Derek Lord to provide contact details. Details obtained from Peter Buck: David Dixon LHCRT Land Officer Tel: 01543 258512 Email: daviddixon21@virginmedia.com *Email has been sent to request*
CRT traffic model and traffic survey data	Kathryn Maye - CRT	Actioned		
Tame, Anker and Mease abstraction licensing strategy Feb 2013	Online	Complete	25/06/2015	
Trunk Road highway drain records for A38 (Highways England)	Ominder Bharj	Actioned	18/08/2015	Peter Buck suggested a potential contact: Ominder Bharj Proect/Assest Manager Staffordshire, Highways England tel: 0121 678 8182 Email: ominder.bharj@highwaysengland.co.uk *Email has been sent to request*
Highway drain records (Staffs County Council)	Contacts to be provided by Rob Price - Pleydell Smithyman Peter Buck - LHCRT	Not urgent	19/08/2015	Flooding Issues/Consents - Jamie Cooper, Flood Risk Officer Tel: 01543 334199 Email: jamie.cooper@staffordshire.gov.uk
Public surface water sewer records	STWL	Not urgent		
Local distict Plan (Lichfield District Council)	Jonathon Allinson	Need to Action	18/08/2015	Peter Buck suggested contact.
Planning consents	Jonathon Allinson	Not urgent	18/08/2015	Jonathon Allinson Principal Planning Officer, Lichfield District Council
FRA - persimmon	Peter Buck - LHCRT	Not urgent	18/08/2015	Peter Buck's last contact was with Martin Probert Technical Director of RPS Group in 2011 Tel: 01902 771 331 Email: martin.probert@rpsgroup.com Although LHCRT has recently had contact with the Persimmon directors to discuss the interaction of the housing development on the canal and what LHCRT could do for them.
Plan of proposed canal route		Complete	20/08/2015	
Local Lead Flood Authority Planning Application Response	Robin Smithyman	Complete	24/08/2015	
Cranebrook Quarry HIA	Robin Smithyman	Complete	24/08/2015	
Meeting minutes from pre app enquiry	Robin Smithyman	Complete	24/08/2015	
Cranebrook Quarry eastern mineral extension and restoration to Marina Basin an	Robin Smithyman	Complete	24/08/2015	
Cranebrook Quarry eastern mineral extension and restoration to Marina Basin an	Robin Smithyman	Complete	24/08/2015	
Meeting minutes from follow up meeting with CRT (Bob and Kathryn)	Bob Sargent	Complete	02/09/2015	
Drainage plans from SCC Flood Risk Managers	Derek Lord	Complete	17/09/2015	
Draft Proposals for Marina adjacent to pound 27	Peter Buck - LHCRT	Complete	18/09/2015	
Locations of restored side pounds	Peter Buck - LHCRT	Complete	18/09/2015	
Southern Staffordshire Surface Water Management Plan	Derek Lord	Complete	16/10/2015	

APPENDIX B

Pound 27 Marina



SECTION THROUGH RETAINING WALL

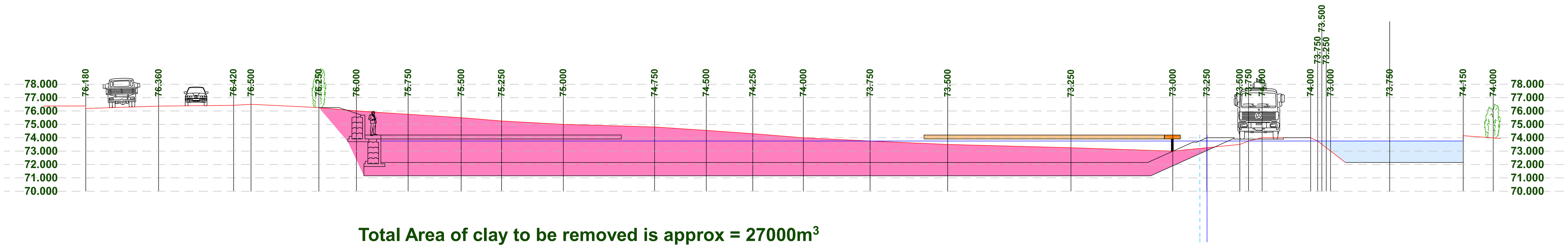


SECTION A-A

Area of puddling clay to basin floor is 6230m^2 x 1.0m deep = 6230m^3

Area of puddling clay to basin soft edge is 1015m^2 x 1.0m deep = 1015m^3

Total Area of puddling clay required is approx = 7245m^3



Total Area of clay to be removed is approx = 27000m^3

Rev	Description	Edited	Date
G	CAR PARKING INCREASED AT CLIENT REQUEST - BOAT Nos. REDUCED	AG	29.07.15
F	EXISTING SLIPWAY POSITIONED	AG	29.07.15
E	SITE AMENDED TO TAKE INTO ACCOUNT BUILDING AMENDMENTS	AG	29.07.15
D	BOUNDARY RED LINE ADDED	AG	27.05.15
C	SERVICES COMPOUND & CYCLE RACK ADDED	AG	22.04.15
B	APPROXIMATE SPOIL VOLUMES ADDED	AG	01.12.14
A	DISABLED PARKING AMENDED - PATH ADDED - DECKING INCREASED - BUILDING UPDATED - BUILDING ACCESS INDICATED	AG	21.10.14

GJP MARINA DEVELOPMENTS LTD

Georgian House, 63 - 73 Saltisford
Warwick CV34 4TR

Tel: 01926 353 550
Fax: 01926 353 559
Email: info@gjpmarinas.co.uk
Web: www.gjpmarinas.co.uk

MARINA DEVELOPMENTS

CLIENT Jack Moody Limited

PROJECT Proposed New Community Water Activity Centre adjacent to Tamworth Road, Lichfield, Staff's.

DRAWING Proposed Site Plan

SCALE	DRAWN	DATE	DRG. NO.	REV
1:500@A1	AG	28/04/14	237 - 004	G

APPENDIX C

Canal and River Trust Report

1 DEMAND ESTIMATES – LOCKAGE & LOSSES

1.1 FULL RESTORATION:

1.11 Baseline Lockage estimates undertaken using existing annual lockage totals, as published in the CRT Annual Lockage Reports, 2000 onwards.

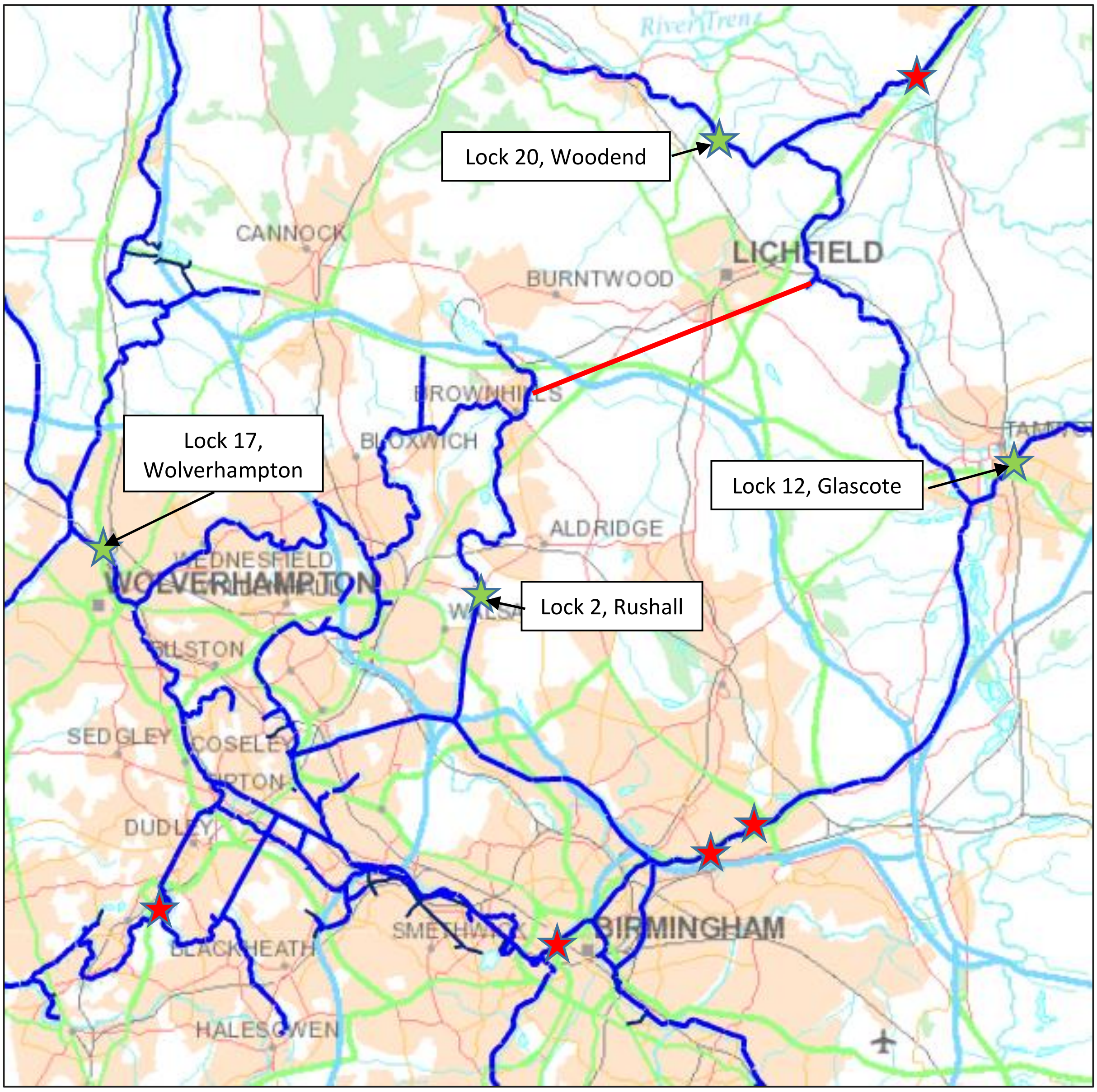


Figure 1 Location of proposed restoration and lockage data available.

Figure 1 above shows the approximate line of the restored canal in red and the locations of annual lockage totals available, represented by stars. Those represented in green have been used in the estimate of lockage below, assuming lockage totals at all other locations will be taken into account within the lockage totals of those used in the estimation.

Canal & River Trust

Assuming the Lichfield Canal is **fully restored**, and that at each junction, boats travel 50/50* in each direction:

<u>At Glascote</u>:	5844	Long term average annual lockage recorded (see Table 1 below)
Junction 1 with B&F:	2922	
Junction 2 **onto restored canal**:	**1461**	
<u>At Woodend</u>:	8299	Long term average annual lockage recorded (see Table 1 below)
Junction 1 with Coventry Canal:	4150	
Junction 2 **onto restored canal**:	**2075**	
<u>At Rushall</u>:	252	Long term average annual lockage recorded (see Table 1 below)
Junction 1 with Anglesey Branch:	126	
Junction 2 **onto restored canal:**	**63**	
<u>At Wolverhampton</u>:	1946	Long term average annual lockage recorded (see Table 1 below)
Junction 1 with Wyrley & Essington:	973	
Junction 2 with Walsall Canal:	487	
Junction 3 with Cannock Ext Canal:	244	
Junction 4 **onto restored canal:**	**122**	

<u>TOTAL ESTIMATED ANNUAL LOCKAGE: 3721</u>

* The 50/50 split applied in this estimation is based on the proportionate split used in the CRT Boat Traffic Model, as confirmed by Chris Barnett, *pers comm*, 2015.

Table 1 - <u>Annual Lockage Data –Summary Statistics</u>

Lock	Min	Max	Latest	LTA	Period
Lock 2, Rushall	143	328	328	***252***	2009-13
Lock 17, Wolverhampton	1350	2710	1803	***1946***	2000-6, 2008-14
Lock 12, Glascote	5191	6538	5890	***5844***	2000-3, 2006, 2009-10, 2012-14
Lock 20, Woodend	6082	9525	7068	***8299***	2000-2014

Annual Lockage Demand

Based on the assumption made by Atkins in their 2009 Feasibility Report (Atkins, 2009), that the deepest lock chamber has a volume of 0.21 Ml (3.5m deep, 25m long, 2.4m wide), this is equivalent to an **annual demand of 781 Ml/yr.**

Based on the assumption that peak weekly lockage is approximately equivalent to 4.5% of the annual total and that the peak daily is 25% of that, the estimated peak weekly lockage is 167 lockages or 35.2 Ml/wk, the average daily lockage (in a peak week) is 24 or 5.0 Ml/d, and **peak daily lockage is 42 or 8.8 Ml/d.**

1.12 Future Lockage estimates undertaken using existing annual lockage totals, 2000 onwards, then applying a non-compounded percentage increase, per year.

If we assume a 1.5% increase per year in boat movements/lockage in future (the current national growth in boat numbers, (British Waterways 2011)), the annual lockage total on the fully restored canal increases to:

3777 in YEAR 1 ~ 793 Ml/yr, 170 lockages/wk or 35.7Ml/wk, 24 lockages/d or 5.1 Ml/d average and 42 lockages/d or 8.9 Ml/d peak

4000 in YEAR 5 ~ 840 Ml/yr, 180 lockages/wk or 37.8Ml/wk, 26 lockages/d or 5.4 Ml/d average and 45 lockages/d or 9.5 Ml/d peak

4279 in YEAR 10 ~ 899 Ml/yr, 193 lockages/wk or 40.4Ml/wk, 28 lockages/d or 5.8 Ml/d average and 48 lockages/d or 10.1 Ml/d peak

1.13 Loss estimates undertaken using the loss model - TBC

- Based on four lining scenarios (0.01-1.00):
  1) Best case – Geomembrane (e.g. Bentomat) – whole canal – 0.10
  2) Very Low Density Polyethylene (VLDP) or New Puddle Clay – 0.30 and
  3) New Concrete – 0.35
  4) Worst case – lining in just a few selected areas – 0.45

NB: Only one worse option but unrealistic as is ‘no lining over deep coarse sand/gravel – 1.00’

Modelling to determine loss demands on the fully restored canal suggests that the loss model is not sensitive to annual lockage totals, as modelled with annual lockage totals ranging from 1000 to 4279. The maximum estimated annual lockage for the fully restored canal after 10 years i.e. 4279, has therefore been used as a default value in the modelling exercise to determine the loss rates on the partially restored canal.

The results of the modelling to estimates loss rates on the fully restored canal are shown below in table 3:

Table 3 Loss Rates for Range of Lining Types

Lining Scenario	Average Summer Loss Rate Ml/km/wk	Summer Range Ml/km/wk
Geomembrane (e.g. Bentomat)	0.62	0.25-0.99
Very Low Density Polyethylene (VLDP) or New Puddle Clay	1.37	0.55-2.20
New Concrete	1.55	0.62-2.47
Lining in just a few selected areas	2.10	0.84-3.37

Loss demands

Based on the assumption that the canal is 11.7 km in length and fully restored, the average weekly loss rate is estimated to range from **7.3 Ml/wk to 24.6 Ml/wk**, depending on the lining type chosen. On a daily basis, this is equivalent to an average loss demand of between **1.04 Ml/d and 3.5 Ml/d.**

1.2) PARTIAL RESTORATION:

Restoration of the canal will be undertaken in phases. Although it is currently unclear, which sections of the canal will be restored when, the canal has been split into 7 discrete sections as shown in Table 3 below:

Table 3 - Restoration Sections/Phases

Section	Location
A	Ogley Jn to Toll Road
B	Toll Road to Walsall Road
C	Walsall Road to Watling Street
D	Watling Street to Lichfield Road
E	Lichfield Road to Fosseway
F	Fosseway to Tamworth Road
G	Tamworth Road to Huddlesford Jn

1.21 Lockage

The demands required at each stage of the restoration will need to be determined by ESI once the phasing has been confirmed. As noted above, the estimated annual lockage for the fully restored canal is 3721. This figure will need to be used to estimate lockage on the partially restored canal as appropriate.

1.22 Loss estimates

As noted above, restoration will be undertaken in phases. As this phasing is as yet unconfirmed, the CRT loss model has been used to estimate the loss rates for each section of canal, A to G. ESI will then need to combine this with lockage estimates to determine the demand that needs to be met at each phase of the restoration. Table 4 below shows the results of the loss modelling:

Table 4 - Loss estimates by section of restored canal

Section	Canal Length km	Best Case Average Summer Loss Rate Ml/wk	Worst Case Average Summer Loss Rate Ml/wk
A	1.1	0.7	2.3
B	1.1	0.7	2.3
C	0.9	0.6	1.9
D	1.6	1.0	3.4
E	2.9	1.8	6.1
F	1.9	1.2	4.0
G	2.2	1.4	4.6
Total	11.7	7.3	24.6

2 IMPACTS ON BCN, OXFORD & GU HYDROLOGICAL UNITS AND WIDER CRT NETWORK

The CRT Water Resources Model has been used to determine the potential impacts of the full restoration of the Lichfield Canal on CRT's network using four scenarios, as agreed with ESI, as follows:

Scenario 1: Best Case - 100% of demand at Ogley Junction, Wolverhampton Level, BCN

Scenario 2: Worst Case - 100% of demand at Ogley Junction, Wolverhampton Level, BCN

Scenario 3: Best Case – 50% of demand at Ogley Junction, Wolverhampton Level, BCN, 50% of demand at Huddlesford Junction, Coventry Canal, Ox & GU

Scenario 4: Worst Case - 50% of demand at Ogley Junction, Wolverhampton Level, BCN, 50% of demand at Huddlesford Junction, Coventry Canal, Ox & GU

Please note: these scenarios do not include the demands of the two proposed marinas on CRT's network. Modelling of the impacts of these will be undertaken, as agreed by the end of October.

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).

2.1 Results

The results show that under scenarios 1 and 2, with 100% of the demand from the Wolverhampton Level, the fully restored canal would have no net impact on the level of service of the BCN Hydrological Unit, nor the wider canal network.

Under scenarios 3 and 4, with 50% of the demand on the Wolverhampton Level and 50% on the Coventry Canal, the results show that the fully restored canal would have a net impact on the level of service of a neighbouring hydrological unit.

2.2 Conclusions

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

References

Atkins (2009) Lichfield Canal – Restoration Feasibility Study – Final Report, July 2009, 131pp

British Waterways (2011) National Water Resource Plan - Summary, 24pp

3 REVISED IMPACTS ON BCN, OXFORD & GU HYDROLOGICAL UNITS AND WIDER CRT NETWORK

The impacts of the full restoration of the Lichfield Canal on the CRT network have been assessed using the CRT Water Resources Model. The results of this modelling have been outlined in section 2 above. For each scenario, this modelling looked at the impacts of adding a virtual customer to the model, at both Ogley and Huddlesford Junctions, applying the agreed estimates for lockage and loss demands at these locations. This, in effect, assessed whether the demand on the restored canal could potentially be met by existing CRT resources. The modelling did not take into account any additional boat traffic that may be created on the wider connected CRT canal network, as a result of the full restoration of the Lichfield Canal.

It was originally proposed that this could be estimated using our bespoke CRT Boat Traffic Model, and following this, the impacts of the two proposed marinas. However, it has since been confirmed that this work could not be undertaken as the time required to set up, run and extract the results would have been prohibitive. An alternative methodology has therefore been applied. Please see section 3.1 below.

3.1 Additional demand on wider CRT network as result of restoration

In 2000, work was undertaken by CRT (then British Waterways) to estimate boat movements in association with the restoration of the Droitwich Canal. This work included running the CRT 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 5 below for details:

Table 5 – 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 CRT to estimate the number of additional boat movements as a result of marina developments.

Canal & River Trust

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 CRT 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.

3.2 Results

Table 6 below shows the additional lockage demands estimated for each hydrological unit within 50 km of the Lichfield Canal Restoration.

Table 6 – Additional lockage demand on wider CRT network as result of restoration

Hydrological Unit	Additional Annual Lockage Demand Ml/yr
BCN	215
Oxford & GU	163
10 Mile	43
Peak & Potteries	111
Shropshire Union/S&W	95

Based on these estimates, the results show that there is *no net impact* on the level of service of any of the above hydrological units i.e. the additional demands resulting from the full restoration of the Lichfield Canal, could potentially be met by the CRT network.

3.3 Conclusions

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

4 MARINA DEMANDS

As noted above, it was originally proposed that additional demands as a result of the two marina developments proposed on the restored canal could be estimated using our bespoke CRT Boat Traffic Model.

However, as with the above demands, it has since been confirmed that this work could not be undertaken as the time required to set up, run and extract the results would have been prohibitive. An alternative methodology has therefore been applied. This is the screening methodology currently used by CRT to estimate the number of additional boat movements as a result of marina developments.

For each marina development, boat movements were estimated at strategic locks within a 50 km radius from the marina. A decay rate was applied as follows:

Table 7 – Boat movements decay rate with increasing distance from marina developments

Distance from Junction of restored canal	Additional boat movements per year
<5 km	100%
<10 km	80%
<20 km	50%
<30 km	25%
<40 km	15%
<50 km	7.5%

Using the above methodology, an increase in annual boat movements as a result of each marina development has been estimated at strategic locks, within 5 Hydrological Units. 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.

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.

4.1 Results

Table 8 below shows the additional lockage demands estimated for each hydrological unit within 50 km of the Lichfield Canal Restoration.

Table 8 – Additional lockage demand on wider CRT network as result of Marina Developments

Hydrological Unit	**Marina 1 - Additional Annual Lockage Demand Ml/yr**	**Marina 2 - Additional Annual Lockage Demand Ml/yr**
BCN	158	94
Oxford & GU	9.8	21
10 Mile	25	7.4
Peak & Potteries	28	17
Shropshire Union/S&W	9.8	7.4

Based on these estimates, the results show that there is *no net impact* on the level of service of any of the above hydrological units i.e. the additional demands resulting from both marinas, could potentially be met by the CRT network.

4.2 Conclusions

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

APPENDIX D

Email Correspondence

Jennifer Bassford

From:	Lord, Derek <Derek.Lord@WSPGroup.com>
Sent:	03 November 2015 09:32
To:	Davenhill, Matthew (Place)
Cc:	Cooper, Jamie (Place); Burns, David, A (Place); Arthur, Dale (Place); Peter Buck (bucksafloat@gmail.com); Antonio Gennarini; Jennifer Bassford
Subject:	RE: Highway Drains and Lichfield Canal

Hi Matthew

Thank you for your response below as promised. This is very helpful and just what we required for the purpose of the Water Supply study. At this stage we do not need anything more although if the council needs the use of canal for flood alleviation, for example at Marsh Lane Lichfield we will be happy to work with you.

Regards Derek

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From: Davenhill, Matthew (Place) [mailto:matthew.davenhill@staffordshire.gov.uk]
Sent: 02 November 2015 17:12
To: Lord, Derek
Cc: Cooper, Jamie (Place); Burns, David, A (Place); Arthur, Dale (Place)
Subject: Highway Drains and Lichfield Canal

Derek,

Further to our conversation a couple of weeks ago, I can confirm that in principle we would consider the request to divert highway drainage assets under the control of Staffordshire County Council into the new canal, providing that as a minimum the following issues were addressed:

1. No adverse impact on the hydraulic performance of the highway drain resulting in increased flood risk
2. Long term guarantee of the canals existence such that security of discharge is secured in perpetuity
3. Formal legal agreement guaranteeing the right of discharge into the canal at no cost to SCC, irrespective of future ownership of the canal
4. All costs of diversion to be met by others with no cost to SCC
5. Notwithstanding any wider water resource implications
6. Any connection should not increase flood risk to any third party

With regards to item 3, Staffordshire County Council would require a cast iron guarantee that this couldn’t be renegotiated in the future.

Should you have any questions regarding the above please don’t hesitate to contact me.

Regards,

Matthew Davenhill
Senior Project Engineer(Highway Asset Strategy)
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Disclaimer

Jennifer Bassford

From: Lord, Derek <Derek.Lord@WSPGroup.com>
Sent: 21 September 2015 20:25
To: Antonio Gennarini; Jennifer Bassford
Cc: Peter Buck (bucksafloat@gmail.com)
Subject: FW: Lichfield Canal Water Supply Study

Hi Antonio

Please see below. This gives a form of words endorsed by Severn Trent for incorporation in the WSS. It means that we can assume subject to negotiation that in principle it would be possible to divert flows from public surface water sewers into the canal providing a good source of water. We need to compare the public sewer records with the route of the canal and identify locations where we could consider diversion into the canal.

I will try and get a similar response from Staffs County re highway drains.

I will leave you to deal with David Pyner as you have made the contact and I do not know him. I would suggest that we put a similar form of words to him for comment.

Regards Derek

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From: Russell, Lisa [mailto:Lisa.Russell@severntrent.co.uk]
Sent: 21 September 2015 16:15
To: Lord, Derek
Subject: RE: Lichfield Canal Water Supply Study

Hi Derek

Looks good to me.

Kind regards

Lisa

From: Lord, Derek [mailto:Derek.Lord@WSPGroup.com]
Sent: 19 September 2015 13:02
To: Russell, Lisa
Subject: FW: Lichfield Canal Water Supply Study

Hi Lisa

As per email chain below I have put together a suggested form of words which I think represents STW concerns. If you are happy with the text I would get our consultant to put this in the Water Supply Study. As you can see it just sets out the general STW position and does not commit STW to agreeing any diversion. If you can review with colleagues and either confirm you are happy or suggest amendments that will be very helpful.

Burntwood STW

Burntwood Sewage Treatment Works is located within about 800 m of the canal. It currently discharges treated final effluent to the Burntwood brook. The Burntwood brook passes under the line of canal in an existing culvert. Based on relative levels it would be possible to direct flows to the canal. A preliminary enquiry was made to Severn Trent Water to establish their view on the possibility of diversion of flow. Severn Trent Water have confirmed that they would not consider this due to regulatory and financial concerns.

Surface Water Sewers

Severn Trent Water have surface water sewers which currently discharge into the national canal network which is owned by the Canal and River Trust. There is nothing in water legislation which prohibits a discharge from a surface water sewer to a watercourse or canal. However the right of discharge is the subject of a formal legal agreement between Canal and River Trust and Severn Trent Water referred to as the 'Omnibus Agreement'. Any new discharge point required by Severn Trent Water can be added to the Omnibus Agreement but will incur an annual charge.

There are surface water sewers at various locations adjacent to or crossing the line of the canal before discharging to watercourse. Severn Trent Water have confirmed that they would in principle be prepared to consider a request to divert a surface water sewer into the Lichfield canal. However they would have to be satisfied that there is no detriment if this is to be permitted. Issues to be addressed would include

- . No adverse impact on the hydraulic performance of the surface water sewer resulting in increased flood risk
- . Long term guarantee of the canals existence such that security of discharge is secured in perpetuity
- . Formal legal agreement guaranteeing the right of discharge into the canal at no cost to Severn Trent Water, irrespective of future ownership of the canal
- . All costs of diversion to be met by others with no cost to Severn Trent Water

Regards Derek

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From: Russell, Lisa [mailto:Lisa.Russell@severntrent.co.uk]
Sent: 14 September 2015 18:05
To: Lord, Derek
Subject: RE: Lichfield Canal Water Supply Study

Hi Derek

That sounds perfectly reasonable. Look forward to receiving more info when available.

A friend of mine ran the GNR yesterday, you may have seen him, he was running dressed as the Beast alongside a Beauty in a pink dress for breast cancer awareness.

Martin Sharp! I was thinking of him just the other day when discussing diversions with Bill, neither of us could remember his surname so you have made me feel better now for bringing it back to me!

Take care

Lisa

From: Lord, Derek [mailto:Derek.Lord@WSPGroup.com]
Sent: 14 September 2015 17:55
To: Russell, Lisa
Subject: RE: Lichfield Canal Water Supply Study

Hi Lisa

Thanks for additional comments and information.

Re use of treatment works its what I would expect but raised by consultant as an option so we need to get clarity on issues.

Re canal discharge it is not clear as to at what stage if ever the canal would become owned by CRT so the question of financial cost to STW may not arise in terms of CRT and the omnibus agreement. The issue is more subject to detail whether in principle STW would consider a diversion of flow from an existing public surface water sewer into a canal. I am satisfied that the issue of continuity of discharge from sewer to controlled water/source of control is covered because the canal meets the appropriate requirements, this being confirmed by the EA.

I am also aware of cases where a S104 surface water sewer has no outfall and discharge has been made to canal with water company and CRT agreement.

By the way I have discovered a case in Lichfield where the existing public surface water sewer discharges to Darnford Brook via a Highway Drain network which is legally dubious but due to construction of the A38.

I think for the Water Supply Study the answer is for the consultant to identify the locations where an existing STW surface water sewer could be diverted to feed into the canal and separately set out the legal, financial and technical issues which would need to be addressed in order to allow diversion to take place.

Does the above sound reasonable to you?

Regards Derek

P.S on the social front I attended a meeting at EA today on Barton Flooding. Ian Hodgkiss and Martin Sharp were there for STW so we had a bit of a chat over old times which was nice. Martin is now working for Forkers as a Level 2 supplier.

Also Great North Run went well yesterday. I did it in 2 hours 8 minutes and Janet finished in 2 hours 38. It was a nice weekend away. We went on a combined coach/accommodation package staying in Newcastle Uni Halls of Residence which is 5 minutes from the start.

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From: Russell, Lisa [mailto:Lisa.Russell@severntrent.co.uk]
Sent: 14 September 2015 16:12
To: Lord, Derek
Subject: RE: Lichfield Canal Water Supply Study

Hi Derek

Quick update

The manager of Burntwood is on leave at the moment but I have had feedback from the Environmental Permitting team and for various reasons they don't think using FE would be something we would want to pursue considering the potential risks from an operational, permitting and financial point of view.

From a SWS perspective while permitting should not be an issue from an EA angle, it does raise questions regarding reaching agreement with the CRT and potential future financial liabilities by adding new outfalls into canal which would be added on to the 'Omnibus Agreement' and incur an annual charge – for arguments sake if we are currently discharging to the brook under relevant powers and not paying a fee to do so why would we seek to change that situation to our detriment so to speak(and incur the ongoing costs to the customer base)? Not ruling it out entirely, just wanted to share the feedback I have had so far which have just confirmed a few alarm bells that started ringing when I saw your previous emails.

Think we would need much more detail on the SWS proposals before we would be able to confirm our position.

Hope this is of use, sorry not to be more positive at this stage!

Hope all is well

Lisa

From: Russell, Lisa
Sent: 11 September 2015 11:51
To: 'Lord, Derek'
Subject: RE: Lichfield Canal Water Supply Study

Hi Derek

Sorry for the delay coming back to you, been a mad week.

Comments in red below.

Thanks and have a great weekend

Lisa

From: Lord, Derek [mailto:Derek.Lord@WSPGroup.com]
Sent: 08 September 2015 19:49
To: Russell, Lisa
Subject: RE: Lichfield Canal Water Supply Study

Hi Lisa

Thanks for getting back to me. I knew you were expecting and that's really good news that you've now got to 20 weeks.

I am still down in London but just back from holiday on the boat so Janet and I had two good weeks off. We both needed it.

On the voluntary work front Lichfield and Hatherton Canals Restoration Trust have got a specialist consultant ESI who are undertaking a Water Supply study for the Lichfield canal. They have to look for potential sources of water for the canal. This involves STW amongst other parties.

So I have a number of specific points

Can you supply a contact name for someone responsible for Burntwood Sewage Treatment Works. There is a potential interest in use of the treated final effluent for water supply to the canal. I have asked who can advise you on this from STW, might be some permitting issues as obviously we have quality constraints into main water which are consented by the EA and I don't know enough about that to know what the impact is in using a canal instead of watercourse. Will get back to you when I hear back

I am interested in the surface water arrangements for the Persimmon Chesterfield Road development. This discharges into the head of the drain that runs in the bed of the former canal. This is the drain that at the time was shown as a public surface water sewer but was then changed to culverted watercourse. I recall that there was supposed to be some form of reservoir next to the Sandfield Pumping Station and that Persimmon were to discharge into this reservoir and a flow control would be provided downstream on the sewer to limit flows. I have just been out to have a look and can see no reservoir but a few manholes and a completely developed site. Any chance you could look this out for me and confirm what was actually done. I can then advise our consultant. I will look out the old ref and see if we can still get the file out of storage or if has been destroyed now. If we no longer have the file I will chase with Ops to see if they have any experience out there.

Can you confirm who we would need to speak to about the potential diversion of public surface water sewers into the canal. To give an example there is a public surface water sewer which crosses Darnford Park to the north of Tamworth Road and south of Darnford Lane. This passes under the A38and I assume it discharges to Darnford Brook. Technically this could be diverted to the canal in Darnford Park but we need to discuss it from a policy point of view. I think this would be between me, New Connections, Legal and Ops, as if it was viewed favourably we'd need the diversions to be constructed to adoptable standards obviously including headwalls etc, and we would also need to secure perpetual discharge agreements into the Canal as these will be new outfalls so not affected by the BWB or Manchester Ship Canal test cases other than to the agreed extent that discharges to canal will require a license (or maybe need to be added to the current agreement with the CRT). I think legal will want to be pretty clear on who owns the canal and who we would potentially be agreeing this with so we can draw up some suitable agreements. Also we need to understand any potential ongoing financial implications in discharging to canal rather than watercourse especially if this will end up with the CRT in the end.

Before anything though I need to get advice from legal and Standards about the current company approach to discharges into canal.

Can you give me a week to chase these various things up and then I will be back in touch?

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APPENDIX E

Surface water drainage

E. EXISTING HIGHWAY DRAINS AND POTENTIAL WATER SOURCES FOR THE CANAL

Potential diversions are considered in 4 categories below

1. The Big Pipe which is located within the base of the canal over its length from a point just upstream of London Road
2. Pipes which will have a hard clash occupying the same space as the canal
3. Pipes which do not clash with the canal but can be diverted to provide a source of water
4. Highway locations where surface water runoff can be diverted to the canal

E.1 The Big Pipe

As the time of closure of the canal to navigation in 1954 there was a requirement for the Lichfield canal to be retained due to its land drainage function. Allowance was made for the canal to be culverted subject to consent of the relevant land drainage authority. On that basis the canal was gradually culverted through the urban area of Lichfield in an ad hoc manner which has resulted in the presence of what is locally known as the Big Pipe within the invert of the former canal.

The Big Pipe commences at Sandfields Pumping Station, Chesterfield Road and runs through southern Lichfield, terminating at discharge point into the Darnford Brook to the east of Lichfield. The original discharge point is unclear at this time but is understood to be the original canal. However as a result of construction of the A38 trunk road in the 1960s all traces of the canal were removed and the current discharge point created.

In order to restore the canal it is necessary to remove the Big Pipe and this has been done at the downstream end in the Tamworth Road area at Locks25/26 and Pounds 26/27. This will continue upstream in due course.

The Big Pipe provides the main outfall for surface water drainage for much of southern Lichfield the catchment area being as shown in Figure E.1. One highway drain and one surface water sewer which are connected into the Big Pipe within the currently restored section of canal now discharge into Pound 27 open channel. As restoration proceeds upstream other drains and sewers will be connected directly into the canal (“replaced Big Pipe catchment” on Figure E.1)..

Due to development which has taken place since culverting, it is not possible to restore the canal on its original line. The new line of canal runs between the point where Lichfield Southern Bypass crosses the former Lichfield to Walsall railway and the London Road canal bridge. As a result the Big Pipe will be retained from its upstream end at Chesterfield Road to point of discharge into the Lichfield canal at London Road (“retained Big Pipe catchment” on Figure E.1).

The canal will provide a new outfall for the retained Big Pipe.

E.2 Pipes which will have a hard clash

There are locations known to LHCRT where the alignment and level of the canal would result in hard clashes with both public surface water sewers and highway drains. Examples are set out from downstream to upstream in Table E.1 below. See Figure E.2 for locations and catchment extents.

Table E.1 Existing highway drains/surface water sewers that will have a hard clash with the canal

Map ID	Name	Type	Description
HC1	Darnford Park SW Sewer	Surface Water Sewer	450 mm surface water sewer in the field to the east of the A38.
HC2	A38 Highway Drains	Highway drain	300 mm and 525 mm highway drains which run along the A38 to the north of Tamworth Road Bridge at the point where the canal will tunnel across the road.
HC3	Pound 27 SW Sewer	Surface Water Sewer	300 mm surface water sewer in Pound 27 next to Tamworth Road Bridge.
HC4	A5 Highway Drain	Highway drain	300 mm highway drain along the A5 to the east of Muckley Corner.
HC5	A461 Highway Drain	Highway drain	300 mm highway drain along the A461 to the south of Muckley Corner, adjacent to the Boat Inn. Plans provided by Staffordshire County Council show that the highway drain did discharge into the canal prior to its abandonment.

E.3 Pipes that do not clash with the canal

Pipes which do not clash with the canal but can be diverted to provide a source of water are shown in Table E.2 below. Figure E.3 shows the catchment extent of each source.

Table E.2 Existing highway drains/surface water sewers that will not clash with the canal

Map ID	Name	Type	Description
NC1	Culvert	Highway drain	Staffordshire County Council has made use of the canal in the past when a canal size culvert was constructed beneath the roundabout at the junction of the Lichfield Southern Bypass with Birmingham Road. This culvert is used to attenuate highway flows which are pumped up to a public surface water sewer at a low flow rate to avoid flooding of the downstream sewer. When the canal is opened the pump will be removed and all highway flow will drain into the canal.
NC2	Lichfield Southern Bypass	Highway drain	Staffordshire County Council are currently designing the next section of Lichfield Southern Bypass providing a road and canal crossing beneath the Lichfield to Birmingham railway and with a view to using the canal for disposal of highway drainage.
NC3	Muckley Corner Highway Drain	Highway drain	A 300/375 mm highway drain runs from a point just to the west of Muckley Corner and outfalls to the Crane Brook. It would be possible to divert this drain to discharge into the canal. However this would require it to pass through the Crane Brook quarry.

E.4 Highway locations where surface water runoff can be diverted to the canal

A number of potential highway locations where surface water could be diverted to the canal have been identified. They are summarised in Table E.3 and shown in Figure E.4.

Table E.3 Highway locations where SW run off can be diverted

Map ID	Name	Type	Description
D1	Darnford Lane	Highway drain	Darnford Lane does not have formal highway drainage but surface water runoff is directed to Darnford Brook from both directions. The construction of the Darnford Lane canal bridge will cut off the flowpath from the east and these flows can be directed into the canal.
D2	Birmingham Road	Highway drain	Birmingham Road drains from a high point to the south of Lichfield, north of the roundabout with Falkland Road where it discharges into the canal culvert beneath the railway.
D3	Claypit Lane	Highway drain	Claypit Lane has no formal drainage and will require to pass over the canal on a new bridge. There may be an opportunity to discharge runoff from the bridge into the canal.
D4	Fosseway Lane	Highway drain	Fosseway Lane has no formal drainage and overland flow currently collects in the lowpoint to the west of the railway level crossing. A new canal bridge will be required to the east of the crossing. There may be an opportunity to discharge runoff from the bridge into the canal.
D5	Wall Lane	Highway drain	Wall Lane has no formal highway drainage but crosses over the canal at a high level such that no change of road longfall is required. There is long length of road draining towards the canal and an opportunity to discharge surface water runoff into the canal.
D6	A461	Highway drain	The canal passes under the A461 Lichfield to Walsall Road twice through bridges which remain in place. No works are expected so it is unlikely that any change to highway drainage will be made.
D7	A461	Highway drain	The A461 Walsall Road falls from Muckley Corner towards Lichfield. There is no record of any underground highway drain but there are gullies at the low point which is just to the south of the canal crossing. These gullies appear to drain to soakway but ponding is observed during rainfall. The gullies could be connected to the canal providing a source of water whilst at the same time resolving ineffective highway drainage.
D8	Coppice Lane and Moat Bank	Highway drain	The canal runs alongside Coppice Lane and Moat Bank Lane neither of which have any formal drainage. Runoff is from the road onto the verge but will be limited such there will be effectively no potential contribution of flow to the canal.
D9	Cranebrook Lane and Boat Lane	Highway drain	The canal runs alongside Cranebrook Lane and Boat Lane neither of which have any formal drainage. Runoff is from the road onto the verge but will be limited such there will be effectively no potential contribution of flow to the canal.
D10	Barracks Lane	Highway drain	The canal crosses under Barracks Lane just to the south of the roundabout with Lichfield Road. There is a long length of Barracks Lane which falls towards the canal crossing where a new bridge will be required. There is an opportunity to discharge surface water runoff from this length of road into the canal.
D12	Barracks Lane Roundabout	Highway drain	The roundabout at the junction of Barracks Lane with Lichfield Road does have formal highway drainage. However because there is a fall in road level from the canal crossing to the roundabout it is unlikely that flow can be diverted to the canal.

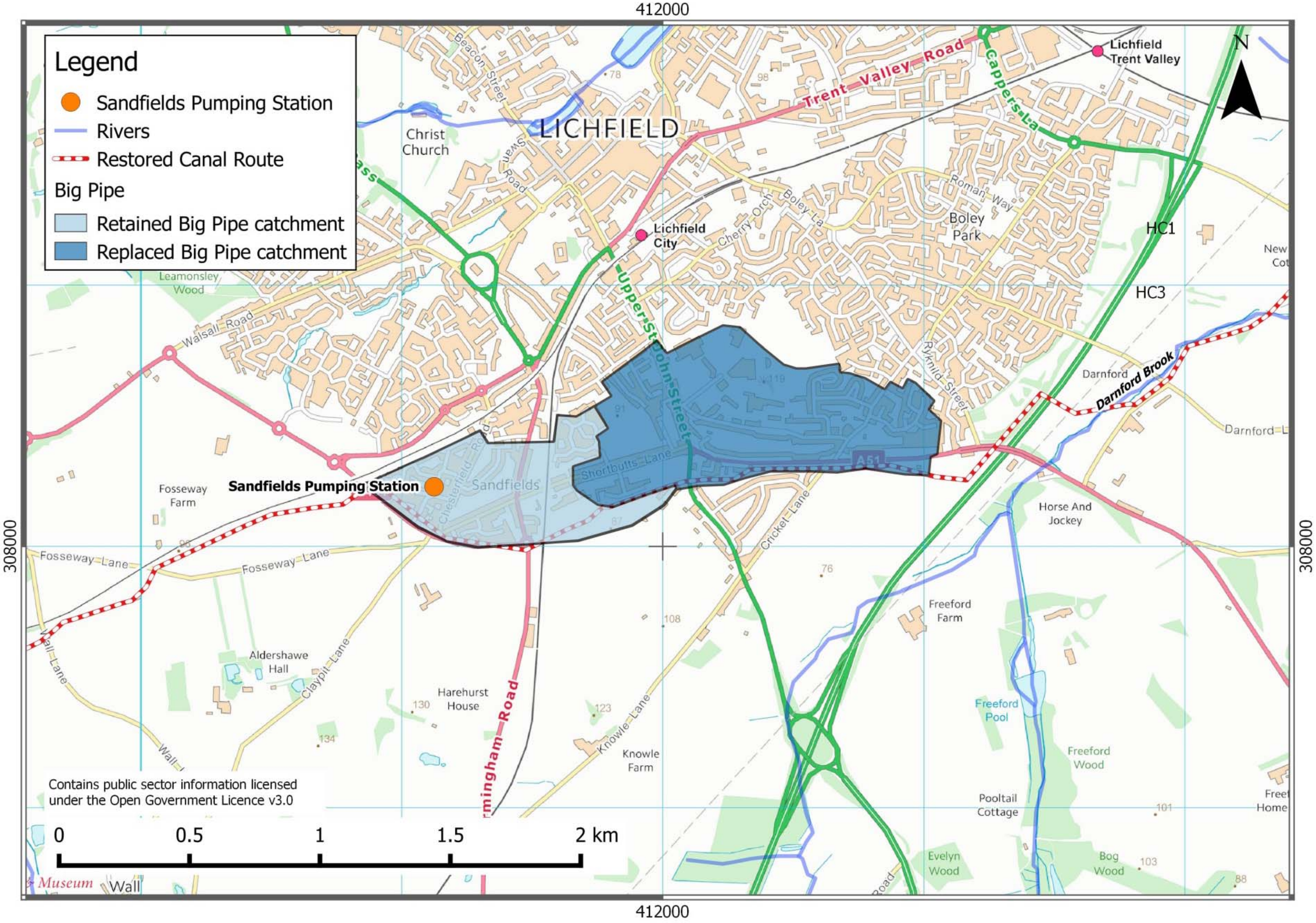

Figure E.1 Big Pipe

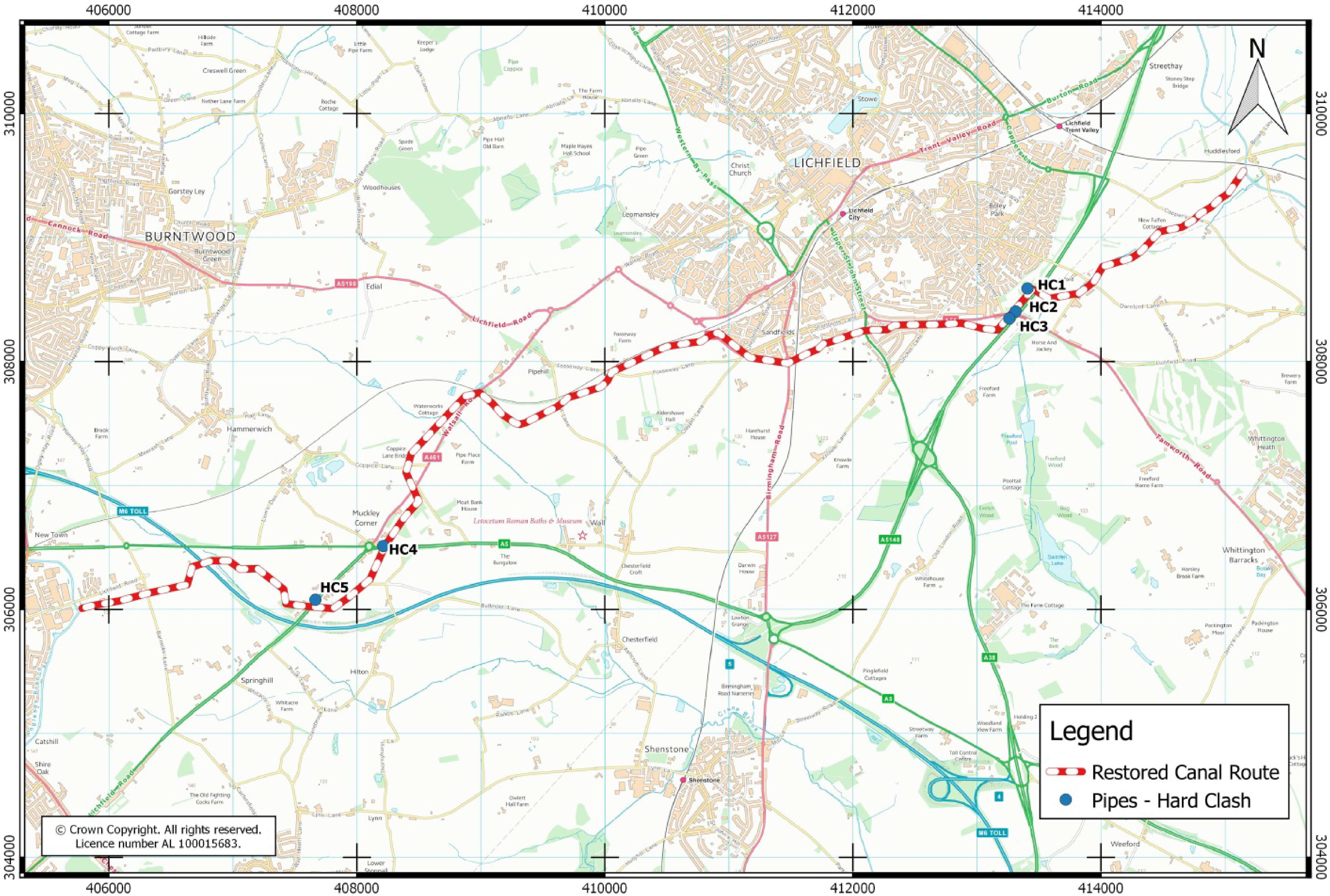

Figure E.2 Pipes which will have a hard clash with the canal

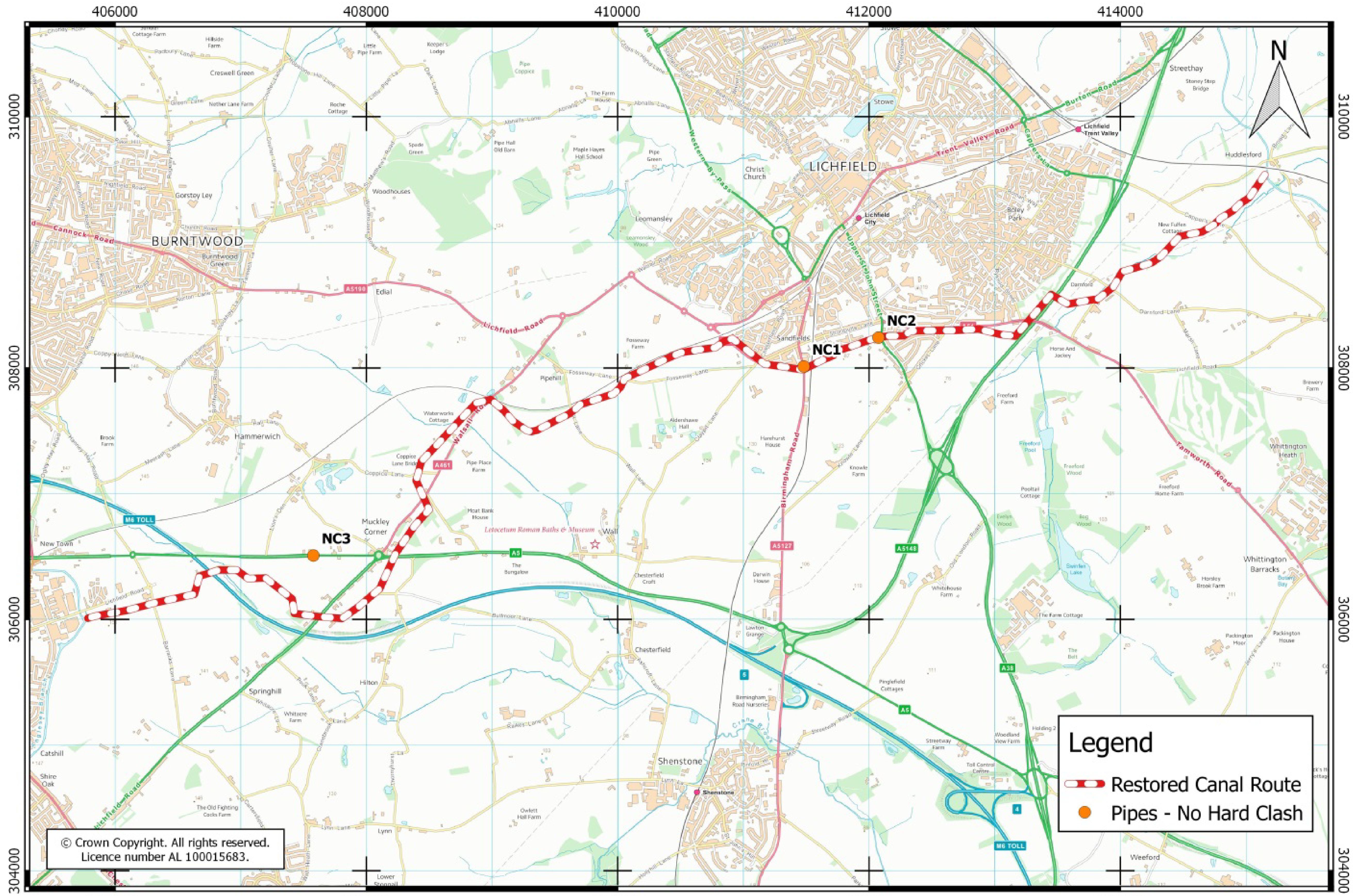

Figure E.3 Pipes which will have no hard clash with the canal

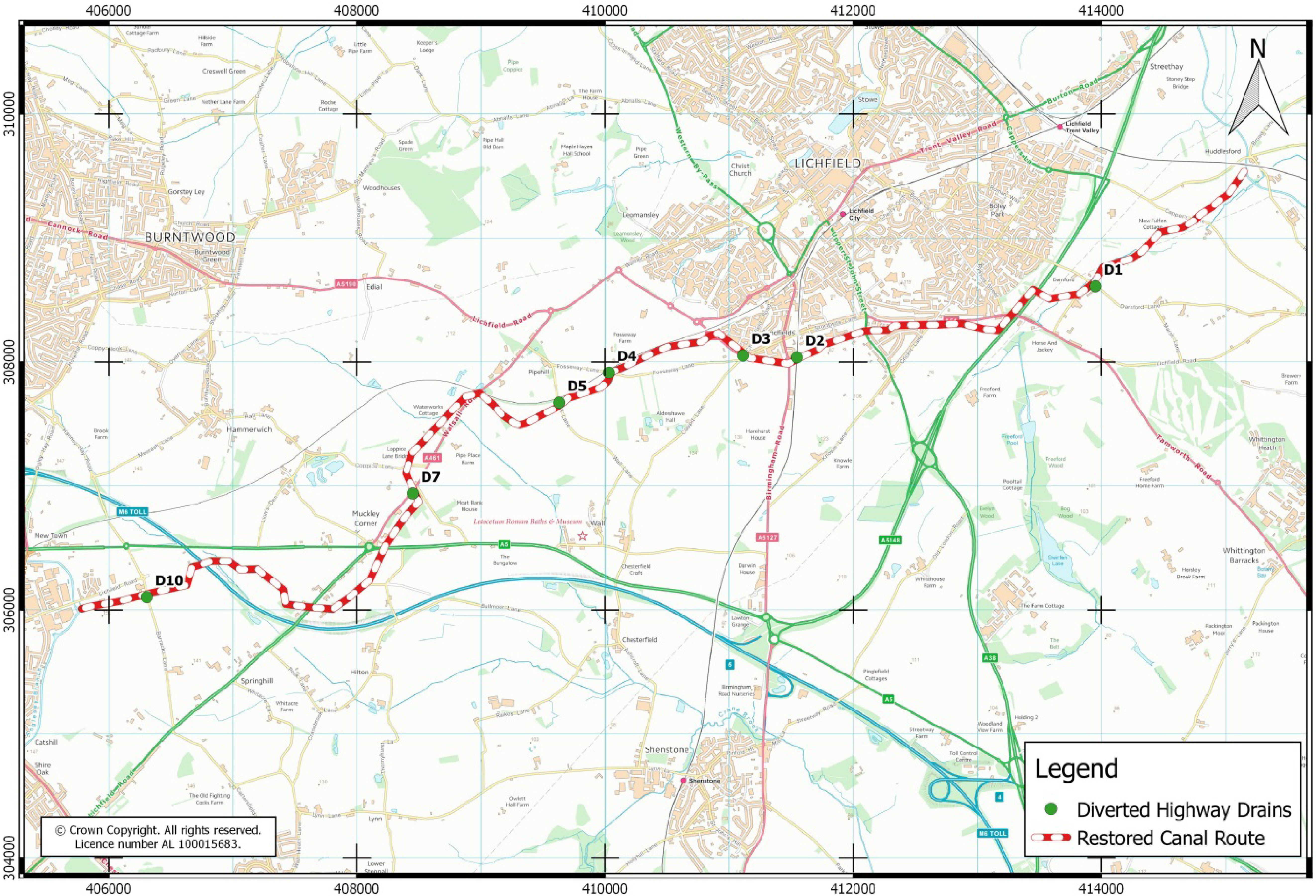

Figure E.4 Highway drains/surface water sewers that could be diverted to the canal