[redacted]

Ecological Assessments

The content of this document is draft and relates to material [or data] which is still in the course of completion in travel to Gate 2 and should not be relied upon at this early stage of development. We continue to develop our thinking and our approach to the issues raised in the document in preparation for Gate 2.

Grand Union Canal Transfer SRO

Affinity Water, Severn Trent Water, Canal & River Trust

Grand Union Canal PMB: Grand Union Canal Strategic Transfer – Ecological literature review and gap analysis. Summary report

Official Sensitive

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Grand Union Canal PMB: Grand Union Canal Strategic Transfer – Ecological literature review and gap analysis. Summary report

Prepared for:

Severn Trent Water Ltd

2 St John's Street

Coventry

CV1 2LZ

[redacted] June 2021

OFFICIAL SENSITIVE

Report status: Draft

CONFIDENTIAL

New Zealand House, 160-162 Abbey Foregate,
Shrewsbury, Shropshire
SY2 6FD

Telephone: +44 (0)1743 276 100
Facsimile: +44 (01743 248 600

Registered Office:
Stantec UK Ltd
Buckingham Court
Kingsmead Business Park
Frederick Place, London Road
High Wycombe HP11 1JU
Registered in England No. 1188070

Grand Union Canal PMB: Grand Union Canal Strategic Transfer – Ecological literature review and gap analysis. Summary report

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[redacted]	16/03/2021	Draft	Response to additional PMB comments	[redacted]			
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1 Introduction

The Grand Union Canal (GUC) project management board (PMB) (comprising principally Severn Trent Water Ltd (STWL), Affinity Water Ltd and the Canal and River Trust (the Trust)) is working to collate and improve baseline data relating to a potential transfer of water from Minworth Sewage Treatment Works (STW) to the Affinity Water Ltd supply area, via the Grand Union Canal network.

This project comprises a literature review and gap analysis, which will inform further ecological appraisal studies. The project is commissioned by STWL (under their Water Resources Management Planning framework) on behalf of the PMB.

This chapter provides an introduction to the project: it sets out the aims and objectives (Section 1.2); overview requirement (Section 1.1); and scope (Section 1.3), which includes hyperlinks to separate topic investigations). The chapter provides an overview of the project methodology in Section 1.5, an introduction to the GUC Strategic Transfer (Section 1.6) and an introduction to the GUC and associated canal networks of relevance to the proposed SRO (Section 1.7).

1.1 Project requirement

It is inevitable that regulators and water companies will need to make difficult decisions in the near future in response to climate change, the need to improve water supply resilience and manage water resources sustainably and the need to protect and improve the environment. In some cases, the needs of the various parties will be well-aligned; however, there are also cross-policy considerations with regards legislation. Pursuit of the objectives of some pieces of legislation, if made in isolation, could result in an outcome at odds with the objectives of other pieces of legislation.

It is essential that regulatory and business planning decisions are based on the best available information, robust evidence, and clear acknowledgement of knowledge gaps, risks and uncertainty. There is therefore a need for this literature review to collate an up to date evidence-base of information related to the identified drivers and topic areas, and for it to identify knowledge gaps and how these might be filled.

The above requirements are being addressed within the framework of the Regulatory Alliance for Progressing Infrastructure Development (RAPID) regulatory process. RAPID "has been formed to help accelerate the development of new water infrastructure and design future regulatory frameworks. The joint team is made up of the 3 water regulators Ofwat, Environment Agency (EA) and Drinking Water Inspectorate. It will provide a seamless regulatory interface, working with the industry to promote the development of national water resources infrastructure that is in the best interests of water users and the environment."[1]

This literature review and gap analysis is required to inform, and meet the requirements of, Gate 1 of the RAPID process; to gather baseline information and to undertake a gap analysis on the current understanding of the physical and ecological environment of the canal network and connected waterbodies, of relevance to the proposed GUC Strategic Transfer. Table 1.1 outlines the Gate 1 activities, defined within the PR19 final determination report (OFWAT, 2019), that this literature review and gap analysis addresses. This piece of work represents one of many parallel workstreams that are being completed to inform the PMBs Gate 1 reporting. The Gate 1 outputs (including recommendation made within this report) will inform the Gate 2

[1] https://www.ofwat.gov.uk/regulated-companies/rapid/

investigations, should the scheme progress. Figure 1.1 represents where this report fits within the wider timescales of the RAPID process.

It should be noted that this 'summary' version of the report contains only short summary sections for each work topic; however, all recommendations are listed within this report. Each individual work topic has been written up as a standalone technical note and these contain more information than is reported here. A fully collated report, with all work topic technical notes included as appendices, will be issued in April 2021. The staggering of these reports resulted from the need to ensure the PMB and the EA had sufficient time to meet the RAPID Gate 1 reporting requirements. This approach was agreed through consultation between the PMB and the National Appraisal Unit (NAU) of the EA.

Table 1.1 PR19 final determinations, Gate 1 activities addressed by the literature review and gap analysis

Gate 1 activities	Details of activities addressed by the literature review and gap analysis
Preliminary solution feasibility and data collection presented in a conceptual design report, using comparable methodologies and consistent assumptions:	
• Initial configuration/sub-option solution designs	• n.a.
• Initial costing and estimating report supported by benchmarking evidence	• n.a.
• Initial water resource benefit	• n.a.
• Initial data available and provided to regional groups to support high-level assessment of regional water resource benefit	• n.a.
• Initial option-level Strategic Environmental Assessment and Habitat Risks Assessments12T,12T including consideration of in-combination effects and identification of environmental risks that need mitigating through the solution design and costing	• Initial option-level Strategic Environmental Assessment (SEA) and Habitat Risks Assessments (HRA) have been made under separate parallel workstreams. Consideration of designated sites has been made within this literature review and gap analysis; however, this has not, at this stage, identified a need for further SEA or HRA assessments.
• Initial environmental, social and economic valuations (or metric benefits) consistent with principles in the National Planning Statement and Water Resources Planning Guidelines	• Work topic 12 and 13 summarise evidence of socio-economic, recreational and natural capital benefits from canals. It encompasses both methods available for identifying and estimating benefits, and evidence related to the quantities and values associated with these benefits.
• Initial drinking water quality considerations	• n.a.
Initial outline of the solution procurement strategy.	n.a.
Initial considerations of planning application route (high level view of process and timelines).	n.a.
Initial comparison of solutions' costs and benefits in early draft regional plans with consideration given to inter-regional supply options and systems impacts.	n.a.
External assurance of data and approaches supported by Board statement.	n.a.

Gate 1 activities	Details of activities addressed by the literature review and gap analysis
Regional stakeholder engagement including customer preferences to identify any issues that need further investigation.	Regional stakeholder engagement (environmental and ecological) took place in the form of workshops, as outlined in Section 1.5.2.
Details of efficient spend to gate submission on gate one activities, including a breakdown of costs against activities, evidence of efficiency of spend (benchmarking or tenders) and assurance.	n.a.
Assessment of key risks to identify potential regulatory barriers, guidance or changes required for the solution to progress.	This is the primary activity this literature review and gap analysis addresses. Environmental and ecological risks are considered regarding the baseline situation and relevant legislation.
Identify impacts of solution on current supply-demand balance delivery plan with simple comparison to current programme solutions.	n.a.
Identification of any changes in solution partner (other water company) or solution substitutions.	n.a.
Develop solution programme plan to determine the activities that need to be undertaken prior to each subsequent gate.	The key output of the literature review and gap analysis is the recommendations for Gate 2 and post Gate 2 investigations.
Proposals for gate two activity and outcomes, and penalty scale, assessment criteria and contributions.	The key output of the literature review and gap analysis is the recommendations for Gate 2 and post Gate 2 investigations.

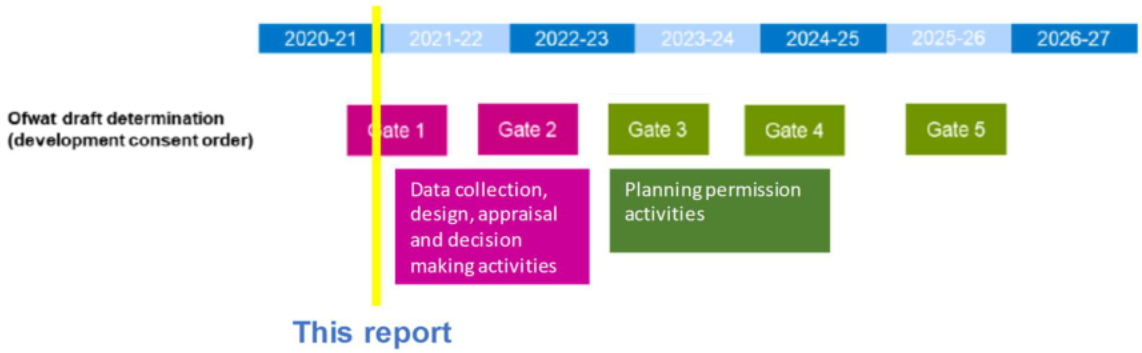

Figure 1.1 The sequencing of the RAPID process and the timing of this literature review and gap analysis within the timeline – this report represents the current timeline in at March 2021 (figure modified from Ofwat's PR19 draft determinations: Strategic regional water resource solutions appendix, 2019).

1.2 Project aims and objectives

A collated baseline is needed upon which all water companies and the regulatory agencies can readily base future analyses and risk assessments. This project will help to define this baseline.

The topic areas of this literature review and gap analysis are wide ranging, with 15 topic areas for investigation identified by the PMB prior to project commissioning (Table 1.2). Ultimately the project will assist the PMB to:

1. Ensure best available information is available for decision-making;

2. Ensure the sustainable management of natural resources; and

3. Make best use of water resources.

The specific objectives of this project are a) to collate and review the current state of baseline ecological understanding of relevance to the proposed SRO; and b) to make recommendations for Gate 2 investigations (and beyond) to enable adequate ecological appraisal of the proposed GUC Strategic Transfer scheme.

1.3 Project scope

The broad technical scope of the project, and the structure of this report follow the 15 topic areas set out in Table 1.2 below.

The geographical scope of the project was partly defined at project start-up, described as:

- Birmingham & Fazeley Canal;
- Coventry Canal;
- Oxford Canal; and
- GUC.

However, it was also acknowledged that additional water bodies might require inclusion once connectivity with neighbouring catchments along the proposed canal route became better understood. It was within the scope of work topic 2 to identify water bodies that interact with the canal system and that could therefore potentially be affected by the proposed scheme. Outputs of this work topic informed the scope of other work topics accordingly.

Table 1.2 Overview description of project topics

Topic	Description	Appendix link
Work topic 1	Identify environmental policy and legislation relating to canals that may need to be considered for the transfer scheme.	
Work topic 2	Identify the surface and groundwater bodies that interact with the canal along the transfer route and capture baseline information on current ecology status.	
Work topic 3	Understand the historical use of the GUC and how it performs under drought and flood conditions.	
Work topic 4	Identification of relationships between canal sediment loading, microbiology, and water quality impacts on receiving canals / watercourses.	
Work topic 5	Review the potential water quality impacts of catchment runoff and ingress along the route of the transfer.	
Work topic 6	Review existing information on canal sediment dynamics and identify potential impacts of the transfer on the canal and associated water bodies.	
Work topic 7	Confirm existing Water Framework Directive status and reasons for not achieving good status for the canal and the affected water bodies, using existing Environment Agency datasets.	
Work topic 8	Collate the current/baseline information and understanding of species and habitats that utilise the canal environment.	

Topic	Description	Appendix link
Work topic 9	To identify any crucial supporting habitats that are not designated or protected	
Work topic 10	Collate information on the existing relationship between migratory birds and the GUC plus associated wetland environments.	
Work topic 11	Identify existing invasive non-native species (INNS) pathways and risks along the canal transfer route and the associated water bodies and the potential risks of encouraging future INNS due to the introduction on Minworth water to the system.	
Work topic 12	General literature review to identify methods and values to be used in when quantifying the socioeconomic and recreational benefits from canals.	
Work topic 13	General literature review to identify methods and values to be used in when quantifying the natural capital benefits from canals.	
Work topic 14	Based on the baseline data collected, recommend what information and methods the project team should use to satisfy impact assessments at Gate 1 and Gate 2, and whether additional information should be gathered to fill any gaps in knowledge.	n.a. recommendations are made throughout the work topics.
Work topic 15	Topic 15: Identification and collation of existing core datasets and recommendations for future data gathering where necessary.	n.a. datasets collated with GIS project and recommendations made within work topics, as appropriate.

1.4 Timeline

A timeline for the GUC Strategic Transfer ecological literature review and gap analysis is shown in the following table.

Table 1.3 Timeline

Item	Date
STWL, Affinity Water, Environment Agency, The Trust, Natural England: GUC Ecology Workshop	March 2020
Project start-up meeting	22nd September 2020
Stakeholder start-up meeting	20th October 2020
Information request issued	23rd October 2020
Stakeholder workshop – Birmingham to Milton Keynes	30th November 2020
Stakeholder workshop – Milton Keynes to London	4th December 2020
Response to information request provided by the Environment Agency	14th December 2020

Item	Date
Project outcomes summary presentation to the Environment Agency and Natural England	16th February 2021
Draft summary report issued to client	1st March 2021
RAPID Gate 1 deadline	5th July 2021

1.5 Methodology

1.5.1 Work packages approach

Project delivery was split into four linked but discrete work packages. 13 of the 15 topics were each assigned to a work package (see Table 1.4), with individual work topics being assigned to experts with relevant backgrounds to complete the relevant investigations. Work topics 14 and 15 are not standalone but are encompassed by recommendations made throughout the various work topics and the project GIS outputs.

Work Package 1 focused on a single topic concerning the legislation that is relevant to the proposed SRO. Consideration of all relevant legislation within the context of the GUC Strategic Transfer is an important step at this early stage of the RAPID process to ensure that relevant stakeholders are being engaged with and that cross-policy considerations can be taken into account.

Work Package 2 included topics that relate to the baseline situation as regards themes for potential 'pathways' of effect on ecology, should the proposed GUC Strategic Transfer scheme progress. This work topic assessed the baseline situation as regards hydrology (although it should be noted that hydrological investigation has been carried out under Gate 1 in a separate work stream), water quality and geomorphology.

Work Package 3 relates to the baseline understanding of the ecological 'receptors' (habitats and species) of the GUC network and connected surface water bodies and builds a conceptual understanding of the potential for the proposed SRO to affect these ecosystems; i.e. to recognise potential sensitivities in the context of the proposed GUC Strategic Transfer. Topics include consideration of baseline Water Framework Directive (WFD) status, designated sites, protected species and invasive non-native species (INNS).

Work Package 4 is comprised of two work topics that relate to socio-economic 'receptors' and natural capital. The outputs of the study will be used to help the project team design a solution that maximises opportunities for net gain and possible ways to mitigate any negative impacts of the transfer.

Table 1.4 Assigment of the individual work topics within work packages

Work Package	Work topics under package
Work Package 1 (legislation)	Work topic 1
Work Package 2 (pathways)	Work topic 2 – identification of water bodies
	Work topic 3 – canal performance in flood and drought
	Work topic 4 – WQ and microbiology
	Work topic 5 – catchment run-off and ingress

Work Package	Work topics under package
	Work topic 6 – sediment dynamics
Work Package 3 (ecological receptors)	Work topic 7 – WFD status and RNAGS[2]
	Work topic 8 – species and habitats of the canal (& receiving water bodies)
	Work topic 9 – supporting habitats
	Work topic 10 – birds
	Work topic 11 – invasive non-native species
Work Package 4 (socio-economic receptors)	Work topic 12 – socio-economic receptors
	Work topic 13 – natural capital receptors

Whilst the reporting has been structured in a source, pathways, receptors framework (see Figure 1.2), it is not the case that any novel assessments/ impact assessments are required at this RAPID Gate 1 stage. Rather, this stepwise approach has been used to ensure important gaps are not missed and to enable the correct sequencing of recommendations for RAPID Gate 2 assessments/ impact assessments. For example, recommendations for some specific ecological requirements are contingent on first establishing whether the SRO is likely to result in a pathway for an effect.

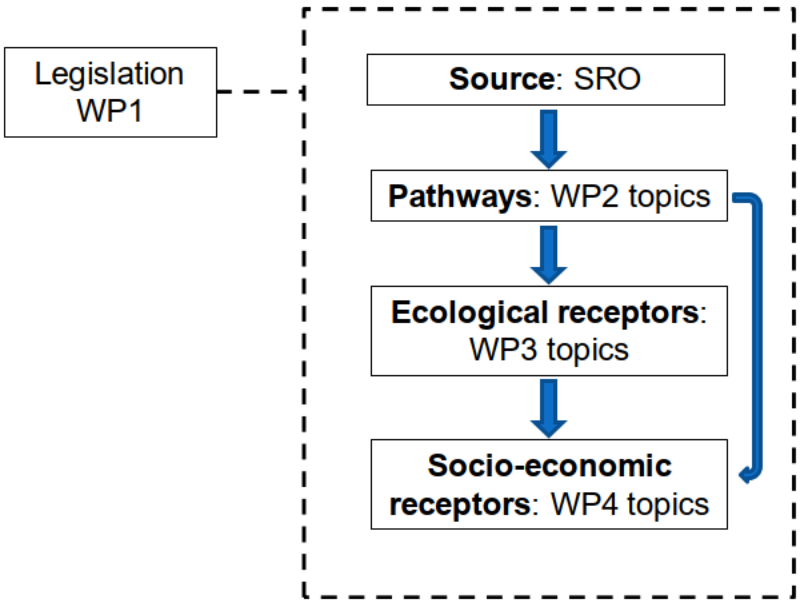

Figure 1.2 **Structuring of the literature review and gap analysis within a source, pathways, receptor framework.**

[2] Reasons for Not Achieving Good Status

1.5.2 Stakeholder engagement

As noted in Section 1.5.1, an important step at this early stage of the RAPID process is to ensure that relevant stakeholders are being engaged with and that cross-policy considerations can be taken into account. With this in mind, stakeholder engagement was prioritised at project outset, with an initial stakeholder meeting the first priority and subsequent stakeholder workshops held at the first possible opportunity, based on stakeholder availability (see Table 1.3 in Section 1.4 for the project timeline). Stakeholder engagement throughout the project has been facilitated by the NAU of the Environment Agency, whose role extended to liaising with Natural England. The Trust is a key stakeholder and hold a position on the PMB.

In order to draw on the pool of relevant local knowledge of the ecology of the canal network and associated surface water bodies of the proposed GUC Strategic Transfer route, and to elicit gaps/ concerns regarding this proposed SRO, video-teleconference calls were held with the Trust and Environment Agency staff on 30th November and 4th December 2020 (Natural England representatives were also sought via the NAU). The workshops involved a general discussion on what the Trust and Environment Agency staff considered to be the key ecological issues within the canal and associated surface water bodies, gaps in current understanding and any concerns around a potential GUC Strategic Transfer, as well as a reach-by-reach discussion of notable habitat/ species/ other site-specific considerations for the study reaches of interest. Screen-sharing of the GIS project within the workshops allowed for site specific themes/ concerns to be raised, and these have fed into the various work topic reports, as appropriate.

1.5.3 Literature reviews

Review of the published scientific literature and the available 'grey literature' was undertaken to support the building of a comprehensive understanding of the canal environment and connecting water bodies, and to improve understanding of the mechanisms by which the proposed water transfer could potentially affect the canal network (including its functional operation, ecology, habitats, and associated socio-economic factors).

The literature review approach was designed to make best use of the available scientific literature as well as capturing relevant information from 'grey literature'. Grey literature was a key source of the available information on the canal and associated river systems of interest, which would not have been available under a formal systematic review type process. Such sources included regulatory related assessments, regulatory position statements and guidance, data summaries and designated site citations.

Computerised literature searches (of published and grey literature) were supplemented with review of documents provided by the GUC PMB from within their partner organisations and the information request submitted to the Environment Agency and the Trust.

On the whole, there was a paucity of information relating to the GUC network, and associated canal waterbodies. This was perhaps unsurprising, given the infancy of the proposed GUC Strategic Transfer scheme, the absence of ongoing ecological monitoring by the Environment Agency within the canal water bodies and the lack of any statutory requirement for the Trust to collect ecological data as part of their business as usual activity. There is, therefore, an emphasis on the gap analysis aspect of this piece of work, rather than review of literature, and recommendations to fill gaps in existing knowledge are the key output.

1.5.4 GIS analyses

Freely available GIS datasets were collated to map existing data and information and to provide an interactive deliverable for this project as regards baseline information of relevance to the work topics considered throughout the study area. Where data were necessary, but not freely available, requests were made to the relevant authority.

1. Water body layers

Water body layers were determined through the work done under Work Topic 2. The project team were provided with a poly-line shapefile of the study feature (the GUC and other select canal arms). This polyline was used to identify canal line features from spatial data retrieved from the Trusts Open Data repository. The revised polyline was then utilised to identify the WFD surface and groundwater bodies which intersect the canal along the transfer route. The surface waterbody catchment areas identified during this process form the area of interest for the study and spatial information to inform other work topics (e.g. current ecological status – reported in Work Topic 3) were clipped to this area.

2. Designated sites

Designated sites GIS data were sourced (from NE and filtered to only include those directly hydrologically connected to the GUC.

3. Invasive non-native species

All INNS data were downloaded from the NBN Atlas as CSV files. Additionally, INNS data was also provided by the Environment Agency (as CSV files). The datasets downloaded include: WFD UK TAG, Species of Union Concern and Wildlife and Countryside Schedule 9. Once downloaded, each file was inputted into QGIS and filtered by area to show species present within 20m of the GUC and relevant water bodies (work topic 11).

4. Protected species

All protected species data were downloaded from the NBN Atlas as CSV files. The datasets downloaded include: Wildlife & Countryside Act Schedules 5 and 8, NERC Section 41, and the Habitats Directive Annex 2. Each file was inputted into QGIS and filtered to show species present within 20m of the GUC and associated water bodies (work topic 9).

6. Environment Agency monitoring points

Monitoring locations were collated for the following (sourced from the Environment Agency):

- Macroinvertebrates;
- Macrophytes; and
- Fish counts.

1.6 Grand Union Canal Strategic Transfer option introduction

The proposed GUC Strategic Transfer scheme aims to transfer water from the Midlands to the South East using the existing canal network from source water identified as surplus at Minworth Wastewater Treatment Works in Birmingham. This report relates to the transfer of water through the canal network only. The scheme will consider various transfer volumes between 50Ml/d to 100Ml/d and various sub-option routes in the upper and lower sections of the canal. The main route options are illustrated in Figure 1.3. It should be noted that this literature review and gap analysis was carried out in parallel with the scheme optioneering; therefore, the long-list of route options are covered within the report, rather than the three sub-options which will be presented in the GUC Gate 1 report.

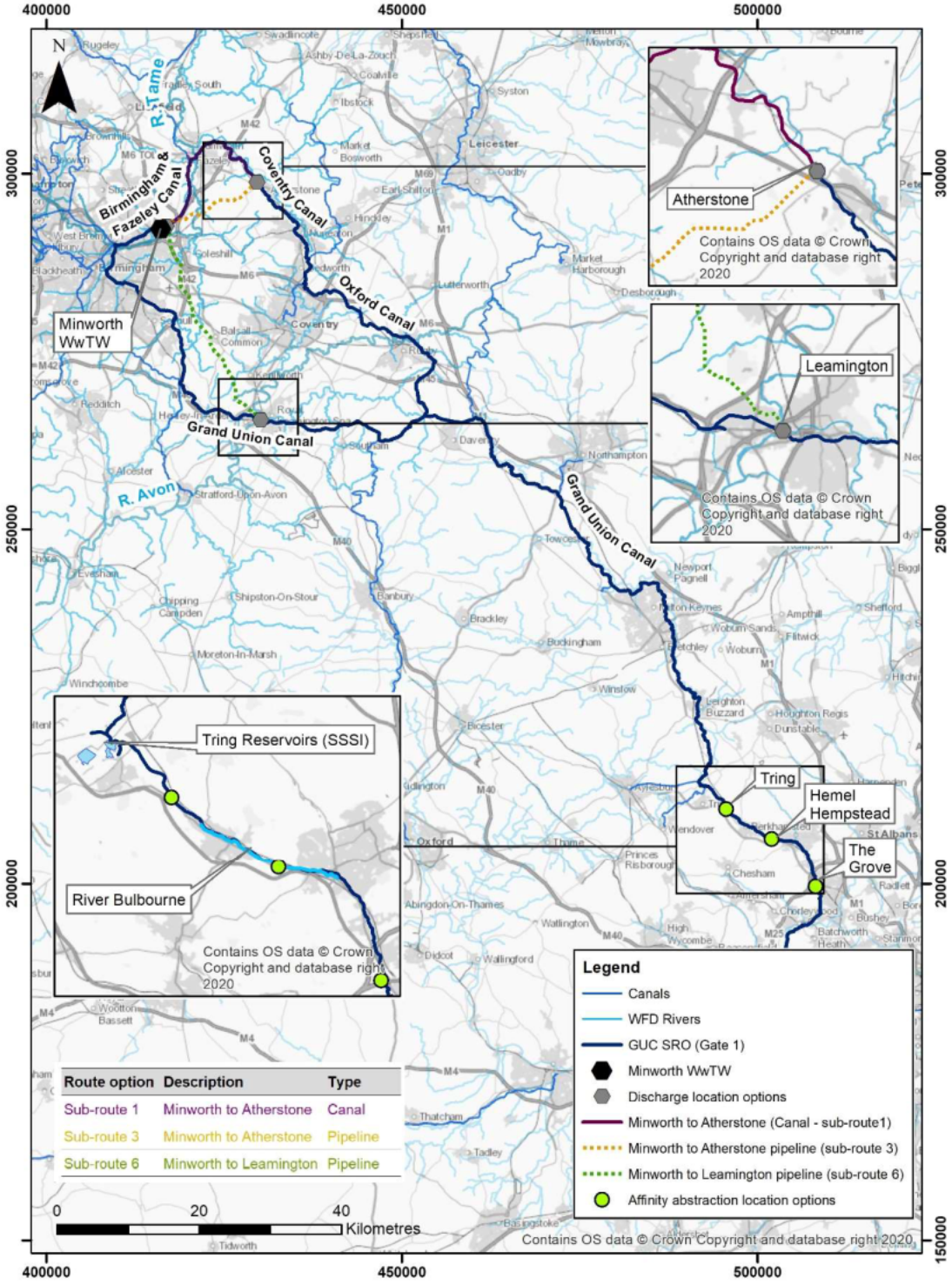

Figure 1.3 Proposed water transfer route (sub-route options 1, 3 and 6) (provided by Stantec)

1.7 Grand Union Canal and associated canal water bodies introduction

1.7.1 Grand Union Canal

The GUC is culturally significant – joining London and Birmingham with the main line comprising 137 miles in length and 158 locks. The GUC flows through Chiltern Hills, Northamptonshire, and Warwickshire. Construction began in 1793 after The Act of Parliament was passed and by 1805 it was fully open. Initially, it was not intended to be a single entity and rather consisted of several independent canals – largely the Leicester line and the GUC. However, these were merged between 1894 and 1929 and it received a new name: The GUC (the Trust, 2021a).

The primary purpose of development was to increase connectivity between Birmingham, the Midlands and London. However, the advancement of railways provided much competition for the canal system, which was too narrow for large boats and a slower form of transportation. Many construction efforts took place to keep the GUC alive, including back-pumping to improve flow and the replacement of narrow locks to accommodate larger boats. The government financially supported these endeavours, which also helped to decrease unemployment during the Great Depression in the 1930s (the Trust, 2021a; London Canal Museum, 2021).

The GUC was greatly used for commerce and was one of the last canals in Britain allowing commercial traffic. However, upon the development and expansion of roads, canal commercial traffic ceased (London Canal Museum, 2021). Today the GUC is enjoyed by leisure boats, walkers, cyclists, kayakers and anglers, to name a few.

1.7.2 Oxford Canal

The Oxford Canal is 75 miles in length with 46 locks traveling from Oxford city to Coventry. It was opened in sections between 1774 to 1790 and is one of the earliest in the canal age. It was developed to interlink the Thames, Mersey, Trent and Severn rivers. It was a busy route as it provided a connection to London; however, with the creation of the Grand Junction Canal (later becoming the GUC), the Oxford Canal became less trafficked. This is because the Grand Junction Canal bypassed the southern portion of the Oxford Canal (the Trust, 2021b).

1.7.3 Coventry Canal

The Coventry Canal is 38 miles in length with 13 locks joining the Trent & Mersey Canal in the North with the Oxford Canal in the South. It was opened in 1790 with the purpose of transporting coal from the Warwickshire coalfields. The Coventry Canal was nearly built over; however, it endured largely due to local support. It is now primarily used by leisure boats (the Trust, 2021c).

1.7.4 Birmingham & Fazeley Canal

The Birmingham & Fazeley Canal is 15 miles in length comprising 38 locks. It links the Coventry Canal to the city of Birmingham and opened in 1799. In the 1980s, the canal underwent renovations, such as increased access points and paved walking and cycling paths. This caused increased local usage as it passes through many Birmingham landmarks (the Trust, 2021d).

1.7.5 Overview of the proposed route

A map of the Trust's network and associated hydrological response units (HRUs - the unit by which the Trust split the canal network to manage water resources more effectively and help with strategic analysis, and which are defined as waterways that are supplied from the same water sources. See work topic 3) is shown in Figure 1.4 with HRUs related to the GUC Strategic Transfer labelled. Moving from north to south, the HRUs and their associated types are:

- Birmingham Canal Navigation – reservoir / groundwater / feeder supported

- Oxford and Grand Union Canals (Ox&GUC) – reservoir / groundwater / feeder supported;
- Grand Union Tring (GUT) - reservoir / groundwater / feeder supported; and
- Grand Union South (GUS) – river navigation.

The topography of the GUC from Camp Hill Locks to Brentford is presented in Figure 1.5 for the 'western' route sub-option along with the delineation of the Oxford Grand Union, Grand Union Tring and Grand Union South. This has been included to illustrate how the canal interacts with the landscape and to give context to how canal systems behave differently to rivers (river systems more typically being appraised in aquatic ecological assessments such as this). Of note are summits at Braunston (at which point the canal passes through Braunston tunnel) and Tring. Also noted is the profile of the canal from the summit at Tring to the Thames at Brentford which is more akin to a natural river elevation profile, where controls on flow are governed less by lockage and more by interactions with river systems.

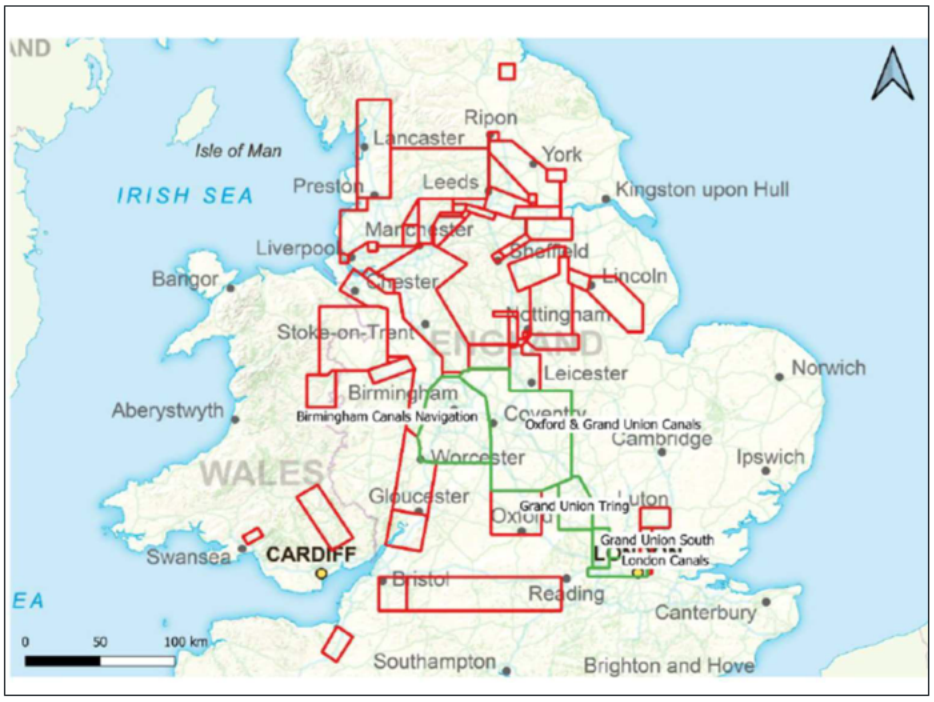

Figure 1.4 **The Trust Hydrological Response Units (HRUs) with those relevant to the GUC highlighted in green and labelled for reference. Reproduced from JBA (2020)**

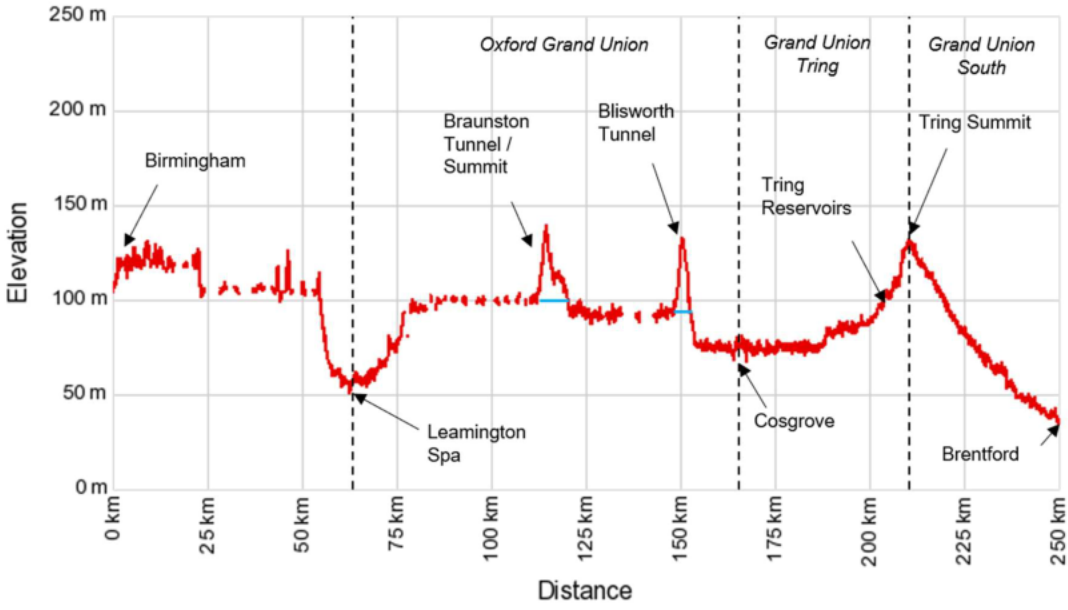

Figure 1.5 **Elevation profile of the 'western' route sub-option for the GUC Strategic Transfer scheme from Birmingham to Brentford ('eastern' route sub-option not available at time of writing)**

2 Work Package 1 - Legislation

Work Package 1 relates to legislation relevant to the proposed SRO; it contains only one work topic, which aims to identify environmental policy and legislation relating to canals that should be considered in relation to the transfer scheme.

2.1 Work topic 1 - legislation

Topic 1: Identify environmental policy and legislation relating to canals that may need to be considered for the transfer scheme.

Reason: To ensure that the SRO project team has visibility of the policies and legislation that would apply to a canal transfer scheme and any legislation that could conflict with the aims and objectives of the transfer. The study should identify what permits / consents would be needed in the discharge, transfer and abstraction of water through the system and identify any additional studies or evidence that would be needed to meet their requirements.

2.1.1 Summary

The permits and consents that would be needed in the discharge, transfer and abstraction of water through the canal system have been outlined, and the key legislative bodies identified.

The Trust holds the guardianship of 2,000 miles of canals, rivers and reservoirs in England and Wales. The legislative duties, powers and liabilities of the Trust were transferred from British Waterways in 2012 via the British Waterways board (transfer of functions) order 2012. The Trust will ensure their responsibilities are met through their position on PMB.

Legislation relevant to canals is largely the same as standard legislation covering river water bodies, although application of the legislation may vary (e.g. WFD). While the normal application process applies for discharge consent and abstraction licensing.

Key considerations regarding environmental policy include:

- Environment Bill and future legislative change
    - The Environment Bill sets out environmental legislation aimed at filling the governance gap created by Brexit and a new framework for environmental law post-Brexit. The Bill had the first day of its Report Stage on Tuesday 26 January 2021, where amendments can be made to the Bill at Report Stage.
- Any development associated with abstraction and discharge may be included in either Schedule 1 or 2 of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) 1999 (SI 1999 No. 293). Some cross-policy considerations arise between key pieces of policy/ legislation in relation to the need to secure water resources and adapt to climate change and the need to prevent the spread of INNS and protect aquatic and terrestrial ecosystems.

2.1.2 Recommendations

Recommendations outlined for work topic 1 are summarised in Table 2.1.

Table 2.1 Topic 1 recommendations

Knowledge / information gap	Recommendation	Sequencing
Future legislative changes – incl. Environment Bill.	Monitoring of future legislative changes and the resultant impact on GUC transfer scheme as applicable.	Ongoing
Application of environmental legislation	Early liaison with regulators on their interpretation and application of the finer details of all relevant environmental legislation to ensure the needs of all relevant legislation are met.	Ongoing

3 Work Package 2 - Pathways

Work Package 2 relates to 'pathways' – a mechanism or series of interactions that results in an impact upon a receptor. The pathways assessed under Work Package 2 include hydrology, water quality and geomorphology, including the WFD.

Work Topic 2 aimed to identify the surface and groundwater bodies that interact with the canal along the transfer route and capture baseline information on current ecology status. Where available, this information was taken through to inform subsequent work topics, which aim to characterise the hydrology, geomorphology, and water quality elements of the canal environment, within the context of the proposed transfer scheme.

The following work topics are included within Work Package 2:

- Work Topic 2 – Identification of waterbodies;
- Work Topic 3 – Canal performance in flood and drought;
- Work Topic 4 – Water quality and microbiology;
- Work Topic 5 – Catchment run-off and ingress; and
- Work Topic 6 – Sediment dynamics.

3.1 Work topic 2 - identification of water bodies

Topic 2: Identify the surface and groundwater bodies that interact with the canal along the transfer route and capture baseline information on current ecology status.

Reason: To produce a common baseline dataset that the project team can use to inform future impact assessments and potential mitigation measure.

3.1.1 Summary

Surface and groundwater bodies that interact with the GUC along the transfer route were identified using geospatial data. These water bodies were limited to catchments which are directly transected by the proposed GUC Strategic Transfer route and WFD canal water bodies which represent those that would potentially be used for the proposed transfer.

Using flood risk extent data, it was determined that most of the 64 surface water bodies identified are assumed to be connected with the GUC, at least during flood events – see Table 3.1. Furthermore, an assessment of the Trust's and JBA's (who are building a hydraulic and hydrological model to cover the extent of the GUC Strategic Transfer) GUC schematic data determined direct connectivity for a large number of surface water bodies; most notably the chalk streams of Hertfordshire – see Figure 3.1 and Figure 3.2. On the whole, information pertaining to the connectivity and mechanics of connectivity of the GUC, in relation to other surface water bodies, was relatively sparse.

Table 3.1 Summary of surface water body connectivity assessment results.

Connectivity classification	Count of surface waterbodies
Assumed connectivity	36
Confirmed connectivity	26
No evidence to reject connectivity	2

Although the paucity of information available means other waterbodies cannot be discounted outright, stakeholder engagement enabled identification of several key surface water bodies; the rivers Blythe, Ouzel, Tove, Bulbourne (chalk stream), Gade (chalk stream), Chess (chalk stream) and Colne (chalk stream) were deemed of note. In particular the chalk streams were considered to have potential sensitivity to the proposed GUC Strategic Transfer (work topic 8; see Section 4.2.1), and thus these water bodies have been given additional consideration more widely throughout the review and gap analysis.

There is a need to better understand connectivity between the canal network and surface water bodies (see Table 3.2), and requirements for further investigation should be reappraised following parallel and Gate 2 hydrological assessments that are likely to identify any further significant connectivity associated with the proposed GUC Strategic Transfer and whether this connectivity would be affected by the proposed SRO or otherwise.

Similarly, evidence pertaining to the connectivity between the canal network and neighbouring groundwater bodies was limited to considerations in the vicinity of the River Bulbourne (see work topic 3 appendix). There is a need to better understand connectivity between the canal network and groundwater bodies, and therefore further investigation may be required following parallel/ Gate 2 hydrological assessments that may identify any further significant groundwater connectivity associated with the proposed GUC Strategic Transfer.

Baseline information on current ecology status was captured in the form of WFD classifications and Reasons for Not Achieving Good Status (RNAGs) and is reported on within work topic 7.

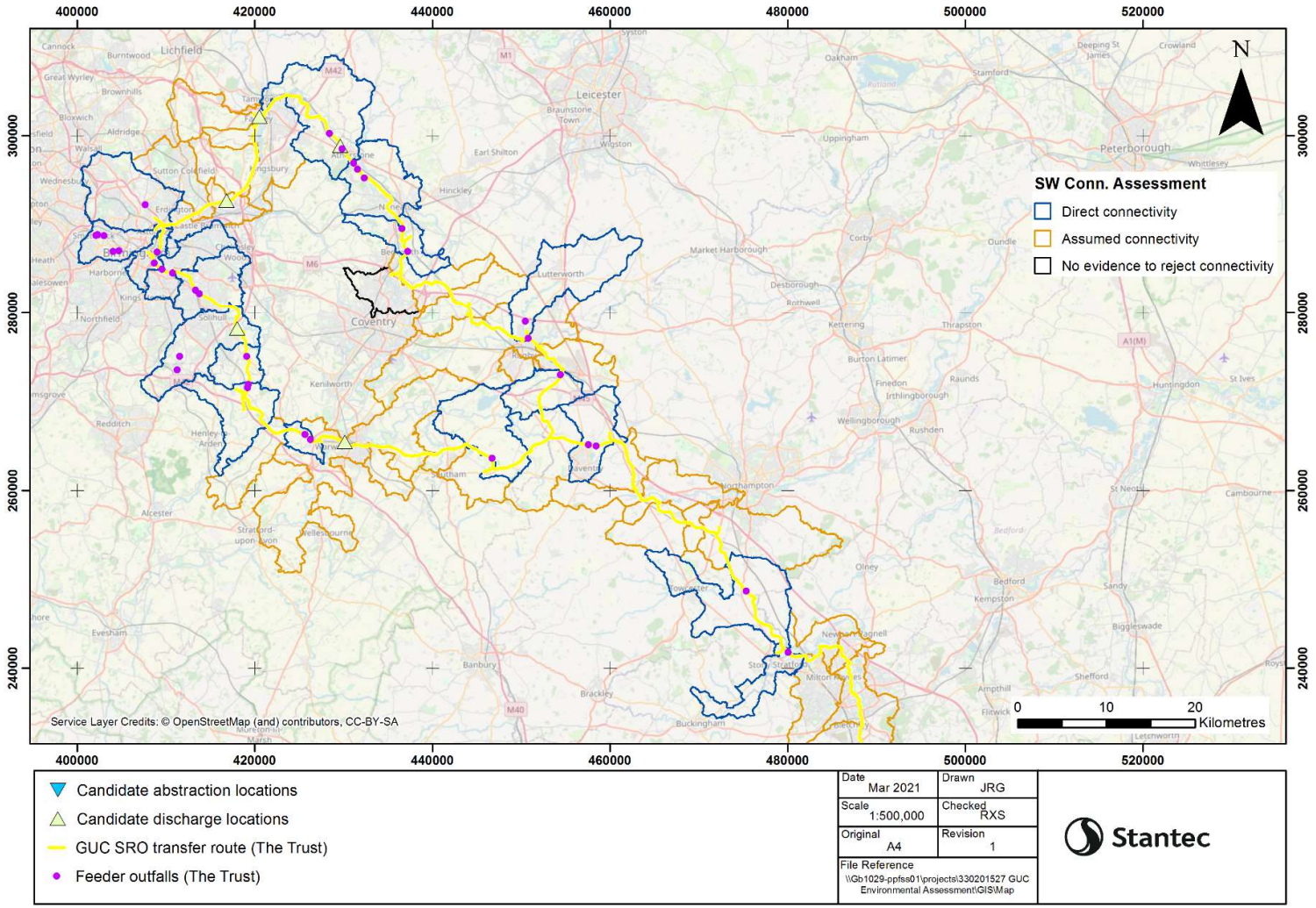

Figure 3.1 GUC and WFD surface water (SW) connectivity assessment, Birmingham to Milton Keynes

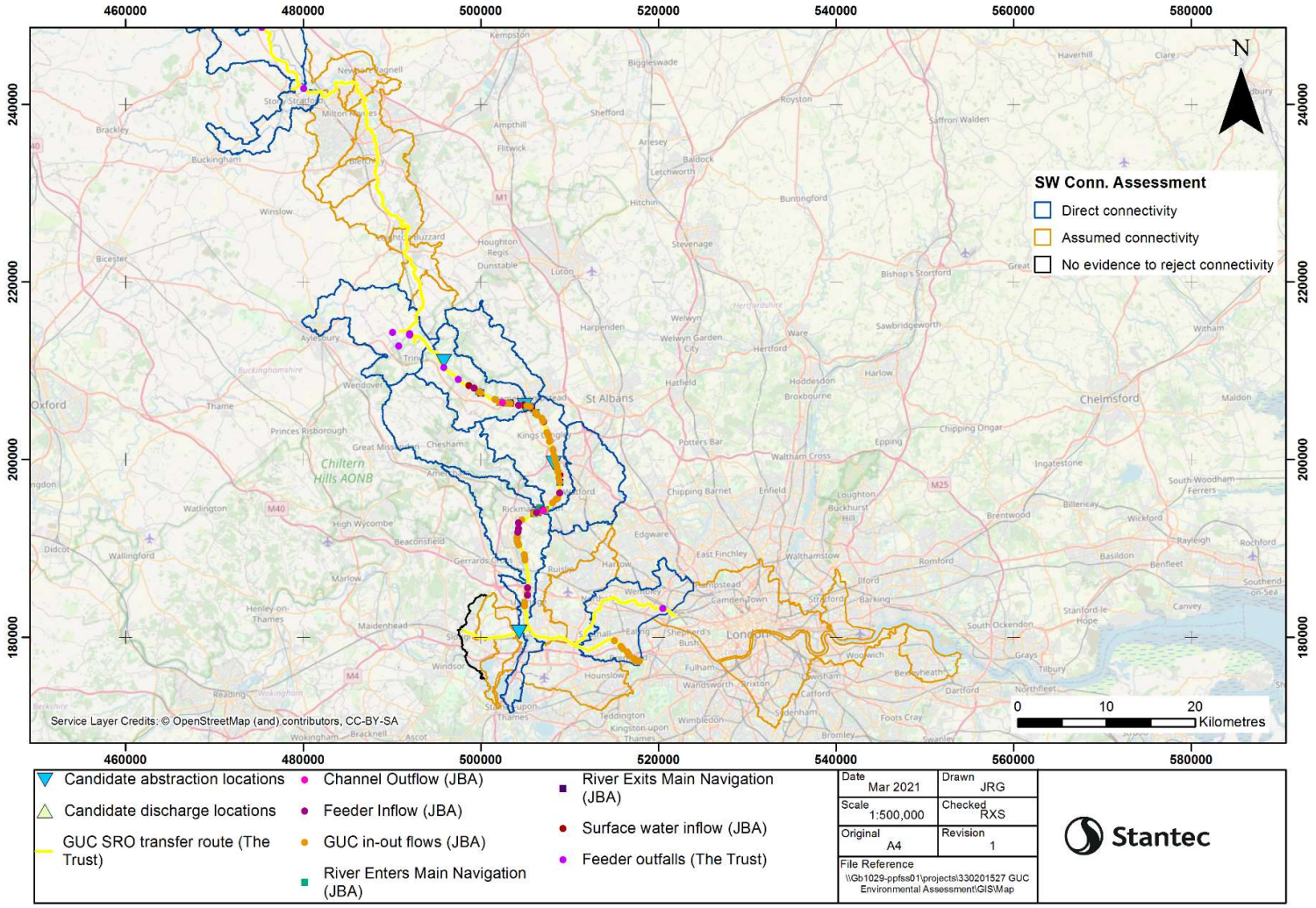

Figure 3.2 GUC and WFD surface water (SW) connectivity assessment, Milton Keynes to London

3.1.2 Recommendations

Recommendations outlined for work topic 2 are summarised in Table 3.2.

Table 3.2 Topic 2 recommendations

Knowledge / information gap	Recommendation	Sequencing
Requirement to better understand canal and surface water body connectivity	There is a need to better understand the degree of connectivity of those surface water bodies assessed as having 'confirmed' connectivity, and whether these water bodies need to be scoped into future environmental work. This should be reappraised following parallel Gate 1 and Gate 2 hydrological assessments that should quantify significant connectivity as well as inform whether this connectivity would be affected by the proposed SRO or otherwise.	Gate 2 (dependent on whether Gate 1/ 2 hydrological assessment identifies a need)
Requirement to better understand canal and groundwater body connectivity	There is a need to better understand connectivity between the canal network and groundwater bodies, and therefore further investigation may be required following parallel Gate 1 and Gate 2 hydrological assessments that may identify any further significant groundwater connectivity associated with the proposed SRO.	Gate 2 (dependent on whether Gate 1/ 2 hydrological assessment identifies a need)

3.2 Work topic 3 - canal performance in flood and drought

Topic 3: Understand the historical use of the GUC and how it performs under flood and drought conditions.

Reason: To ensure that performance of the canal system is understood and can be used to inform any future impact assessment. The study should seek to understand how the Trust operate the canal under drought and flood conditions, the normal maintenance regime and any implications for the water transfer option under severe water resource conditions.

Please note that the outputs for this work topic are primarily informed by the parallel modelling workstream undertaken by JBA. As a parallel project, the outputs used were not finalised at the time of writing this report. Therefore, this topic summarises the current (at time of writing) understanding for modelling, but this may be superseded by the final modelling outputs. For full detail on the modelling workstream please refer to the modelling report/ technical annex by JBA. Nevertheless, work topic 3 is important within the context of this literature review as gaps in hydrological knowledge are fundamental to gaps in understanding possible consequences of the strategic transfer to ecological receptors.

3.2.1 Summary

The operation of the GUC and its interactions with adjoining watercourses and aquifers are, in places, highly complex. This is being addressed by comprehensive hydraulic and Aquator water resources modelling, which, when complete, will provide powerful tools to further investigate the effect of the proposed GUC Strategic Transfer – although given the complexity of the system, uncertainties will inevitably remain in Gate 1 and the project team will look to address these as the SRO progresses through to Gate 2.

Operation and behaviour of the GUC during drought and flood periods is well understood. In recent history there have been no closures due to drought during the main boating season (spring to summer) in hydrological units covered by the water transfer route, and no drought restrictions at all within the Birmingham Canal Navigations. The Trust's data suggest this is definitely the case as far back as the turn of this century. There may have been problems in the 90's (the Trust / APEM, pers.comm 19/02/21), which led to the installation of temporary pumping schemes in some places that have since become permanent. As such, and going back further in time there may have been drought closures, however the water resources systems have evolved over time, in addition boating demands have changed over a longer period too. The annual profile of commercial traffic would have been flatter (i.e. more consistent all year round) compared to the lockage profile provided – where demands are concentrated in summer months.

Although there have been no closures during the main boating season, restrictions due to drought have been in place on the Ox&GU (Figure 3.3 and Section 1.7.5) canal in recent years (summer 2011, early spring 2012, 2018 and 2019). There have also been winter drought closures. During drought periods, the Trust has historically restricted boat movements on the GUT, particularly due to water shortages at the summit level.

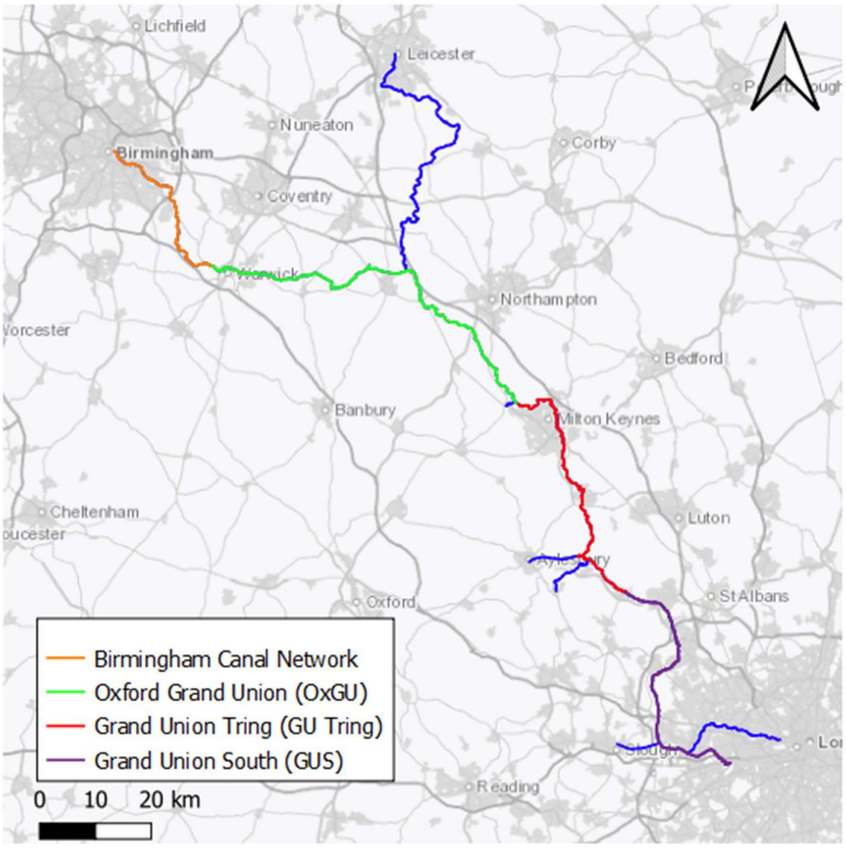

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Figure 3.3 Simplified map of GUC hydrological response units

Interaction between the canal and local watercourses (particularly where the canal merges with rivers to form navigation routes, i.e. Rivers Bulbourne and Gade) can lead to connectivity of watercourses during flood conditions. Most of the fluvial flood risk interaction with the GUC is focused in the GUS reach of the canal, between Tring and Brentford.

Specific to the GUC Strategic Transfer, transfer of water from Minworth to London is highly dependent on the topography of the GUC. As canals cross landscape features, rather than follow an upstream-downstream course, gravity flow is not possible for the entire route; rather, flow is dependent on pumping and an array of different sources in strategic locations. [redacted] The Trust (2020) update to the Water Resources Strategy identifies the Water Act (2003) as a significant pressure with the potential to reduce water availability into the future. [redacted] to restrict the quantities of water that may be extracted, and hence water resource availability within the GUC system is subject to uncertainty.

The proposed GUC Strategic Transfer will represent a change to hydrological pathways throughout the GUC system due to the change in distribution of inflow and outflow volumes along the route of the proposed transfer. Water resources modelling should be extended therefore to consider specific questions such as whether increased inflows change the hydrological pathways regarding where water is supplied from and in what volumes (where inflows are controlled from impounding or pumped storage reservoirs). Work should also

consider whether the balance of water between HRUs is significantly changed under the GUC Strategic Transfer. Once complete, model interrogation should assist in characterising the change in reservoir levels and spill regime from waste weirs to local watercourses between baseline and the SRO for a range of drought and flood years. This will assist in understanding how hydrological pathways change under the SRO and aid in assessment of impacts on water quality and ecological receptors.

Within the GUT and GUS HRUs, the GUC Strategic Transfer also has the potential to positively affect both management of the Tring reservoir group and change the abstraction regime from the Cowroast and Northchurch boreholes, with subsequent effects on groundwater levels within the Bulbourne catchment. For example, preliminary scenario testing indicates potential benefits to reservoir levels within the Tring reservoir group and this could facilitate draw-down targets associated with the SSSI status of these reservoirs (see work topic 8).

3.2.2 Recommendations

Recommendations for work topic 3 are summarised in Table 3.3.

Table 3.3 Topic 3 recommendations

Knowledge / information gap	Recommendation	Sequencing
How applications for abstraction licences under the Water Act (2003) may change the water resources situation within the GUC	PMB to discuss with the Trust to understand any likely variations to abstraction licenses within the GUC HRUs and to account for this within future water resources modelling scenarios related to the SRO.	Gate 2 (dependent on processing and finalisation of applications)
How hydrological/ hydromorphological pathways change between baseline and scheme conditions	Once water resources modelling is finalised, characterisation of change between baseline and scheme reservoir levels, pound hydromorphology and spill regimes and subsequent impact on connected water bodies across the flow regime should be assessed. Detailed assessment of potential pass-forward benefits to resources between Canal HRUs.	Gate 2
How proposed SRO might affect abstraction regime at Cowroast and Northchurch boreholes and hence impacts on the Bulbourne water body	Once water resources modelling is sufficiently progressed, detailed assessment of how the scheme might affect abstraction rates at Cowroast and Northchurch and whether this might confer benefit to groundwater levels in the Bulbourne catchment, should be assessed.	Gate 2 (dependent on line two recommendation)
How proposed SRO might affect canal management at Tring	Once hydrological work is sufficiently progressed, detailed assessment of how the scheme might affect water resource at Tring, and whether this might confer benefit to reservoir level management, should be assessed.	Gate 2 (dependent on line two recommendation)
Extent (if any) to which changing canal flows will affect flooding extents	Review results of future scheme specific water resources modelling and Flood Risk Assessments (FRA).	Gate 2 (dependent on line two recommendation)

3.3 Work topic 4 - water quality and microbiology

Topic 4: Identification of relationships between canal sediment loading, microbiology, and water quality impacts on receiving canals / watercourses.

Reason: There are still outstanding concerns relating to transfers where donor and receiving water courses have different quality and microbiology populations. Sediment loadings from canal conveyance is another outstanding concern. We need to understand how existing microbiology and ecology is impacted by GUC water quality and sediment load, how potential changes could impact on existing ecology and whether changes could create new pathways for migratory species. An improved understanding would help target mitigation techniques (where required) and transfer scheme specific risk assessments. Canals can provide important supportive habitats for numerous species.

3.3.1 Summary

The baseline water quality of the entire GUC is not well understood. There is currently an absence of water quality and chemical data as there has been very little WFD monitoring for these components, including a lack of measurements for physico-chemical supporting elements for ecological assessment. There is also a paucity of literature available for the water quality of the GUC. In-canal water quality data collected by the Environment Agency are highly limited and no data available for canal sediment quality. Currently, the proposed scheme is not well enough understood for consideration of water quality changes that may occur throughout the proposed transfer route to be made. Furthermore, insufficient data are available for a WFD assessment (although ongoing sampling being carried out on behalf of the PMB will ensure a dataset that allows for WFD compliant assessment). A detailed water quality modelling study will be necessary to understand how changes in flow may impact water quality as well as to determine WFD condition status; both in canal water bodies and within receiving water bodies that are directly hydrologically connected.

The proposed GUC Strategic Transfer could impact the concentration of dissolved oxygen (DO) in the GUC by additional inputs of Biochemical Oxygen Demand (BOD) and total ammonia. Treatment would be installed prior to any transfer of the discharge. The Minworth WwTW discharge would adhere to discharge permit conditions so there would be mitigation in place to prevent issues with WFD standards and this will avoid a negative impact occurring to water quality. During transfers, the flow rate in the GUC will increase which could mobilise sediment in the channel (although this has not been established and is expected to be secondary to sediment mobilisation caused by boat traffic – see work topic 6). However, if there were a high sediment oxygen demand this would cause a reduction in the DO concentration.

The transfer of nitrate and phosphate could compromise the achievement of the Good Ecological Potential (GEP) in the GUC and Good Ecological Status (GES), under the WFD, in receiving water bodies. If phosphate exists in the sediment at high concentrations this may be remobilised due to chemical changes to water quality by the Minworth WwTW discharge. Elevated phosphate and nitrate concentrations are considered unlikely to increase the risk of algal blooms, as in-canal turbidity, a key driver of algal growth, is expected to primarily be associated with boat traffic. The Minworth WwTW discharge will be controlled to ensure that the concentrations of nitrate and phosphate meet stringent permit conditions, but further data is needed to understand the concentration of nutrient contained in the sediment in the canals. However, this is uncertain. Recommendations regarding turbidity are made under work topic 6, see Table 3.6.

The data for specific pollutants, priority substances and other pollutants that have been collected by the GUC PMB as part of Gate 1 activities since May 2020 are being analysed by APEM. This is an initial assessment of the potential for the GUC Strategic Transfer to affect water quality in the northern part of the GUC, where the potential discharge locations are sited. The initial findings based on a high-level assessment show that some substances are present in the GUC at low concentrations, but some are either close to or already exceeding the WFD EQS. This is a preliminary finding from the Grand Union Canal Water Quality Phase 1 Assessment (unpublished). The analysis shows the GUC Strategic Transfer may dilute concentrations of some substances leading to potential improvements in water quality. If the GUC Strategic Transfer is predicted to

cause an EQS exceedance, or an increase that is not acceptable to the Environment Agency, further investigations will be carried out in Gate 2. The outcomes of further investigation will inform any treatment needs at Minworth WwTW to ensure the concentrations do not cause an unacceptable impact. The source of any elevated substances already present in the GUC is unknown.

3.3.2 Recommendations

Recommendations for work topic 4 are summarised in Table 3.4

Table 3.4 Topic 4 and 5 recommendations

Knowledge / information gap	Recommendation	Sequencing
Minworth WwTW discharge requirements	High-level assessment to understand the potential for effect on WFD status at the potential discharge locations on the GUC	In progress
Water quality monitoring	Current monitoring of water quality should continue for a longer period to build up a good dataset over several seasons. A minimum of 12 monthly samples taken throughout the year will be needed to assess the concentrations of hazardous substances against EQS. The Environment Agency will require evidence that the transfer will not lead to deterioration in WFD status over time.	In progress
Detailed water quality modelling	Once the hydrology of the transfer has been modelled in more detail, and sufficient baseline water quality data have been collected, this will need to be applied to sophisticated water quality modelling to better understand risk beyond immediate discharge points and to allow for inclusion of other sources of inputs (e.g. from diffuse runoff).	Gate 2 (dependent on timing of hydrological modelling outputs and collection sufficient baseline water quality data)
Sediment quality	We recommend that the monitoring programme should be extended to include the collection of sediment quality data in the canals. Sediment quality should be sampled once at the locations close to existing water quality sampling sites, but where the sediment is deepest as this is where the levels of contamination are likely to be the highest.	Gate 2
Modelling of in-canal *in situ* processes	Modelling should investigate if it is possible that changes would occur in water quality and sediment quality, including from the transfer and while the water is 'held' in sections of the canal (i.e. canal pounds). This includes process such as breakdown, dilution, precipitation and remobilisation from sediment. Associated sampling of sediment would be required.	Gate 2 (dependent on detailed WQ modelling recommendation)
Microbiology	Should modelling indicate risk regarding increases in nutrients in canal sections with low levels of boat traffic further appraisal of potential effects on microbiology may be required.	Gate 2 (dependent on detailed WQ modelling recommendation)

Knowledge / information gap	Recommendation	Sequencing
Water quality monitoring programme	It is recommended that the monitoring programme reflects the outcome of an assessment being carried out by APEM and it is streamlined to only include parameters flagged as likely to cause EQS exceedance or a breach of the standstill policy. The high-level assessment is for the northern canal sites and Minworth WwTW at this stage but should be extended to include the rest of the GUC.	Gate 2
Water quality monitoring programme	We recommend that the source water that supplies the canals is monitored for the same parameters as the GUC PMB monitoring programme. The source water in addition to the transfer water from Minworth WwTW will need to be included in any detailed modelling.	Post Gate 2 (dependent on outcomes of Gate 1/ 2 hydrological workstreams and decisions regarding the mechanics of the transfer (see Section 3.2.1))
WFD Water quality assessments	WFD assessment of the water bodies identified as in direct hydrological connectively with the GUC, to assess WFD risks (but caveat of legislation topic findings)	Post Gate 2 (dependent on outcomes of recommendations made above)

3.4 Work topic 5 - catchment run-off and ingress

Topic 5: Review the potential water quality impacts of catchment runoff and ingress along the route of the transfer.

Reason: To improve understanding of the wider water quality catchment risks to water quality to the transfer scheme. The outputs will be used by the SRO project team to inform water quality risk assessments and treatment design.

3.4.1 Summary

The potential water quality impacts of catchment runoff and ingress along the route of the transfer were reviewed.

The review concentrated on the influence of the surface water catchment owing to the lack of understanding on connectivity between ground water and the proposed GUC Strategic Transfer route. The potential of water ingress to the canal was classified at WFD river water body scale. A high-level review of river and canal water quality, with particular focus on the most ecologically relevant physico-chemical classification elements, was undertaken with reference to the relevant WFD classification for analysed determinands. A further pathway for water to enter the proposed GUC Strategic Transfer route may be via urban surface water drains, such as road drainage; however, there was limited information available to the review on the location of these and their outfalls, although this may change with the development of the Drainage and Wastewater Management Plans.

There is a current lack of Environment Agency canal water quality data. To facilitate a comparative analysis, and thus the risk intersecting water bodies pose on the canal, a parallel work stream is collecting water quality data throughout the canal system and outputs will enable a more through spatial assessment. Also, parallel ecological monitoring work has indicated improved biological diversity within the highly interconnected reaches of the GUC with chalk streams in Hertfordshire, and it is possible that this reflects improved canal water quality attributable to this connectivity. However, regarding the surface water bodies that overlap with the proposed GUC Strategic Transfer route, some spatial trends in water quality were identified around urbanised area (see Figure 3.4 and Figure 3.5) as well as interaction with chalk streams and potentially aquifers.

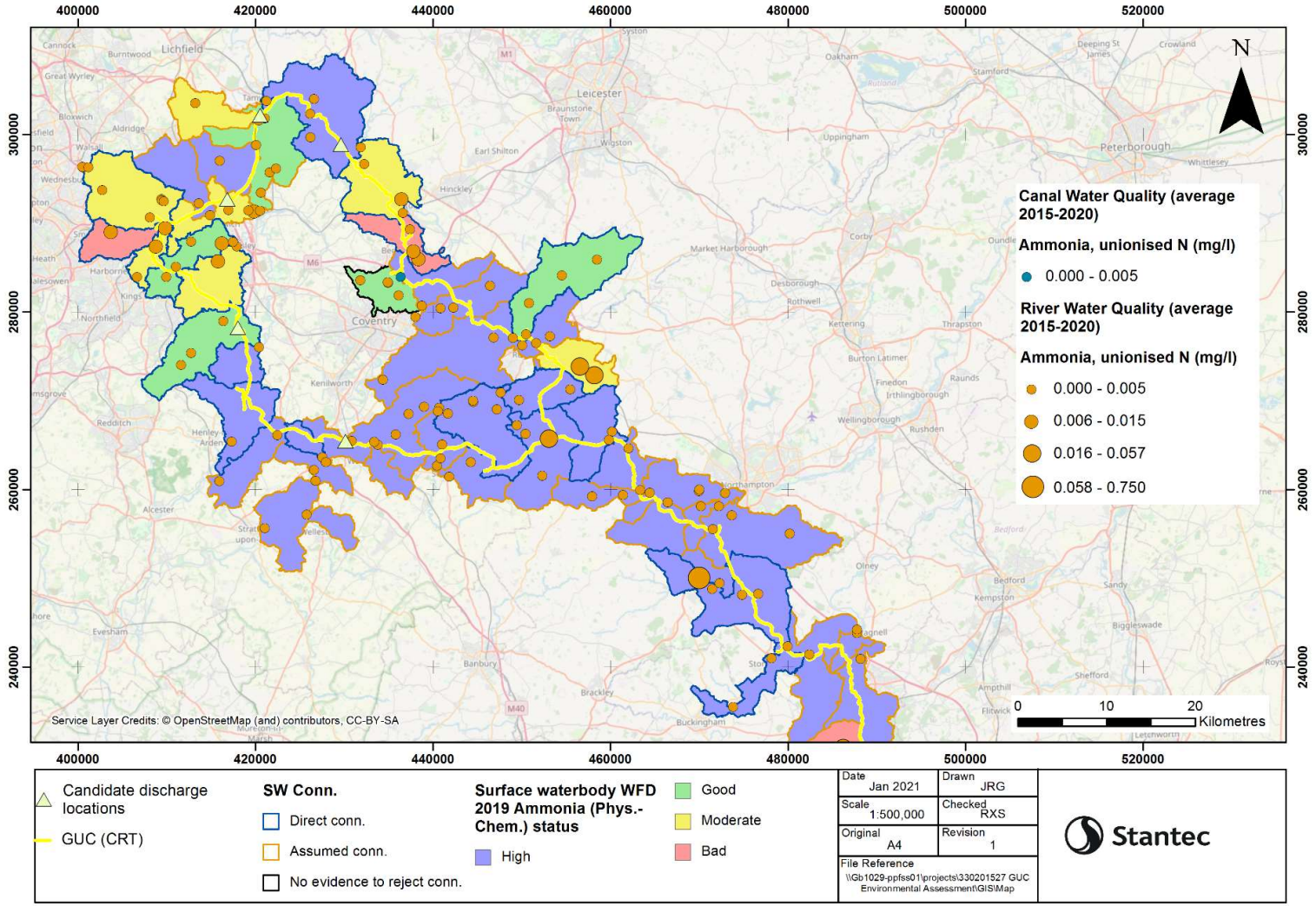

Figure 3.4 Surface water body WFD ammonia Classification (2019) and an indication of water quality trend, Birmingham to Milton Keynes

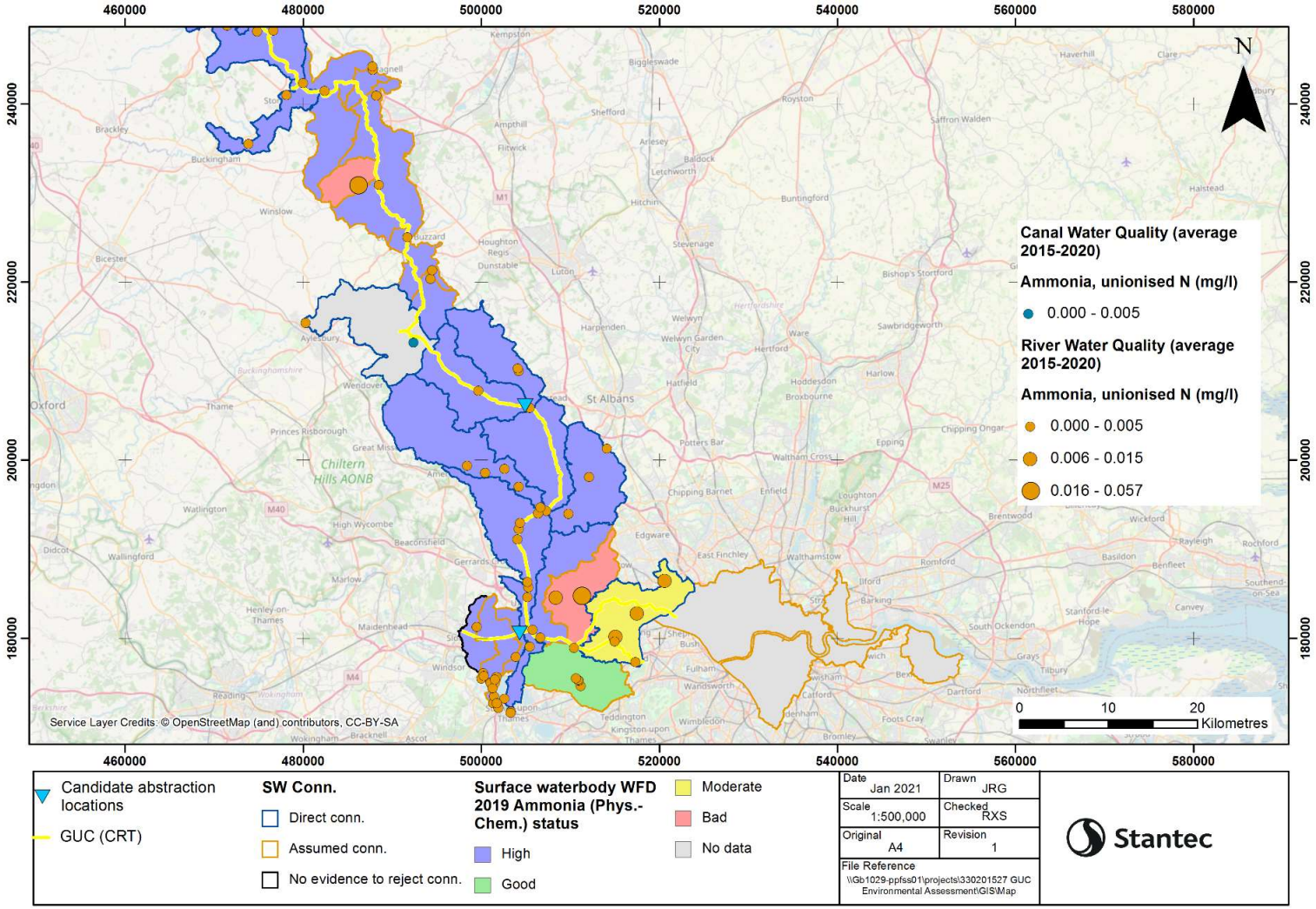

Figure 3.5 Surface water body WFD ammonia Classification (2019) and an indication of water quality trend, Milton Keynes to London

3.4.2 Recommendations

More detailed information being developed through parallel workstreams (water quality monitoring and hydrological work) will provide further information to support future assessments. Particularly, parallel spatial information on canal water quality will enable a better understanding of the risks posed by intersecting water bodies. Ongoing hydrological monitoring and modelling of the GUC network will facilitate a broader understanding of the inflows to and from the GUC system, either through connecting rivers, flooding and baseflow, to determine the interaction with both surface and groundwater systems.

Key recommendations to fill the most important information gaps for work topic 5 are summarised in Table 3.5.

Table 3.5 Topic 5 recommendations

Knowledge / information gap	Recommendation	Sequencing
Detailed water quality modelling (this is as per the second recommendation made in Table 3.4 for work topic 4)	Once the hydrology of the transfer has been modelled in more detail, this will need to be applied to sophisticated water quality modelling to better understand risk beyond immediate discharge points and to allow for inclusion of other sources of inputs (e.g. from diffuse runoff).	Gate 2
Baseline status of priority substances/ hazardous substances has not been reviewed in detail.	Where the hydrological work stream confirms significant inputs to the GUC Strategic Transfer a desk study would be undertaken to identify which waterbodies warrant further investigation with regard to priority substances/ hazardous substances.	Gate 2 (and overlapping with work topic 4 Gate 2 recommendations)
Interaction between ground water and canal (this is as per the second recommendation made in Table 3.2 for work topic 2)	Drawing on outputs from hydrological modelling that indicate baseflow contribution, investigate impacts on canal water quality associated with ground water ingress.	Gate 2 (dependent on whether Gate 1/ 2 hydrological assessment identifies a need)

3.5 Work topic 6 - sediment dynamics

Topic 6: Review existing information on canal sediment dynamics and identify potential impacts of the transfer on the canal and associated water bodies.

Reason: To improve understanding of the sediment and water chemistry dynamics of the current system and the potential changes that could result from the introduction of Minworth effluent. The study should recommend any future new monitoring that might be required to plug gaps in knowledge. The outputs will be used by the SRO project team to inform any future impact assessments.

3.5.1 Summary

It is well known that the GUC interacts, at least to some degree, with a large number of natural water bodies by both receiving water from feeders and river inflows and exporting water to rivers via waste weirs (see work topics 2 and 3 for more details, Sections 3.1 and 3.2). This is particularly the case in the GUS where the rivers Gade, Bulbourne, Chess and Colne are inter-connected to the GUC to varying extents. In some places, the rivers Bulbourne and Gade become part of the canal and the connections between these rivers and the GUC present the greatest opportunity for sediment exchanges that may have existing impacts on the geomorphology and physical habitat of the natural river network.

However, the nature of any sediment transfers between water bodies at these locations has not been established in published literature. Moreover, studies that examine the processes responsible for sediment mobilisation in the GUC have not been identified. Literature regarding sediment dynamics and the impacts of flow transfers on other canals has not been identified or reviewed as it is unlikely to be of relevance to the GUC given the unique operation of different canal systems. As such, information regarding sediment dynamics on the GUC is limited, and all aspects of the canal's sediment system should be considered unknown. Importantly, this means that there is significant uncertainty regarding the baseline contribution of the GUC to the sediment load of associated water bodies, and there is no information on which to base an informed assessment of possible changes in sediment dynamics induced by the proposed water transfers. This is important given the sensitivity of connecting chalk streams which may receive increased sediment loads as a result of the proposed transfer.

Although there is generally limited information on the sediment dynamics of the GUC and the nature of sediment exchanges between the canal and connected water bodies is unknown, it seems unlikely that the proposed GUC Strategic Transfer will result in sufficiently large changes in the operation of the canal to substantially increase rates or volumes of sediment export from the canal to connected water bodies. As a result, the recommendations presented in Section 3.5.2 may not be required if it can be established from desk-based assessments that impacts on sediment dynamics are unlikely to occur. For instance, further information on the hydraulics of the GUC will be provided from modelling studies and can be used to assess sediment dynamics under baseline and proposed GUC Strategic Transfer operation.

3.5.2 Recommendations

Recommendations for work topic 6 are summarised in Table 3.6

Table 3.6 Topic 6 recommendations

Knowledge / information gap	Recommendation	Sequencing
Lack of information on processes responsible for sediment mobilisation	Assess the need for automatic monitoring (standard 15-minute monitoring frequency) of suspended sediment and flow at a small number of representative locations within the canal to determine the nature of the relationship between	Gate 2

	flow magnitude and suspended sediment concentration.	
Lack of information on sediment inputs and exports	Undertake continuous monitoring of suspended sediment and flow at key inputs and outputs to the canal to calculate a sediment budget for reaches of interest should the previous recommendation establish that the SRO may contribute to sediment mobilisation.	TBC (dependent on outcome of first item as well as parallel hydrological modelling work) – may not be required
Lack of information on sediment composition	Undertake canal bed sediment sampling to establish the size distribution of material currently stored within the canal.	Gate 2 (dependent on outcome of first item as well as parallel hydrological modelling work) – may not be required

4 Work Package 3 - Ecological Receptors

Work Package 3 relates to ecological 'receptors' – components of the canal environment and ecology have potential to be affected by the proposed transfer scheme. The receptors assessed under Work Package 3 relate to the ecology of the GUC, including INNS and WFD status.

The following work topics are included within Work Package 3:

- Work topic 7 – WFD status and RNAGS;
- Work topic 8 – Species and habitats of the canal (and receiving water bodies);
- Work topic 9 – Supporting habitats;
- Work topic 10 – Birds; and
- Work topic 11 –INNS.

4.1 Work topic 7 – Water Framework Directive status and Reasons for Not Achieving Good Status

Topic 7: Confirm existing WFD status and reasons for not achieving good status for the canal and the affected water bodies, using existing Environment Agency datasets.

Reason: To produce a common baseline dataset that the project team can use to identify the potential impacts of any future flow regime and water quality changes on WFD status in the associated water bodies. The study should also identify whether there is potential for any additional water bodies to be affected once the transfer is in place. The study should identify any new baseline monitoring data collection that would be needed by the SRO project team to satisfy WFD tests for RAPID's Gate 1 review.

4.1.1 Summary

Work topic 7 confirms existing WFD status and reasons for not achieving good status for the canal and the potentially affected water bodies. The GIS project (which comprises work topic 15) is a key deliverable for this work topic; baseline WFD status for the various supporting WFD supporting elements can be explored therein. Baseline information on current ecology status is summarised in the form of WFD classifications and Reasons for Not Achieving Good Status (RNAGs); however, Environment Agency monitoring data (both water quality and ecological data) for the study area is included within the project GIS database.

Although 2019 WFD classification status has been made available, the following points should be noted regarding the 2019 classifications:

- The Environment Agency has not released 2019 updates to the RNAG dataset with RNAGs to be updated in collaboration with local Catchment Partnerships. Pre-2019 RNAGs are readily available and are drawn upon for the baseline summary.

- Canal mitigation measures assessments are not available.

In summary, the majority of water bodies that are intersected or interact with the proposed GUC Strategic Transfer route are below Good status, see Table 4.1 and Table 4.2; water bodies have generally been notified for multiple Significant Water Management Issues (SWMIs).

Table 4.1 Overall WFD 2019 water body status classification count for those water bodies overlapping with the potential GUC Strategic Transfer route (identified in work topic 2)

Water body	Good	Moderate	Poor
Canal		17	
River		38	25
Groundwater	7		12

Table 4.2 Overall WFD 2019 water body status, ecological status and chemical status classification count for water bodies in assumed connectivity and direct connectivity with the potential GUC Strategic Transfer route; water bodies with no evidence to reduce connectivity were also included.

	Count of Overall water body classification	Count of Ecological water body classification	Count of chemical water body classification
Assumed connectivity			
Moderate	22	22	
Poor	13	13	
Fail			35
Direct connectivity			
Moderate	15	15	
Poor	11	11	
Fail			26
No evidence to reject connectivity			
Moderate	1	1	
Poor	1	1	
Fail			2

Canals are classified as artificial water bodies under the WFD and, consequently, have the less stringent objective of achieving GEP rather than GES. Assessment of the ecological potential of a canal has been outlined by SNIFFER (2012). However, it should be noted that the methods outlined in SNIFFER (2012) are not reflected within current UK Technical Advisory Group (UKTAG) guidance (UKTAG set out environmental standards and conditions to underpin the implementation of the WFD) and have not been put into practice in England. Canal water bodies are not currently monitored by the Environment Agency for ecological elements for WFD assessment (e.g. macroinvertebrates, macrophytes or fish). However, it is noted that the SNIFFER (2012) methods imply an aspiration for this to be the case, with, for example, methods for classification of ecological potential of macroinvertebrates and macrophytes developed for canals. Why these methods have not to date been taken up is unknown and requires follow-up with the relevant National Environment Agency

staff. It is considered likely that this may remain uncertain until legislative consequences of Brexit are further understood (see work topic 1).

It is also significant to note that under the 2019 WFD classifications (available via Catchment Data Explorer), many of the GUC canal waterbodies have seen a change in their Mitigation Measures Assessment, from 'Good' in all previous classifications, to 'Moderate or Less' for 2019. This is important, as in many cases this is the only ecological 'supporting element' – i.e. the Mitigation Measures Assessment drives the WFD ecological classification.

During the stakeholder workshops this theme was discussed. It was the consideration of Environment Agency staff that the designation of canal water bodies in 2009 likely resulted in Good status on the grounds that these are Artificial Water Bodies, and the use for boat traffic would have exempted the need for mitigation measures; i.e. the assessment of 'Supports Good' up until the 2019 classifications was essentially by default.

Information pertaining to mitigation measures assessment was requested; however, no information was received. Given the 2019 classifications it is apparent that this has been reappraised. Therefore, this remains a fundamental gap in understanding some of the needs of ecological appraisal going forwards. It is also important for work that seeks to understand possible mitigation/ benefits that could be put in place alongside the proposed GUC Strategic Transfer. Discussion with the Environment Agency and the Trust to establish the situation regarding the status of mitigation measure requirements is ongoing.

These outputs have been used to aid the formulation of recommendations under the various work topics that comprise this literature review and gap analysis; however, only limited recommendations are specified as a direct result of work topic 7 (which, primarily, has summarised the baseline status).

4.1.2 Recommendations

Recommendations for work topic 7 are summarised in Table 4.3

Table 4.3 Topic 7 recommendations

Knowledge / information gap	Recommendation	Sequencing
Baseline canal Mitigation Measures Assessments are currently not available; this limits the current understanding of how the canal water bodies are assessed under WFD.	It was noted in the summary presentation given for this project that the Environment Agency are currently in discussions with the Trust regarding what are feasible mitigation measures. It will be necessary to follow-up on mitigation measures, in relation to the proposed SRO, once these have been finalised. This is therefore an ongoing item. In the absence of knowing what these measures are there is currently no action other than to check/ understand them.	Ongoing
The need for clarity on how canal WFD water bodies will be assessed in the future.	SNIFFER (2012) includes methodology for the classification of canal water bodies based on many more metrics than are currently employed (i.e. in 2019 classifications). Clarification from the Environment Agency is required regarding the timescales for these methodologies to be put into practice, if at all (and presumably dependent on legislative processes post-Brexit).	Ongoing*

* Clarification on this point as part of the Environment Agency review of this document would be greatly appreciated.

4.2 Work topic 8 – species and habitats

Topic 8: Collate the current/baseline information and understanding of species and habitats that utilise the canal environment.

Reason: To improve understanding of the relationship between canals, canal habitats and any species. Identify whether any existing native species or habitats are protected. Include recommendations to fill any information gaps with a monitoring plan if required. To improve understanding of the potential impacts of changes in flow and water quality on native species and existing habitats, plus the potential for encouraging new migratory species, in order to inform any future impact assessment of the transfer.

4.2.1 Summary

Relevant literature and expert opinion were considered in order to outline possible effects and ecological risk factors associated with the proposed GUC Strategic Transfer. GIS screening identified protected sites (including designated sites, such as SSSIs and Local Nature Reserves) and species (with particular consideration of protected species made) in the canal reaches and river waterbodies of interest, and relevant data, literature, and reports were reviewed to identify any additional species and habitats.

The fundamental gap in knowledge with regards to ecological receptors relates to the current absence of understanding of how the proposed GUC Strategic Transfer would affect ecology as a result of the interactions, influence and relative importance of possible change in water quality, water quantity, and flow in canal water bodies and connecting river water bodies. There is a requirement for the relative scale of change in water quality, water quantity and flow to be better understood, so that it is possible to outline any subsequent impacts to the species and habitats concerned with any confidence.

At its southern reaches in the south east of England (Buckinghamshire, Hertfordshire and Greater London), the GUC interacts with several critically import chalk streams; the River Bulbourne, River Gade, River Chess and River Colne. Due to this high level of connectivity, it is possible that changes in water quality, water chemistry, and water quantity and flow within the GUC may translate to notable change within the neighbouring chalk stream systems; however, the scale of such change is unknown (as highlighted in the above paragraph). Chalk streams are of note for their base-loving *Ranunculus penicillatus ssp. pseudofluitans-Callitriche obtusangula* macrophyte communities (Hatton-Ellis & Grieve, 2003); however, the macrophyte communities of river reaches downstream of river/ canal confluences are generally less well characterised, and macrophyte data relating to these reaches is relatively sparse (both temporally and spatially). There is greater availability of macroinvertebrate and fish monitoring data within these river reaches and therefore no further baseline monitoring of these ecological elements has been recommended[3].

Regarding protected species, the possibility that [redacted] could act as a refuge for white-clawed crayfish was raised as a key issue during stakeholder engagement (Environment Agency, *pers. comm.*). This indicates a possible risk, whereby much increased back-pumping up the summit, which may be required under the proposed SRO, could act as a vector for signal crayfish and/ or crayfish plague. Evidence as to whether this white-clawed crayfish population persists, alongside an assessment of the current distribution of signal crayfish within this reach of the canal, are key in informing possible future monitoring requirements regarding this protected species; however, data relating to these points is relatively limited.

[3] At the time of writing there is uncertainty as to whether or not additional baseline monitoring of fish is required in the River Gade. Liaison with the relevant area Environment Agency staff is ongoing, with a meeting scheduled for June 2021 to make a final determination.

Possible ecological and socio-economic benefits resulting from reduced incidence of drawdown at Tring Reservoirs SSSI have been highlighted. Currently, the Trust maintain navigation in the GUC at Tring, in part, via drawdown of Tring Reservoirs. This can result in opposing needs under the scenario where achieving drawdown regime targets in the Tring reservoirs and balancing navigation requirements both draw on the same source of water. The possibility of delivering both environmental and stakeholder benefits via reduction in drawdown events at Tring Reservoirs SSSI remains uncertain but is highlighted as a key point for further investigation.

Information specific to water quality and flow requirements of the fish species identified within the canal environment (based on Environment Agency and protected species records) is scarce. However, based on existing knowledge from other aquatic environments, it is considered that there are no significant gaps in knowledge relating to these species that are deemed to require further investigation at present. There are, however, the same uncertainties regarding the potential pathways of impact that might affect both protected and non-protected fish species, including eel, bullhead and their habitats. These species may require further assessment; however, modelling of potential water quality and hydromorphological effects is first required before reappraisal is made. Perch and bullhead would be expected to demonstrate the greatest sensitivity to any changes in temperature and/ or dissolved oxygen concentrations.

It should be noted than an ecological monitoring project has been undertaken on the GUC, and associated canal water bodies, as part of the Gate 1 process (n.b. this was a distinct monitoring project, conducted outside the scope of this literature review and gap analysis). The aim of the Gate 1 ecological monitoring programme was to:

- Undertake no-regrets ecological monitoring on the GUC and associated canal water bodies;
- And, in conjunction with this report, to inform future monitoring requirements on the GUC transfer route in relation to the GUC Strategic Transfer.

As part of the Gate 1 monitoring project, fish and chironomid data have been collected at a number of locations throughout the canal network in 2020. Given the paucity of historic data available, this monitoring programme has aimed to provide an improved understanding of the canal ecology, and to highlight canal reaches where ecological value may be significant. Most notably, monitoring data have identified the positive effect of river/ canal confluence on canal species diversity. The Gate 1 monitoring project has identified key ecological monitoring techniques, including Canal CPET, and has provided recommendations for ecological monitoring requirements under Gate 2. Recommendations made as part of the Gate 1 monitoring project are further detailed under Section 6 and Table 6.2.

Continued use of CPET has been recommended as a biological indicator in the establishment of a baseline dataset for the canal environment. Use of CPET is not intended to replace methods that might be used to characterise the full macroinvertebrate community of the canal environment; rather, the technique is appropriate as an indicator of water quality/ general biological quality:

- The macroinvertebrate family Chironomidae colonises a wide variety of water quality habitats, and the CPET method assesses nutrient enrichment using Ecological Quality Ratios (EQRs) based on chironomid species composition. Therefore, the CPET methodology can be used to provide a robust, representative assessment of canal ecological quality and may be particularly useful in cases where there is a requirement to assess changes in nutrients.
- Although chironomid species show a wide range of habitat preferences, all aquatic species of chironomid must reach the water surface as pupae, before adult emergence; thus, a random sample of chironomid pupal exuviae from the canal surface can be representative of recently emerged adults from a variety of habitats.

More complete characterisation of the canal macroinvertebrate ecology has not been recommended at this time, as alternative approaches may not provide additional value for use as a baseline against which potential implementation of the proposed SRO may later be assessed. Selection of the CPET method for the parallel Gate 1 monitoring project was made through liaison with Environment Agency ecology staff (Hertfordshire and North London). Subsequent to review of both the literature review and gap analysis draft summary report and the Gate 1 draft monitoring report, further liaison with Environment Agency technical specialists is ongoing. At the time of writing alternative monitoring (canal PSYM) is not recommended and CPET and INNS monitoring is considered sufficient.

It is acknowledged that use of CPET will leave gaps in knowledge regarding conservation value not captured by assessment of designated species/ sites. However, protected species within the canal, other than white-clawed crayfish, were not identified by the literature review and consultation with the Environment Agency/ the Trust. Furthermore, given the current lack of understanding regarding potential pathways of impact, particularly as regards relative degree of environmental change at specific localities along the proposed route, targeted baseline monitoring cannot at this point be recommended. The exception being the need for consideration of the directly connected water courses.

4.2.2 Recommendations

Recommendations for work topic 8 are summarised in Table 4.4

Table 4.4 Topic 8 recommendations

Knowledge / information gap	Recommendation	Sequencing
Uncertainty regarding the impact of water transfer on water quality, water quantity, and flow in canal water bodies and connecting river water bodies.	As per pathways recommendations for work topics 3 and 4, undertake hydrological and water quality assessments to establish the interactions, influence and relative importance of possible change in water quality, water quantity, and flow. Then re-appraise ecological receptors.	Gate 2
Uncertainty regarding the continued presence of white-clawed crayfish (*Austropotamobius pallipes*)	Undertake a desk-study of current signal crayfish distribution throughout the canal network, to determine whether possible white-clawed crayfish populations would already be exposed to signal crayfish and crayfish plague. If there is not enough evidence to support this, then targeted surveys for white-clawed crayfish should be considered.	Gate 2
Ecological baseline dataset to act as an indicator of water quality/ general biological quality.	As established through Environment Agency liaison for the parallel baseline monitoring project, use of CPET sampling is recommended as an appropriate baseline indicator of water quality/ general biological quality.	Ongoing
Knowledge gap regarding the characterisation of plant communities within the chalk streams at locations downstream of canal confluences.	Undertake macrophyte surveys at river monitoring locations, upstream and downstream of canal confluences.	TBC (dependent on outcome of Gate 2 pathways recommendations)

Knowledge / information gap	Recommendation	Sequencing
Uncertainty regarding possible benefit to Tring Reservoirs SSSI	If hydrological work justifies it, undertake detailed study of the reservoir drawdown system, and undertake assessment of possible ecological and socio-economic benefits resulting from the SRO on the drawdown regime.	TBC (dependent on outcome of Gate 2 pathways recommendations)
Uncertainty regarding the impact of possible changes in temperature and water quality associated with water transfer and the implications this may have for fish species in the GUC.	If the hydrological and water quality assessments recommended anticipate significant change within the canal environment, as a result of the proposed water transfer, then further review of fish data should be considered to determine whether the new information changes our understanding of potential impacts and any mitigation that may be required.	TBC (dependent on outcome of Gate 2 pathways recommendations)
Uncertainty regarding the relative contribution of the Coventry Canal, Oxford Canal and GUC to the overall diversity of designated sites which canal waterbodies directly border or pass through.	If the high priority hydrological and water quality assessments recommended anticipate significant change within the relevant canal reaches, as a result of the proposed water transfer, then targeted surveys to allow for better characterisation of canal ecology (e.g. macroinvertebrates) should be considered. Further detailed in Topic 5.	TBC (dependent on outcome of Gate 2 pathways recommendations)
Limited available information relating to the effects of water quality impacts and flow change within canal systems on ecological receptors considered, as well as designated sites and species.	Low priority to fill 'aspirational' knowledge gaps. Further assessment of the presence and distribution of mammals and protected species within the canal reaches of interest – notably otter and water vole. If the high priority hydrological and water quality assessments recommended anticipate significant change within the canal environment, as a result of the proposed water transfer, then further assessment should be considered.	TBC (dependent on outcome of Gate 2 pathways recommendations)

4.3 Work topic 9 – supporting habitats

Topic 9: To identify any crucial supporting habitats that are not designated or protected.

Reason: Supporting habitats and nursery grounds tend to be less well monitored. The desk study should identify any crucial supporting habitats associated with protected species and recommend localised survey needs as necessary.

4.3.1 Summary

The canal habitat through most of the study area can be characterised as exhibiting a uniform cross-sectional geometry, determined by construction, which has resulted in limited habitat diversity. The exception being the canal from the summit at Tring to the Thames at Brentford; where the canal has a more natural river elevation profile, and where controls on flow are governed less by lockage and more by interactions with chalk river systems (work topic 3). Rare (and therefore potentially limiting) pockets of non-homogenous canal habitat have not been identified by this review. The extent to which the canal network acts as a *supporting* habitat for designated sites and protect species remains uncertain; however, scope for further investigation has been identified within several canal reaches.

There is a knowledge gap regarding the extent to which the GUC, Coventry Canal, and Oxford Canal may contribute to habitat and species diversity of several designated sites; the sites, and their associated canal water bodies, are outlined in Table 4.5.

Table 4.5 Designated sites for which the GUC may act as a *supporting* or *associated* habitat

Designation	Site Name	Associated Canal Water Body
SSSI	Alvecote Pools	Coventry and Ashby Canals
LNR	Swift Valley	Oxford Canal
LNR	Denham Country Park	GUC, Maple Lodge to Uxbridge
LNR	Frays Valley	GUC, Uxbridge to Hanwell Locks, Slough Arm, Padding

Although canal water bodies may not be in direct hydrological connectivity with the designated sites, or their designated features, it is likely that the canal contributes to the overall diversity represented. It is possible that notable change in water quality or flow as a consequence of the proposed water transfer could cause subsequent change in the capacity of the canal to act as a *supporting* habitat for these designated sites.

Regarding the protected species identified, there is uncertainty regarding the extent to which the canal network may provide *supporting* habitat. The potential for level change in some canal pounds, as a result of the proposed water transfer, has been raised by consultants working on the parallel hydrological Gate 1 workstream (JBA, 2021); this could be of note for mammal species, such as water voles or otters, which may use the canal pounds as a direct food or habitat source. However, the canal reaches where this may occur, as well as the scale of such environmental change, is currently unknown. Again, this highlights the significant knowledge gap regarding the impact of the proposed water transfer on hydrological regime and water quantity within the canal network.

Regarding the chalk streams of the south-east, although not necessarily a ***supporting*** habitat, the canal environment is certainly an ***associated*** habitat of these features. This is a product of the inter-connected nature of the GUC and a number of key connecting river waterbodies. This brings a high level of inter-dependency and association between the canal, the river habitats and their associated designated sites or species. As described for work topic 8 in Section 4.2.1, there is a current absence of understanding of how the proposed GUC Strategic Transfer would affect ecology of the chalk streams as a result of the interactions, influence and relative importance of possible change in water quality, water quantity, and flow in the interconnected canal water bodies. There is a requirement for the relative scale of change in water quality, water quantity and flow to be better understood, so that it is possible to outline any subsequent potential impacts to the associated species and habitats. Hydromorphological effects on the chalk streams could, however, be eliminated under SRO options whereby abstraction of the transfer occurs upstream of the chalk rivers. Potential water chemistry/ quality effects may still propagate downstream under this scenario; however, this would depend on the 'mechanics' of the transfer, as discussed in Section 3.2.1.

4.3.2 Recommendations

Recommendations for work topic 9 are summarised in Table 4.6.

Table 4.6 Topic 9 recommendations

Knowledge / information gap	Recommendation	Sequencing
Uncertainty regarding the impact of water transfer on water quality, water quantity, and flow in canal water bodies and connecting river water bodies.	As per pathways recommendations for work topics 3 and 4, undertake hydrological and water quality assessments to establish the interactions, influence and relative importance of possible change in water quality, water quantity, and flow. Then re-appraise ecological receptors.	Gate 2
Knowledge gap regarding the extent to which the Coventry Canal may contribute to habitat and species diversity at Alvecote Pools SSSI.	If notable change in flow/ water quality is anticipated, then a site visit/ habitat walkover at Alvecote Pools SSSI should be undertaken, and targeted surveys to allow for better characterisation of canal ecology should be considered (if notable change in flow/ water quality is anticipated).	TBC (dependent on outcome of Gate 2 pathways recommendations)
Knowledge gap regarding the extent to which the Oxford Canal may contribute to habitat and species diversity at Swift Valley LNR.	If notable change in flow/ water quality is anticipated, then a site visit/ habitat walkover at Swift Valley LNR should be undertaken, and targeted surveys to allow for better characterisation of canal ecology should be considered.	TBC (dependent on outcome of Gate 2 pathways recommendations)
Knowledge gap regarding the extent to which the GUC may contribute to habitat and species diversity at Frays Valley LNR and Denham Country Park LNR.	If notable change in flow/ water quality is anticipated, then a site visit/ habitat walkover at Frays Valley LNR and Denham Country Park LNR should be undertaken, and targeted surveys to allow for better characterisation of canal ecology (e.g. macroinvertebrates) should be considered.	TBC (dependent on outcome of Gate 2 pathways recommendations)

Knowledge / information gap	Recommendation	Sequencing
There is uncertainty regarding the potential for level change in some canal pounds. This raises uncertainties regarding the canal's role as a possible supporting habitat for protect species, such as otter.	If hydrological assessments anticipate significant level change within the canal environment, then further assessment of protect species distribution – and the extent to which species utilise canal habitat – should be considered. E.g. white-clawed crayfish associated with Northampton Arm	TBC (dependent on outcome of Gate 2 pathways recommendations)

4.4 Work topic 10 - birds

Topic 10: Collate information on the existing relationship between migratory birds and the GUC plus associated wetland environments.

Reason: To improve understanding of the relationship between migratory birds, the canal system and associated wetlands in order to inform any future impact assessment of the transfer.

4.4.1 Summary

Given the current understanding of the scheme it is not considered that the proposed GUC Strategic Transfer would have a significant effect on birds at the whole-project level. However, once key gaps regarding pathway (in particular hydromorphology) and receptor effects are filled in Gate 2, this position should be reappraised. Special Protection Areas (SPAs) are protected areas for birds in the UK classified under various items of legislation. SPAs require Habitats Regulations Assessments where planned schemes/ development are identified as having the potential to affect them. No SPAs were identified as part of this review within the water bodies identified under work topic 2. A parallel workstream has, however, identified two sites that feasibly could be affected by the scheme; the Upper Nene Valley Gravel Pits SPA and Wraysbury Reservoir SPA. The potential for the SRO to affect these specific locations has not been established and therefore these sites have not been considered here.

The main gaps to be better understood ahead of any environmental appraisal or EcIA work relate to the scale and magnitude to which any impact pathway changes could affect relevant habitats, bird species and their prey. The key factor being the need to put the current understanding of adaptation responses and tolerances to changes in flow regime (which would be dependent on the timing of changes within any particular species' life cycle and how quickly they occur) into the context of outcomes of modelling of the proposed GUC Strategic Transfer, in particular, canal hydromorphology. The gap is driven by the complexity of multiple site-specific factors that may result from operation of the SRO, rather than principles of understanding. Once pathways are better understood, adequate assessment of birds should reasonably be made via qualitative assessment and expert judgement review of linked environmental change.

4.4.2 Recommendations

Key recommendations outlined for work topic 10 are summarised in Table 4.7.

Table 4.7 Topic 10 recommendations

Knowledge / information gap	Recommendation	Sequencing
Uncertainty regarding the potential for a pathway of effect of the proposed GUC Strategic Transfer on birds of the canal or associated wetlands.	As per pathways recommendations for work topics 3 and 4, need for hydromorphological assessment to better understand whether bird populations associated with the canal would be subject to a pathway of effect resulting from the proposed GUC Strategic Transfer. Then reappraise birds as a receptor.	Gate 2 (dependent on outcome of Gate 2 pathways recommendations)

Knowledge / information gap	Recommendation	Sequencing
Uncertainty regarding the presence of breeding and / or non-breeding birds	If Gate 2 work on modelling of pathways effects identifies risk, undertake further desk-study to identify sections of the canal network that are covered by detailed national survey effort to determine what species are present and in what numbers (for instance in numbers of local, regional or national importance). This could be targeted to specific parts of the transfer route where risk is identified. If no data are available for areas where sensitive species or habitats are located, then targeted surveys for birds should be considered.	TBC (dependent on outcome of Gate 2 pathways and receptors recommendations)

4.5 Work topic 11 – invasive non-native species

Topic 11: Identify existing INNS pathways and risks along the canal transfer route and the associated water bodies and the potential risks of encouraging future INNS due to the introduction on Minworth water to the system.

Reason: To improve understanding of existing and future INNS pathways. Summarise the findings of existing INNS studies along the canal and tributaries and provide data in a format that can be used for future INNS risk assessments for the potential new abstraction. The review must seek to understand how quality, flow and temperature impact risk. Evidence will support future pathway assessments and scheme specific risk assessment to inform thinking on ways to limit INNS movement. Where data is shown to be poor or missing, the study should recommend what additional baseline monitoring should be put in place to resolve this gap.

4.5.1 Summary

Interrogation of the existing data confirms that the canal network encompassed by the potential transfer routes is already home to several high priority INNS with 22 species found (see Figure 4.1 to Figure 4.5). This is unsurprising given that the GUC and associated canals have a high degree of connectivity to other water bodies and are susceptible to species introductions from a variety of pathways including boat navigation, angling and other recreational uses. However, it is important to consider that the accuracy of the information gathered is dependent on the availability, and quality, of the pre-existing data. Common issues with the pre-existing data drawn upon as part of the literature review include unequal sampling effort between reaches, species misidentification, inaccurate or incomplete records and restrictions related to data licensing. These issues, combined with the general reduction in routine monitoring and the fact that many records inevitably go un-reported, mean that species distributions generated from existing data should be interpreted with caution. Indeed, these data cannot be used to rule out the presence of INNS from a given locality and should be used as part of an over-arching pathway-based INNS risk assessment approach.

Based on expert opinion it is considered unlikely that INNS survive the effluent treatment process, which will be a necessary mitigation step before water is discharged into the canal network to support the transfer. Therefore it is unlikely that discharge from Minworth WwTW would affect the diversity of INNS in the canal. However, other aspects of the scheme, such as the back-pumping of water, may affect the distribution of INNS within the canal network and subsequently its hydrologically connected waterbodies, several of which are high profile chalk streams. As such, a key recommendation for Gate 2 is to risk assess and compare the different Minworth WwTW discharge options in relation to the existing INNS distribution within the canal network and the potential affects on this that may result from the proposed transfer.

A number of sub-option routes have been considered by the project team, one of which looked to discharge water into the River Tame (as is the baseline situation) and subsequently transfer into the canal network. This option is no longer being progressed and this is advantageous from an INNS perspective as the River Tame option was considered to be of a greater risk of introducing novel INNS and possibly of increasing density of those that already exist in the Tame and canal water bodies.

Beyond Gate 2, whichever discharge option is selected, mitigation options appraisals will also be key in determining the most appropriate measures to circumvent issues relating to the implementation of high-risk pathways/activities. Furthermore, risk assessments will be required for determining the potential risk of spreading INNS associated with planned engineering/ construction works.

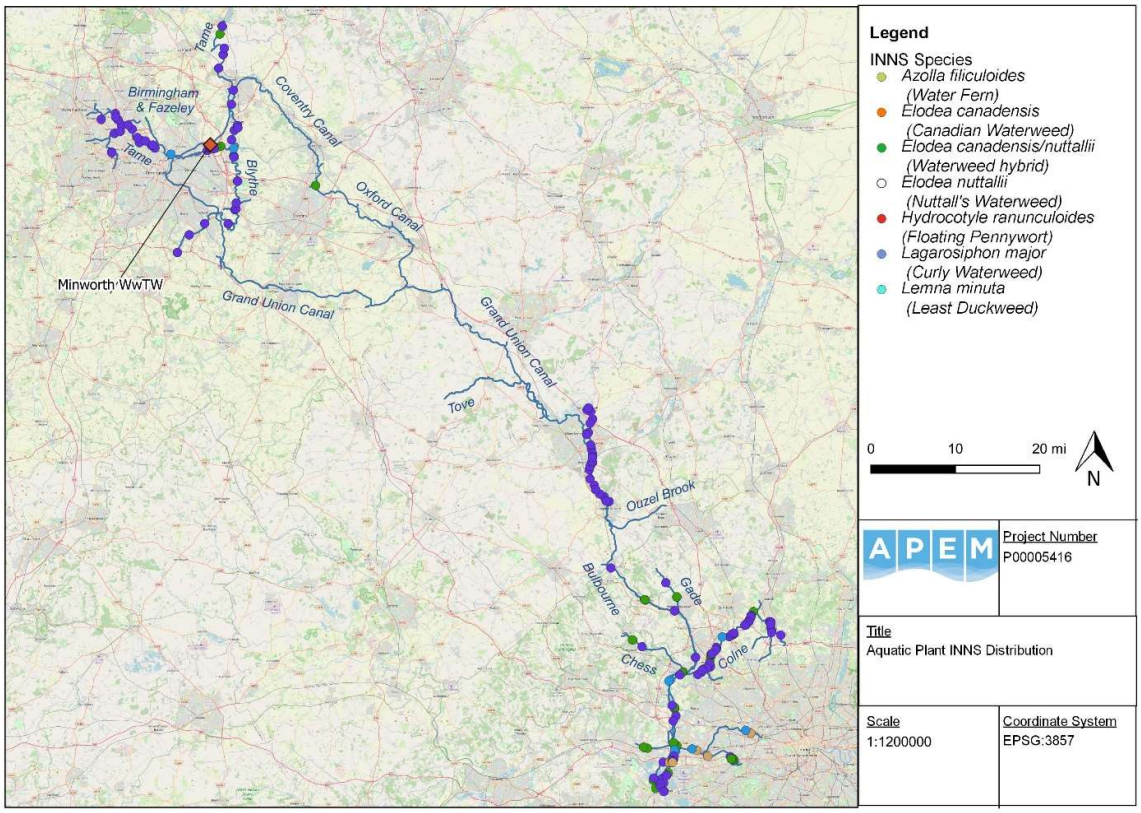

Figure 4.1 Aquatic plant INNS distribution

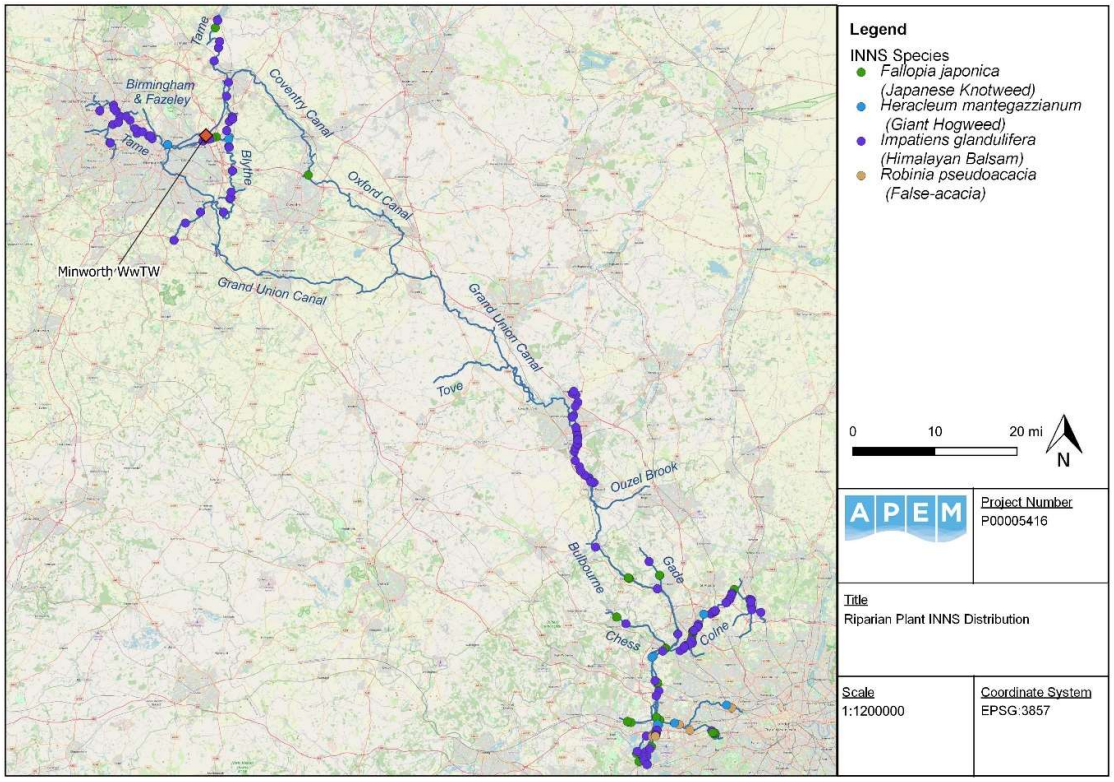

Figure 4.2 Riparian plant INNS distribution

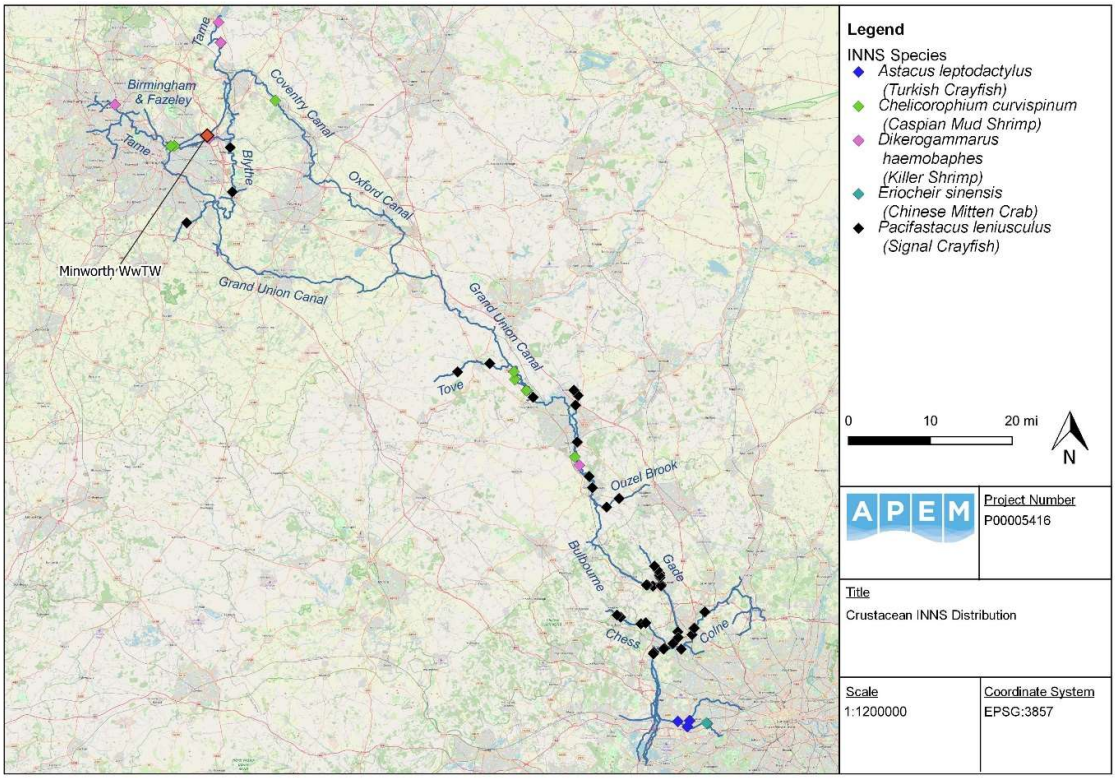

Figure 4.3 Crustacean INNS distribution

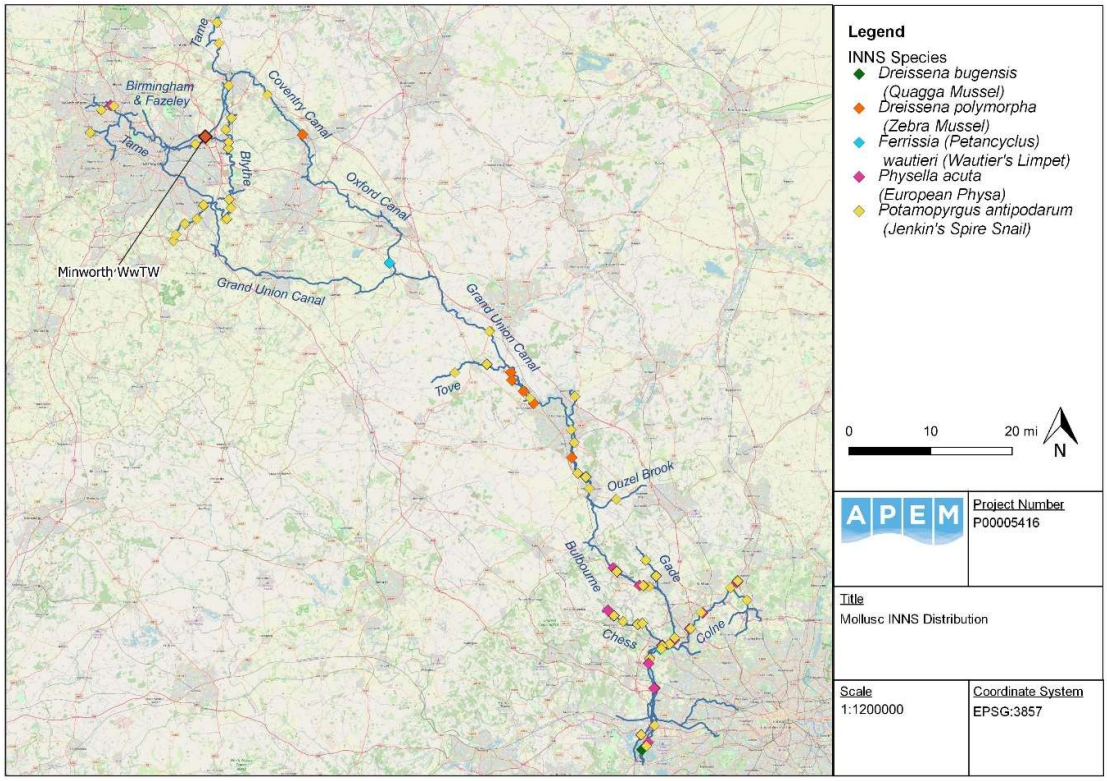

Figure 4.4 **Mollusc INNS distribution**

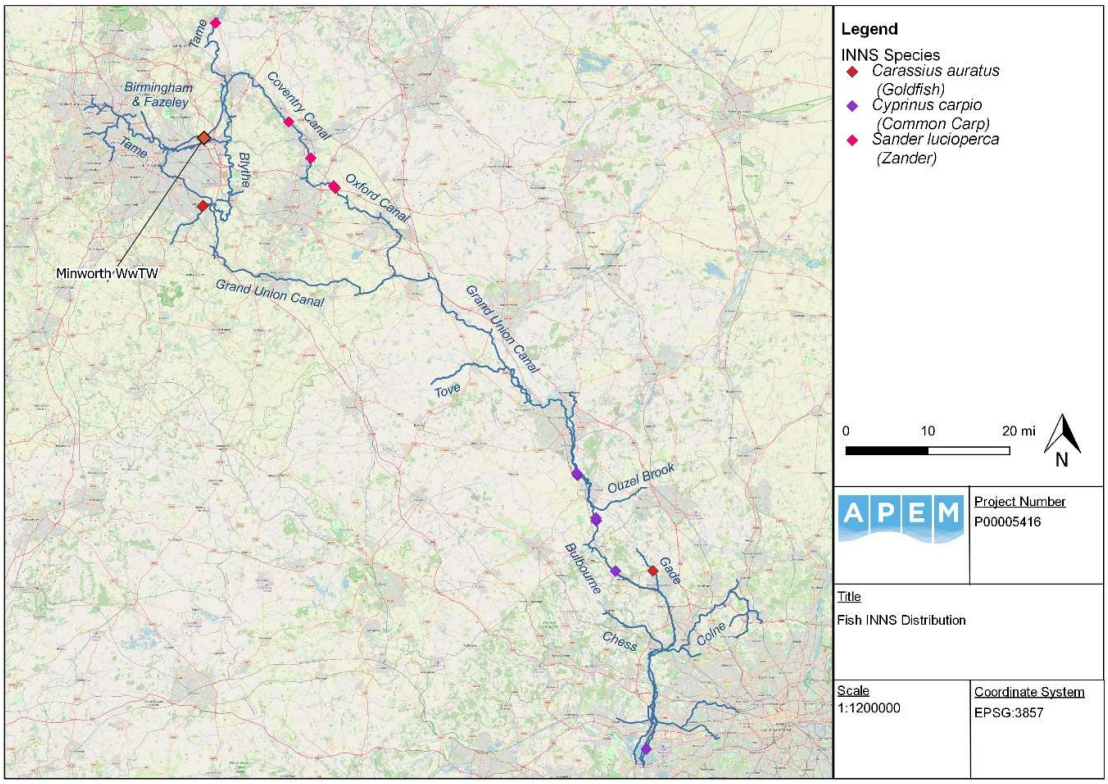

Figure 4.5 **Fish INNS distribution.** ***Note: Zander (Sander lucioperca) have been recorded from GUC, but coordinates are not available for mapping.***

4.5.2 Recommendations

Key recommendations outlined for work topic 11 are summarised in Table 4.8.

Table 4.8 Topic 11 recommendations

Knowledge / information gap	Recommendation	Sequencing
Uncertainty regarding the relative risks posed by different discharge locations and transfer route options	Undertake a semi-quantitative assessment of the relative risks of the different SRO sub-options to affect the existing distribution of INNS within the canal network. This should be conducted using a pathway-based approach which incorporates existing INNS data.	Gate 2
Uncertainty regarding the risk of transferring INNS within the GUC via back-pumping	Conduct a semi-quantitative risk assessment of moving INNS within the GUC via the back-pumping of water.	Gate 2
Consideration of the potential for infrastructure construction to introduce/ spread INNS	Conduct a semi-quantitative risk assessment of the potential pathways of introducing INNS during the construction process.	Post Gate 2
Lack of understanding of the mitigation measures required*	Carry out an options appraisal of mitigation options for the identified risks.	TBC (dependent on first two items)
Consideration of possible impacts of environmental changes on INNS spread	Analyse predicted water quality and/ or flow changes in the context of INNS to determine whether impacts on the spread of species within the system are likely.	TBC (dependent on outcome of Gate 2 pathways recommendations)

5 Work Package 4 - Socio-economic Receptors

Work Package 4 relates to socio-economic and natural capital receptors. These are components of the socio-economic domain and natural capital benefits which relate to canal operation and activities, as well as ecological status, and have the potential to be affected by the impacts or effects of the proposed transfer scheme.

The two work topics are included within Work Package 4:

- Work topic 12 – Socio-economic receptors; and
- Work topic 13 – Natural capital receptors.

5.1 Work topics 12 and 13 - socio-economic and natural capital receptors

Work topic 12: General literature review to identify methods and values to be used when quantifying the socioeconomic and recreational benefits from canals.

Reason: To assist with the quantification of any socio-economic benefits that would arise from the transfer scheme. The study should also consider any existing literature specific to the GUC and the benefits that it provides. The outputs of the study will be used to help the project team design a solution that maximises opportunities for net gain and possible ways to mitigate any negative impacts of the transfer.

Work topic 13: General literature review to identify methods and values to be used when quantifying the natural capital benefits from canals.

Reason: To assist with the quantification of any natural capital and biodiversity benefits that would arise from the transfer scheme. The study should work with the Trust and other partners to identify and map the canal's associated habitats and identify where there may be an opportunity for environmental improvements and other net biodiversity gain opportunities including carbon offsetting/sequestration. The outputs of the study will be used to help the project team design a solution that maximises opportunities for net gain and possible ways to mitigate any negative impacts of the transfer.

5.1.1 Summary

A summary of both Topic 12 and Topic 13 is outlined below, including key evidence gaps identified.

An understanding of the range of socio-economic, recreational and natural capital benefits from canals will help to inform the proposed transfer using the canal network, ensuring that opportunities to maximise such benefits are realised.

The review summarises evidence of socio-economic, recreational and natural capital benefits from canals. It encompasses both methods available for identifying and estimating benefits, and evidence related to the quantities and values associated with these benefits.

In each of the three categories, we have identified a number of benefits that are particularly relevant to canals and could potentially be important in the context of the proposed GUC Strategic Transfer. These include:

- Socio-economic benefits (Jobs and skills, Business activity, Property price, Transport, Tourism, Water supply, Regeneration, Energy, Health and well-being, Heritage, Education Social/community cohesion);

- Recreational benefits (Land recreation, Water recreation); and
- Natural capital benefits (Flood risk, Carbon, Climate change, Water quality, Flow support, Biodiversity, Air quality).

Quantitative and valuation evidence in relation to each of these benefits is presented. This can be applied in subsequent phases of work, where options appraisal will help to identify specific quantities and values relevant to the GUC scheme.

5.1.1.1 Key Evidence Gaps

The main evidence gaps in relation to the benefits of canals and to the proposed GUC Strategic Transfer in particular are as follows:

1. There is limited quantitative and biophysical evidence supporting an impact pathway approach that explicitly links the services provided by canals and canal infrastructure to socio-economic, recreational and natural capital outcomes that can be valued. This applies to all the benefit categories highlighted above and means the benefits of the canal transfer scheme cannot be fully or clearly articulated at this stage.

2. There are some key gaps in the valuation evidence needed to support the assessment of benefits in relation to canals and the transfer scheme, notably:

    a. Economic benefits, specifically business activity, tourism and heritage;
    b. Social benefits, particularly community cohesion and education, and;
    c. Natural capital benefits, for example within-class WFD-related improvements to water bodies and biodiversity/habitat improvements to designated and non-designated sites.

3. It is currently difficult to identify relevant outcome indicators for some benefits that could be relevant to canals and the proposed transfer scheme, e.g. climate change.

4. Better information is needed on the transferability of some valuation evidence from one context to another, e.g. property price premium, and how these values will vary depending on specific characteristics or context of a site or project. This means that the use of existing valuation evidence in the context of the canal transfer scheme will result in uncertainty around the benefits.

5. There are some gaps relating to values not covered by the framework considered here. For example, non-use values may be important in some instances, but valuation evidence is weak here. Jacobs (2010) recommends a non-use value of £0.75 per household per year for the non-use benefits they receive from the continued maintenance of canals (based on Adamowicz *et al*., (1995), with higher values appropriate where the continued availability of boating and tow paths and the preservation of heritage aspects of canals are important. However, consideration should be given to the distance from the site to which these values should be applied, which may require mapping to highlight proximity to populated areas and access.

The approach and evidence set out here can be used to support a design for the GUC scheme that maximises opportunities for benefits and identifies ways to mitigate any negative impacts (costs) associated with the transfer scheme.

Clearly, benefits will be site- and project-specific, and the realisation of benefits will ultimately depend on several factors. However, the potential benefits associated with canals in general are likely to be broad, diverse

and significant. Nevertheless, given a good understanding of the physical impacts and outcomes of the transfer, many of the benefits identified here can be valued, albeit with varying degrees of confidence.

Some benefits appear to have particular potential in the context of the canal transfer scheme, given the scale and importance of these benefits identified in this review. These include water-based recreation (e.g. fishing), enhancements to land and property values and health and well-being. In these (and potentially other) areas, even marginal changes as a result of the transfer scheme could result in significant benefits.

The next step should be to develop and utilise evidence related to the environmental, social and economic impacts of the actual scheme and map these to the valuation evidence presented here. Specific areas of proposed focus are outlined in the next section. The non-water resource benefits workstream, which is ongoing, is investigating the potential benefits of the strategic transfer further.

5.1.2 Recommendations

Key recommendations outlined for work topics 12 and 13 are summarised in Table 5.1.

Table 5.1 Topic 12 and 13 recommendations

Knowledge / information gap	Recommendation	Sequencing
Relevance and significance of key benefits likely to vary amongst stakeholders.	Benefits identified within work topics 12 and 13 are discussed with stakeholders before being assessed in greater detail.	Ongoing (within parallel non-water resource benefits workstream)
Limited quantitative and biophysical evidence supporting an impact pathway approach.	Utilise outputs form relevant workstreams and associated work packages (e.g. impact assessments) to identify and articulate benefits of the canal transfer scheme.	Gate 2 (dependent on outcome of Gate 2 pathways & receptor recommendations)
Gaps in valuation evidence needed to support the assessment of benefits in relation to canals and the transfer scheme.	Identify significant benefits likely to be associated with the transfer scheme and assess adequacy of valuation evidence related to these.	Ongoing (within parallel non-water resource benefits workstream)
Difficulty in identifying relevant outcome indicators for some benefits that could be relevant to canals and the proposed transfer scheme.	Identify outcome indicators for significant benefits likely to be associated with the transfer scheme.	Ongoing (within parallel non-water resource benefits workstream)
Transferability of some valuation evidence from one context to another.	Identify significant benefits likely to be associated with the transfer scheme and assess transferability of valuation evidence related to these.	Ongoing (within parallel non-water resource benefits workstream)

6 Concluding Statements

This literature review and gap analysis has been carried out to meet the needs of RAPIDs Gate 1 step of the regulatory process for the advancement of SROs. The specific objectives being a) to collate and review the current state of baseline ecological understanding of relevance to the proposed GUC Strategic Transfer; and b) to make recommendations for Gate 2 investigations (and beyond) to enable adequate ecological appraisal of the proposed GUC Strategic Transfer.

There was a paucity of information relating to the GUC network, and associated canal waterbodies. This was perhaps unsurprising, given the infancy of the proposed GUC Strategic Transfer scheme and the absence of ongoing ecological monitoring by the Environment Agency within the canal water bodies. There is, therefore, an emphasis on the gap analysis aspect of this piece of work, and associated recommendations to fill these gaps. The recommendations made throughout the individual work topics are collated in Table 6.1.

Additionally, recommendations made as part of the GUC Strategic Transfer Phase 1 Monitoring Report are collated in Table 6.2 (this workstream is summarised in Section 4.2.1, under work topic 8). These outline the monitoring recommended under Gate 2; aiming to capture the quality and diversity of canal ecological communities and build upon data collected under Gate 1. Table 6.2 also includes a recommendation detailing the requirement for macrophyte surveys at the River Bulbourne, River Gade, River Colne and River Chess. This recommendation was proposed based on the information presented in this report (see Section 0 and Section 0) and has been put forward as a recommendation for Gate 2 monitoring, given the sensitive and high-priority nature of the chalk rivers. Monitoring using chironomid pupal exuviae technique (CPET) is recommended as the most appropriate bio-indicator, given the practicality of assessment within a canal and the sensitivity of the associated metric to nutrient status (a potential risk identified under work topic 4). Although the main INNS recommendation relates to a pathways-based risk assessment, targeted monitoring of INNS within the canal at river/ canal confluences would be considered prudent, given the high level of existing connectivity at these locations (work topics 2 and 3).

6.1 Pathways

The fundamental gaps that have been identified for Gate 2 investigations relate to the fact that the detail of how the proposed scheme would operate is still being developed (see work topic 3). How this would manifest as pathway effects regarding hydromorphology and water quality is therefore unknown.

Ongoing hydrological work should be expanded such that the mechanism of transfer from Minworth to the Affinity Water supply area is understood in detail via simulations targeted at specific questions such as whether increased inflows change the hydrological pathways of where water is supplied from and in what volume (where inflows are controlled from impounding or pumped storage reservoirs). Work should also consider whether the balance of water between hydrological response units (the unit by which the Trust split the canal network to manage water resources) is significantly changed under the proposed GUC Strategic Transfer.

Once the above is understood, modelling should be interrogated to understand the change in reservoir levels and spill regime from waste weirs to local watercourses between baseline and the proposed GUC Strategic Transfer for a range of drought and flood years. This will assist in understanding how hydrological pathways change under the proposed GUC Strategic Transfer and aid in assessment of impacts on water quality and ecological receptors.

The fundamental gap in knowledge regarding ecological receptors relates to the current absence of understanding of how the proposed GUC Strategic Transfer would affect ecology as a result of the interactions, influence and relative importance of possible change in water quality, water quantity, and flow in canal water bodies and connecting river water bodies. A large majority of receptor recommendations are dependent on developing an understanding relating to hydromorphology and water quality (with adequate understanding of

water quality effects itself dependent on the progress of hydrological modelling). There is a requirement for the relative scale of change in water quality, water quantity and flow to be better understood, so that it is possible to outline any subsequent impacts to the species and habitats concerned with any confidence.

6.2 Legislation

Further fundamental gaps exist as regards current and future regulation of the canal water bodies by the Environment Agency; and by what measures and standards these water bodies will be classified on the basis of in the years to come.

Canal mitigation measures assessments are currently not available; this limits the current understanding of how the canal water bodies are assessed under WFD. It was noted in the summary presentation given for this project that the Environment Agency is currently in discussions with the Trust regarding what are feasible mitigation measures. It will be necessary to follow-up on mitigation measures, in relation to the proposed SRO, once these have been finalised. In the meantime, this remains a fundamental gap in understanding some of the needs of ecological appraisal going forwards and is required to identify work that would seek to understand possible mitigation/ benefits that could be put in place alongside the SRO as regards WFD status.

There is also need for clarity on how canal WFD water bodies will be assessed in the future. SNIFFER (2012) includes methodology for the classification of canal water bodies based on many more metrics than are currently employed (i.e. in 2019 classifications). Clarification from the Environment Agency is required regarding the timescales for these methodologies to be put into practice, if at all, and presumably this is dependent on legislative processes post-Brexit.

6.3 Site-specific considerations

Despite uncertainties around pathways that will only be resolved in Gate 2, and the legislative uncertainties outlined above, site-specific considerations of particular note are outlined here.

6.3.1 Chalk streams

At its southern reaches in the south east of England (Buckinghamshire, Hertfordshire and Greater London), the GUC interacts with several critically import chalk streams; the River Bulbourne, River Gade, River Chess and River Colne. Due to this high level of connectivity, it is possible that changes in water quality, water chemistry, and water quantity and flow within the GUC may translate to notable change within the neighbouring chalk stream systems; however, the scale of such change is unknown (as highlighted above). There is potential for particular sensitivity of chalk streams to any changes mediated by the proposed GUC Strategic Transfer because of their characteristic baseflow dominated hydrological regimes and water chemistry resulting from chalk groundwater inflows. These characteristics contribute to the ecological communities that make chalk streams unique, for example their base-loving water-crowfoot macrophyte communities. Without mitigation, it is possible that the operation of the proposed scheme could result in a less stable flow regime, compared to the baseline. There is also potential for a significant proportion of non-chalk groundwater derived flow to make up chalk stream flows under the proposed scheme, compared to the baseline situation. However, this would be dependent on where abstraction of the transfer were to occur, as well as whether or not water were to be transferred directly through the canal system from Minworth WwTW in the northwest (as opposed to differential use of feeder sources).

6.3.2 Invasive non-native species

As it is considered unlikely that INNS will survive the effluent treatment process, it is unlikely that discharge from Minworth WwTW would affect the diversity of INNS in the GUC. However, other aspects of the scheme, such as the back-pumping of water and increased flow velocities, may affect the distribution of INNS within the GUC and subsequently its hydrologically connected waterbodies. As such, a key recommendation for Gate 2 is the need for semi-quantitative risk assessment of INNS using a pathways-based approach.

6.3.3 Protected species – white-clawed crayfish

The possibility that [redacted] could act as a refuge for white-clawed crayfish was raised as a key issue during stakeholder engagement. This indicates a possible risk, whereby much increased back-pumping up the summit, as may be required under the proposed GUC Strategic Transfer, could as a vector for signal crayfish and/ or crayfish plague. Evidence as to whether this white-clawed crayfish population persists, alongside an assessment of the current distribution of signal crayfish within this reach of the canal, are key in informing possible future monitoring requirements regarding this protected species.

6.3.4 Potential for environmental and socio-economic benefits

The proposed GUC Strategic Transfer has the potential to positively affect both management of the Tring reservoir group and to change the abstraction regime from the Cowroast and Northchurch boreholes, with subsequent effects on groundwater levels within the Bulbourne catchment. Currently the Trust maintain navigation in the GUC at Tring, in part, via drawdown of Tring Reservoirs. This can result in opposing needs under the scenario where achieving drawdown regime targets in the Tring reservoirs and balancing navigation requirements both draw on the same source of water.

Possible ecological and socio-economic benefits resulting from reduced incidence of drawdown at Tring Reservoirs SSSI are highlighted by preliminary scenario testing (parallel hydrological work) that indicates potential benefits to reservoir levels within the Tring reservoir group. This has the potential to facilitate the draw-down regime of reservoirs (for example refill during a low flow period in late summer/ early autumn), which supports SSSI status. The possibility of delivering both environmental and stakeholder benefits remains uncertain but is highlighted as a key issue for further investigation.

Table 6.1 Compiled recommendations

Work package	Work topic recommendation number	Knowledge / information gap	Recommendation	Sequencing
1	1.1	Future legislative changes – incl. Environment Bill.	Monitoring of future legislative changes and the resultant impact on GUC transfer scheme as applicable.	Ongoing
1	1.2	Application of environmental legislation	Early liaison with regulators on their interpretation and application of the finer details of all relevant environmental legislation to ensure the needs of all relevant legislation are met.	Ongoing
2	2.1	Requirement to better understand canal and surface water body connectivity	There is a need to better understand the degree of connectivity of those surface water bodies assessed as having 'confirmed' connectivity, and whether these water bodies need to be scoped into future environmental work. This should be reappraised following parallel Gate 1 and Gate 2 hydrological assessments that should quantify significant connectivity as well as inform whether this connectivity would be affected by the proposed SRO or otherwise	Gate 2 (dependent on whether Gate 1/ 2 hydrological assessment identifies a need)
2	2.2	Requirement to better understand canal and groundwater body connectivity	There is a need to better understand connectivity between the canal network and groundwater bodies, and therefore further investigation may be required following parallel Gate 1/ Gate 2 hydrological assessments that may identify any further significant groundwater connectivity associated with the proposed SRO.	Gate 2 (dependent on whether Gate 1/ 2 hydrological assessment identifies a need)
2	3.1	How applications for abstraction licences under the Water Act (2003) may change the water resources situation within the GUC	PMB to discuss with the Trust to understand any likely variations to abstraction licenses within the GUC HRUs and to account for this within future water resources modelling scenarios related to the SRO.	Gate 2 (dependent on processing and finalisation of applications)

Work package	Work topic recommendation number	Knowledge / information gap	Recommendation	Sequencing
2	3.2	How hydrological/ hydromorphological pathways change between baseline and scheme conditions	Once water resources modelling is finalised, characterisation of change between baseline and scheme reservoir levels, pound hydromorphology and spill regimes and subsequent impact on connected water bodies across the flow regime should be assessed. Detailed assessment of potential pass-forward benefits to resources between Canal HRUs.	Gate 2
2	3.3	How proposed SRO might affect abstraction regime at Cowroast and Northchurch boreholes and hence impacts on the Bulbourne water body	Once water resources modelling is sufficiently progressed, detailed assessment of how the scheme might affect abstraction rates at Cowroast and Northchurch and whether this might confer benefit to groundwater levels in the Bulbourne catchment, should be assessed.	Gate 2 (dependent on recommendation 3.2)
2	3.4	How proposed SRO might affect canal management at Tring	Once hydrological work is sufficiently progressed, detailed assessment of how the scheme might affect water resource at Tring, and whether this might confer benefit to reservoir level management, should be assessed.	Gate 2 (dependent on recommendation 3.2)
2	3.5	Extent (if any) to which changing canal flows will affect flooding extents	Review results of future scheme specific water resources modelling and Flood Risk Assessments (FRA).	Gate 2 (dependent on recommendation 3.2)
2	4.1	Minworth discharge requirements	High-level assessment to understand the potential for effect on WFD status at the potential discharge locations on the GUC	In progress
2	4.2	Water quality monitoring	Current monitoring of water quality should continue for a longer period to build up a good dataset over several seasons. A minimum of 12 monthly samples taken throughout the year will be needed to assess the concentrations of hazardous substances against EQS. The Environment Agency will require evidence that the transfer will not lead to deterioration in WFD status over time.	In progress

Work package	Work topic recommendation number	Knowledge / information gap	Recommendation	Sequencing
2	4.3	Detailed water quality modelling	Once the hydrology of the transfer has been modelled in more detail, and sufficient baseline water quality data have been collected, this will need to be applied to sophisticated water quality modelling to better understand risk beyond immediate discharge points and to allow for inclusion of other sources of inputs (e.g. from diffuse runoff).	Gate 2 (dependent on timing of hydrological modelling outputs and collection sufficient baseline water quality data)
2	4.4	Sediment quality	We recommend that the monitoring programme should be extended to include the collection of sediment quality data in the canals. Sediment quality should be sampled once at the locations close to existing water quality sampling sites, but where the sediment is deepest as this is where the levels of contamination are likely to be the highest.	Gate 2
2	4.5	Modelling of in-canal *in situ* processes	Modelling should investigate if it is possible that changes would occur in water quality and sediment quality, including from the transfer and while the water is 'held' in sections of the canal (i.e. canal pounds). This includes process such as breakdown, dilution, precipitation and remobilisation from sediment. Associated sampling of sediment would be required.	Gate 2 (dependent on detailed WQ modelling recommendation 4.3)
2	4.6	Microbiology	Should modelling indicate risk regarding increases in nutrients in canal sections with low levels of boat traffic further appraisal of potential effects on microbiology may be required.	Gate 2 (dependent on detailed WQ modelling recommendation 4.3)
2	4.7	Water quality monitoring programme	It is recommended that the monitoring programme reflects the outcome of an assessment being carried out by APEM and it is streamlined to only include parameters flagged as likely to cause EQS exceedance or a breach of the standstill policy. The high-level assessment is for the northern canal sites and Minworth WwTW at this stage but should be extended to include the rest of the GUC.	Gate 2

Work package	Work topic recommendation number	Knowledge / information gap	Recommendation	Sequencing
2	4.8	Water quality monitoring programme	We recommend that the source water that supplies the canals is monitored for the same parameters as the GUC PMB monitoring programme. The source water in addition to the transfer water from Minworth WwTW will need to be included in any detailed modelling.	Post Gate 2 (dependent on outcomes of Gate 1/ 2 hydrological workstreams and decisions regarding the mechanics of the transfer (see Section 3.2.1))
2	4.9	WFD Water quality assessments	WFD assessment of the water bodies identified as in direct hydrological connectively with the GUC, to assess WFD risks (but caveat of legislation topic findings)	Post Gate 2 (dependent on outcomes of recommendations 3.2, 4.3 made above)
2	5.1	Baseline status of priority substances/ hazardous substances has not been reviewed in detail.	Where the hydrological work stream confirms significant inputs to the GUC SRO transfer a desk study would be undertaken to identify which waterbodies warrant further investigation with regard to priority substances/ hazardous substances.	Gate 2 (and overlapping with work topic 4 Gate 2 recommendations)
2	6.1	Lack of information on processes responsible for sediment mobilisation	Assess the need for automatic monitoring (standard 15-minute monitoring frequency) of suspended sediment and flow at a small number of representative locations within the canal to determine the nature of the relationship between flow magnitude and suspended sediment concentration.	Gate 2
2	6.2	Lack of information on sediment inputs and exports	Undertake continuous monitoring of suspended sediment and flow at key inputs and outputs to the canal to calculate a sediment budget for reaches of interest.	TBC (dependent on outcome of item 6.1 as well as parallel hydrological modelling work) – may not be required

Work package	Work topic recommendation number	Knowledge / information gap	Recommendation	Sequencing
2	6.3	Lack of information on sediment composition	Undertake canal bed sediment sampling to establish the size distribution of material currently stored within the canal.	Gate 2 (dependent on outcome of item 6.1 as well as parallel hydrological modelling work) – may not be required
3	7.1	Baseline canal Mitigation Measures Assessments are currently not available; this limits the current understanding of how the canal water bodies are assessed under WFD.	It was noted in the summary presentation given for this project that the Environment Agency are currently in discussions with the Trust regarding what are feasible mitigation measures. It will be necessary to follow-up on mitigation measures, in relation to the proposed SRO, once these have been finalised. This is therefore an ongoing item. In the absence of knowing what these measures are there is currently no action other than to check/ understand them.	Ongoing
3	7.2	The need for clarity on how canal WFD water bodies will be assessed in the future.	SNIFFER (2012) includes methodology for the classification of canal water bodies based on many more metrics than are currently employed (i.e. in 2019 classifications). Clarification from the Environment Agency is required regarding the timescales for these methodologies to be put into practice, if at all (and presumably dependent on legislative processes post-Brexit).	Ongoing*
3	8.1	Uncertainty regarding the impact of water transfer on water quality, water quantity, and flow in canal water bodies and connecting river water bodies.	As per pathways recommendations for work topics 3 and 4, undertake hydrological and water quality assessments to establish the interactions, influence and relative importance of possible change in water quality, water quantity, and flow. Then re-appraise ecological receptors.	Gate 2

Work package	Work topic recommendation number	Knowledge / information gap	Recommendation	Sequencing
3	8.2	Uncertainty regarding the continued presence of white-clawed crayfish (*Austropotamobius pallipes*)	Undertake a desk-study of current signal crayfish distribution throughout the canal network, to determine whether possible white-clawed crayfish populations would already be exposed to signal crayfish and crayfish plague. If there is not enough evidence to support this, then targeted surveys for white-clawed crayfish should be considered.	Gate 2
3	8.3	Ecological baseline dataset to act as an indicator of water quality/ general biological quality.	As established through Environment Agency liaison for the parallel baseline monitoring project, use of CPET sampling is recommended as an appropriate baseline indicator of water quality/ general biological quality.	Ongoing
3	8.4	Knowledge gap regarding the characterisation of plant communities within the chalk streams at locations downstream of canal confluences.	Undertake macrophyte surveys at river monitoring locations, upstream and downstream of canal confluences.	TBC (dependent on outcome of Gate 2 pathways recommendation 3.2)
3	8.5	Uncertainty regarding possible benefit to Tring Reservoirs SSSI	If hydrological work justifies it, undertake detailed study of the reservoir drawdown system, and undertake assessment of possible ecological and socio-economic benefits resulting from the SRO on the drawdown regime.	TBC (dependent on outcome of Gate 2 pathways recommendation 3.4)
3	8.6	Uncertainty regarding the impact of possible changes in temperature and water quality associated with water transfer and the implications this may have for fish species in the GUC.	If the hydrological and water quality assessments recommended anticipate significant change within the canal environment, as a result of the proposed water transfer, then further review of fish data should be considered to determine whether the new information changes our understanding of potential impacts and any mitigation that may be required.	TBC (dependent on outcome of Gate 2 pathways recommendation 4.3)

Work package	Work topic recommendation number	Knowledge / information gap	Recommendation	Sequencing
3	8.7	Uncertainty regarding the relative contribution of the Coventry Canal, Oxford Canal and GUC to the overall diversity of designated sites which canal waterbodies directly border or pass through.	If the high priority hydrological and water quality assessments recommended anticipate significant change within the relevant canal reaches, as a result of the proposed water transfer, then targeted surveys to allow for better characterisation of canal ecology (e.g. macroinvertebrates) should be considered. Further detailed in Topic 5.	TBC (dependent on outcome of Gate 2 pathways recommendations 3.2 and 4.3)
3	8.8	Limited available information relating to the effects of water quality impacts and flow change within canal systems on ecological receptors considered, as well as designated sites and species.	Low priority to fill 'aspirational' knowledge gaps. Further assessment of the presence and distribution of mammals and protected species within the canal reaches of interest – notably otter and water vole. If the high priority hydrological and water quality assessments recommended anticipate significant change within the canal environment, as a result of the proposed water transfer, then further assessment should be considered.	TBC (dependent on outcome of Gate 2 pathways recommendations 3.2 and 4.3)
3	9.1	Knowledge gap regarding the extent to which the Coventry Canal may contribute to habitat and species diversity at Alvecote Pools SSSI.	If notable change in flow/ water quality is anticipated, then a site visit/ habitat walkover at Alvecote Pools SSSI should be undertaken, and targeted surveys to allow for better characterisation of canal ecology should be considered (if notable change in flow/ water quality is anticipated).	TBC (dependent on outcome of Gate 2 pathways recommendations 3.2 and 4.3)
3	9.2	Knowledge gap regarding the extent to which the Oxford Canal may contribute to habitat and species diversity at Swift Valley LNR.	If notable change in flow/ water quality is anticipated, then a site visit/ habitat walkover at Swift Valley LNR should be undertaken, and targeted surveys to allow for better characterisation of canal ecology should be considered.	TBC (dependent on outcome of Gate 2 pathways recommendations 3.2 and 4.3)
3	9.3	Knowledge gap regarding the extent to which the GUC may contribute to habitat and species diversity at Frays Valley LNR and Denham Country Park LNR.	If notable change in flow/ water quality is anticipated, then a site visit/ habitat walkover at Frays Valley LNR and Denham Country Park LNR should be undertaken, and targeted surveys to allow for better characterisation of canal ecology (e.g. macroinvertebrates) should be considered.	TBC (dependent on outcome of Gate 2 pathways recommendations 3.2 and 4.3)

Work package	Work topic recommendation number	Knowledge / information gap	Recommendation	Sequencing
3	9.4	There is uncertainty regarding the potential for level change in some canal pounds. This raises uncertainties regarding the canal's role as a possible supporting habitat for protect species, such as otter.	If hydrological assessments anticipate significant level change within the canal environment, then further assessment of protect species distribution – and the extent to which species utilise canal habitat – should be considered. E.g. white-clawed crayfish associated with Northampton Arm.	TBC (dependent on outcome of Gate 2 pathways recommendation 3.2)
3	10.1	Uncertainty regarding the potential for a pathway of effect of the proposed GUC Strategic Transfer on birds of the canal or associated wetlands.	As per pathways recommendations for work topics 3 and 4, need for hydromorphological assessment to better understand whether bird populations associated with the canal would be subject to a pathway of effect resulting from the proposed GUC Strategic Transfer. Then reappraise birds as a receptor.	Gate 2 (dependent on outcome of Gate 2 pathways recommendations 3.2 and 4.3)
3	10.2	Uncertainty regarding the presence of breeding and / or non-breeding birds	If Gate 2 work on modelling of pathways effects identifies risk, undertake further desk-study to identify sections of the canal network that are covered by detailed national survey effort to determine what species are present and in what numbers (for instance in numbers of local, regional or national importance). This could be targeted to specific parts of the transfer route where risk is identified. If no data are available for areas where sensitive species or habitats are located, then targeted surveys for birds should be considered.	TBC (dependent on outcome of Gate 2 pathways and receptors recommendations and item 10.1)
3	11.1	Uncertainty regarding the relative risks posed by different discharge locations and transfer route options	Undertake a semi-quantitative assessment of the relative risks of the different SRO sub-options to affect the existing distribution of INNS within the canal network. This should be conducted using a pathway-based approach which incorporates existing INNS data.	Gate 2
3	11.2	Uncertainty regarding the risk of transferring INNS within the GUC via back-pumping	Conduct a semi-quantitative risk assessment of moving INNS within the GUC via the back-pumping of water.	Gate 2
3	11.3	Consideration of the potential for infrastructure construction to introduce/ spread INNS	Conduct a semi-quantitative risk assessment of the potential pathways of introducing INNS during the construction process.	Post Gate 2

Work package	Work topic recommendation number	Knowledge / information gap	Recommendation	Sequencing
3	11.4	Lack of understanding of the mitigation measures required	Carry out an options appraisal of mitigation options for the identified risks.	TBC (dependent on items 11.1 and 11.2)
3	11.5	Consideration of possible impacts of environmental changes on INNS spread	Analyse predicted water quality and/ or flow changes in the context of INNS to determine whether impacts on the spread of species within the system are likely.	TBC (dependent on outcome of Gate 2 pathways recommendations 3.2 and 4.3)
4	12&13.1	Relevance and significance of key benefits likely to vary amongst stakeholders.	Benefits identified within work topics 12 and 13 are discussed with stakeholders before being assessed in greater detail.	Ongoing (within parallel non-water resource benefits workstream)
4	12&13.2	Limited quantitative and biophysical evidence supporting an impact pathway approach.	Utilise outputs form relevant workstreams and associated work packages (e.g. impact assessments) to identify and articulate benefits of the canal transfer scheme.	Gate 2 (dependent on outcome of Gate 2 pathways & receptor recommendations)
4	12&13.3	Gaps in valuation evidence needed to support the assessment of benefits in relation to canals and the transfer scheme.	Identify significant benefits likely to be associated with the transfer scheme and assess adequacy of valuation evidence related to these.	Ongoing (within parallel non-water resource benefits workstream)
4	12&13.4	Difficulty in identifying relevant outcome indicators for some benefits that could be relevant to canals and the proposed transfer scheme.	Identify outcome indicators for significant benefits likely to be associated with the transfer scheme.	Ongoing (within parallel non-water resource benefits workstream)

Work package	Work topic recommendation number	Knowledge / information gap	Recommendation	Sequencing
4	12&13.5	Transferability of some valuation evidence from one context to another.	Identify significant benefits likely to be associated with the transfer scheme and assess transferability of valuation evidence related to these.	Ongoing (within parallel non-water resource benefits workstream)

** Clarification on this point as part of the EA review of this document would be greatly appreciated.*

Table 6.2 Compiled monitoring recommendations for Gate 2 from the parallel, and ongoing, ecological monitoring project

		Jan 2021 – March 2022														
Activity	**Location**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Canal drawdown for fish population assessment	1 or 2 locations, co-located with 2020 fish survey location(s)									■	■					
Canal CPET	In-line with 2020 monitoring locations*					■	■	■	■	■	■					
Targeted INNS monitoring (bivalves, amphipods)	Canal at river/ canal confluences					■	■	■	■	■						
Canal PYSM**	Canal at river/ canal confluences					■										
Macrophytes	Chalk streams (rivers Bulbourne, Gade, Colne & Chess) – US & DS of river/ canal confluences						■	■	■	■						

**It is acknowledged that this may require further consideration, as the GUC Strategic Transfer progresses in determining the proposed route of water transfer*

*** The need for canal PSYM has not been confirmed by this literature review and gap analysis. However, it is an item that has been subject to ongoing discussion with the Environment Agency as part of the parallel monitoring project.*

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