ANNEX A2

Pipeline Route Appraisal Report

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

Minworth SRO

Severn Trent Water & Affinity Water

Pipeline Route Options Appraisal

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Severn Trent Water
A7W13155

Minworth SRO
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Pipeline Route Options Appraisal

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Executive Summary

Minworth Strategic Resource Option (SRO) is included as an SRO in the Price Review 19 Final Determination as a source option for the Severn to Thames Transfer (STT) SRO and Grand Union Canal (GUC) SRO. The project is now advancing through the Regulators' Alliance for Progressing Infrastructure Development (RAPID) gated process and is proceeding to Gate 2.

This document details the appraisal of pipeline route options from Minworth Sewage Treatment Works to the River Avon at predefined Gate 1 outfall locations.

The methodology of this appraisal takes a staged approach as outlined in the figure below:

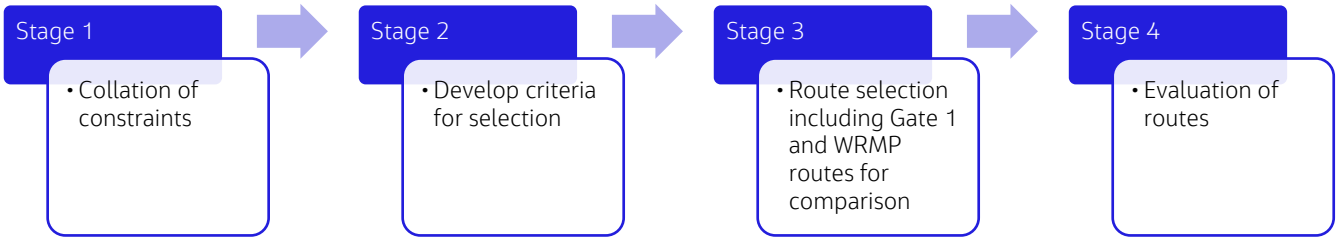

Figure 0-1. Staged methodology

- Stage 1: Opensource datasets have been compiled for the area of interest including Environmental, Geotechnical, Major services, and Ground level data. The output of stage 1 is a list of GIS datasets used and a series of Environmental Constraints Plans. The plans identify environmental features and designations of national and some local importance which the options may have a potential impact on or define the route and design choices.
- Stage 2: To allow comparison of the routes, to identify the preferred option, comparative costs have been developed for both capital expenditure (CAPEX) and operational expenditure (OPEX). In addition to cost comparison, a Multi-Objective Decision Analysis (MODA) has been developed to allow the inclusion of non-monetary factors important in option selection.
- Stage 3: A preliminary steady state hydraulic analysis has been undertaken in this stage and the output is the identification of long-list of potential routes for the pipeline. The general approach in defining the routes/corridors is based on achieving a balance between achieving the shortest distance from the pumping station to the outfall location (River Avon), and ensuring the route is functional in terms of pipeline hydraulics, as well as avoiding environmentally sensitive areas such as ancient woodland, SSSI etc.
- Stage 4: The routes were assessed against the criteria developed at Stage 2 for inclusion in the multi objective decision analysis tool MODA. To aid transparency of assessment, items included were digitised: either by a point denoting crossing location or a polyline indicating the length of pipeline estimated to be affected. These are included in the GIS data package issued alongside this appraisal.

The conclusion of this appraisal is that Pipeline Route G2 WRMP19 is ranked 1. This conclusion considers cost, constructability, crossings numbers, and other difficulties. Route G2 WRMP19 is the preferred option due to its low cost of construction and its high rating on the MODA criteria. The route has low elevations giving it a lower hydraulic profile, and overall, it goes through open field grounds avoiding environmental and social constraints. Also, the route has a suitable break pressure tank location with easy access for construction.

In contrast, the pipeline routes G1 North Warwick and G1 South Warwick are ranked least favourable due to their high cost of construction and low rating on the MODA criteria, these routes are long routes that go through a high number of crossings (including crossing the HS2 three times), also, long sections of these routes are along or adjacent to existing highways, this creates a high-risk construction process due to traffic disruption and numerous buried services. See below Figure 0-2: Shortlisted routes and Figure 0-3: Preferred Route G2 WRMP19

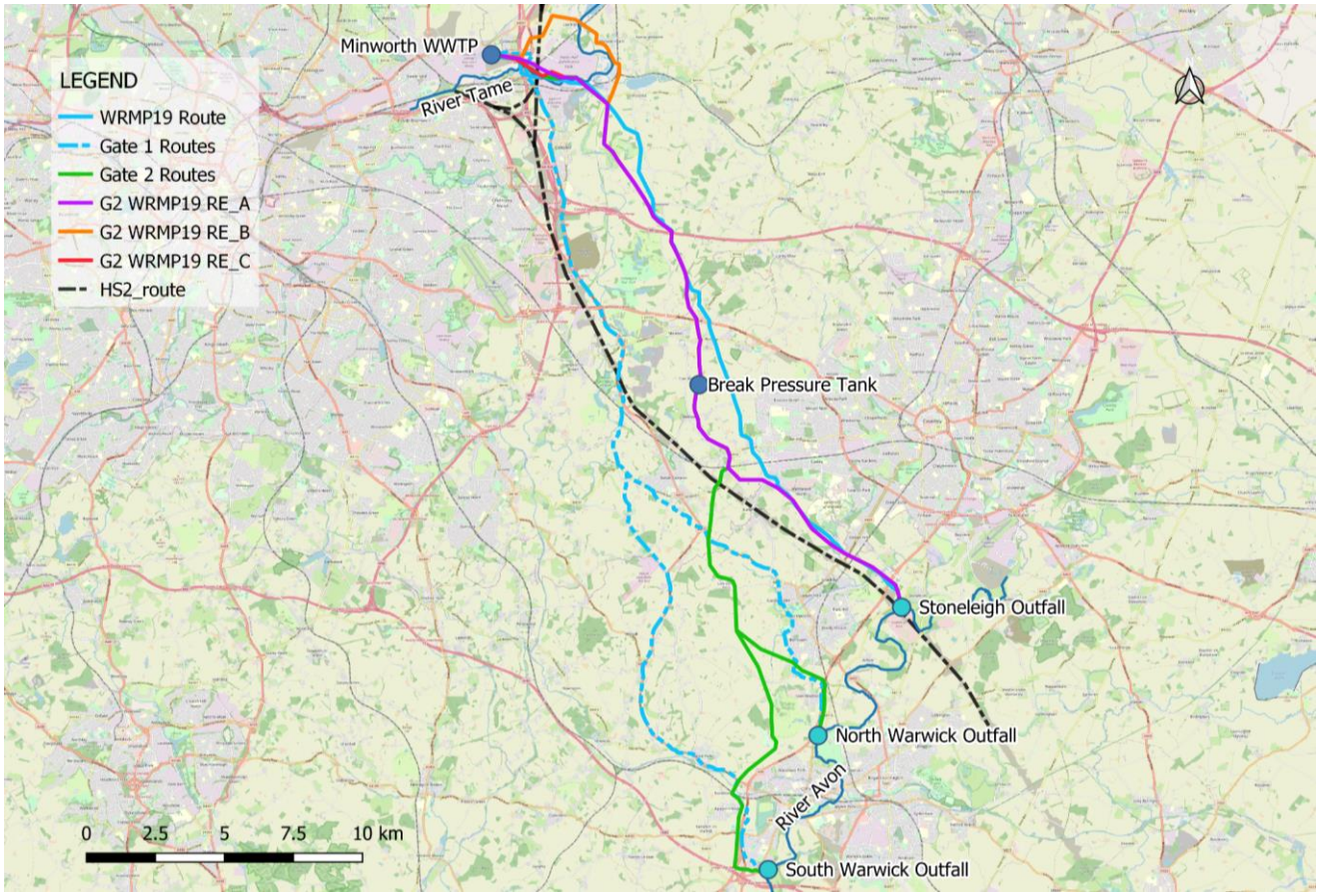

Figure 0-2: Shortlisted routes.

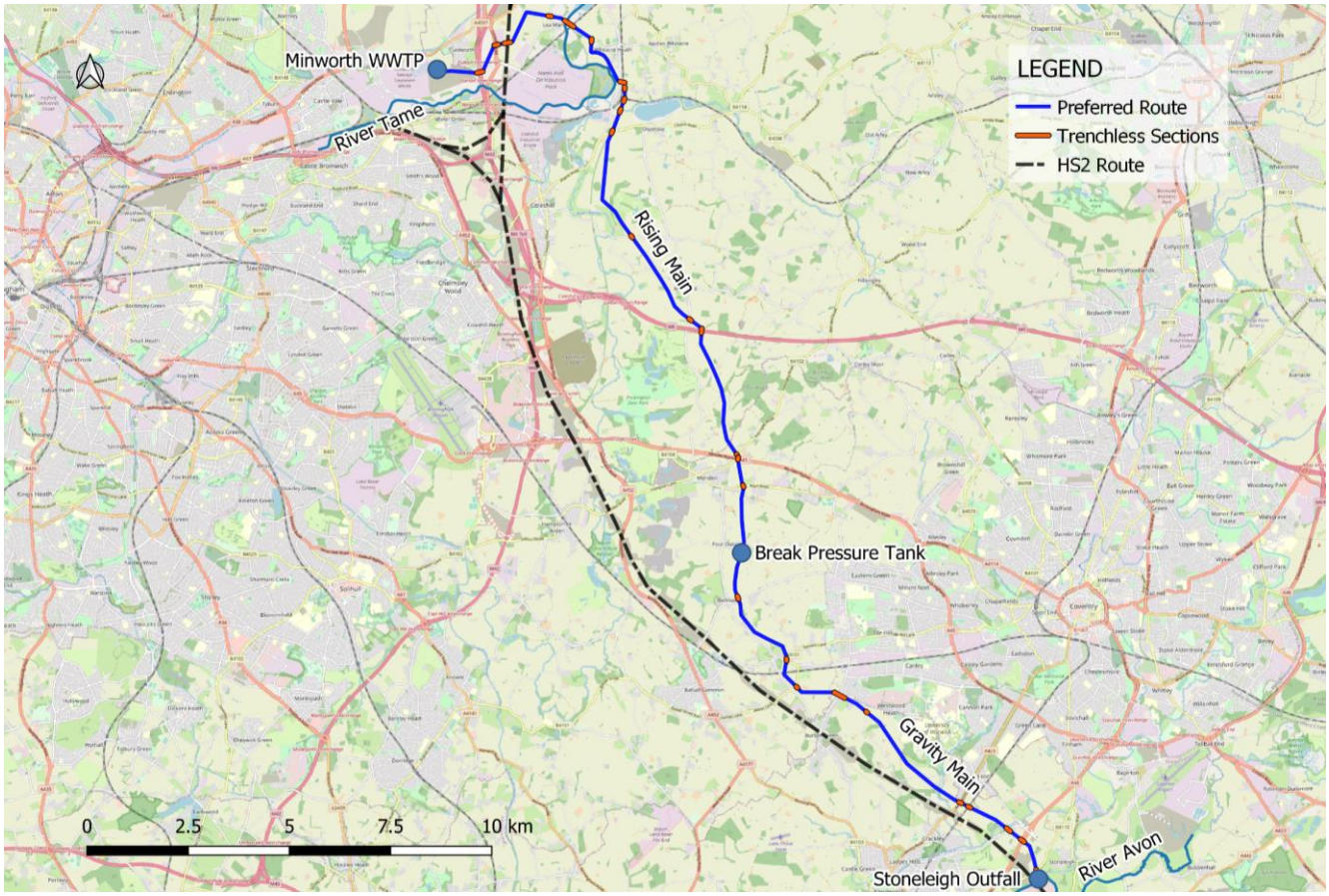

Figure 0-3: Preferred Route G2 WRMP19 RE_B

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Acronyms and Abbreviations

BPT	Break Pressure Tank
CAPEX	Capital Expenditure
GIS	Geographic Information System
GUC	Grand Union Canal
MODA	Multi-Objective Decision Analysis
NPPF	National Planning Policy Framework
NPV	Net Present Value
OPEX	Operational expenditure
PROW	Public Right of Way
STT	Severn to Thames Transfer
SRO	Strategic Resource Option
SSSI	Site of Special Scientific Interest
TOTEX	Total Expenditure
WwTW	Wastewater Treatment Works

1. Introduction

1.1. Background

Minworth Strategic Resource Option (SRO) was included as an SRO in the Price Review 19 Final Determination as a source option for the Severn to Thames Transfer (STT) SRO and Grand Union Canal (GUC) SRO.

The GUC pipeline appraisal is being undertaken by GUC SRO team, whereas this appraisal addresses the conveyance scope of Minworth SRO which proposes the provision of a pipeline to transfer 115Mld from Minworth Wastewater Treatment Works (WwTW) to the River Avon to supply STT SRO.

At Gate 1 two routes were developed, one to the North of Warwick and one to the South of Warwick, which also discharged to the GUC. In addition to this a further route was developed during WRMP19, to a discharge location downstream of the confluence of River Avon and River Sowe. See Figure 1-1 below.

The two routes developed during Gate 1 and WRMP19 have been included in the appraisal to allow comparison with alternative options developed as part of this routing exercise.

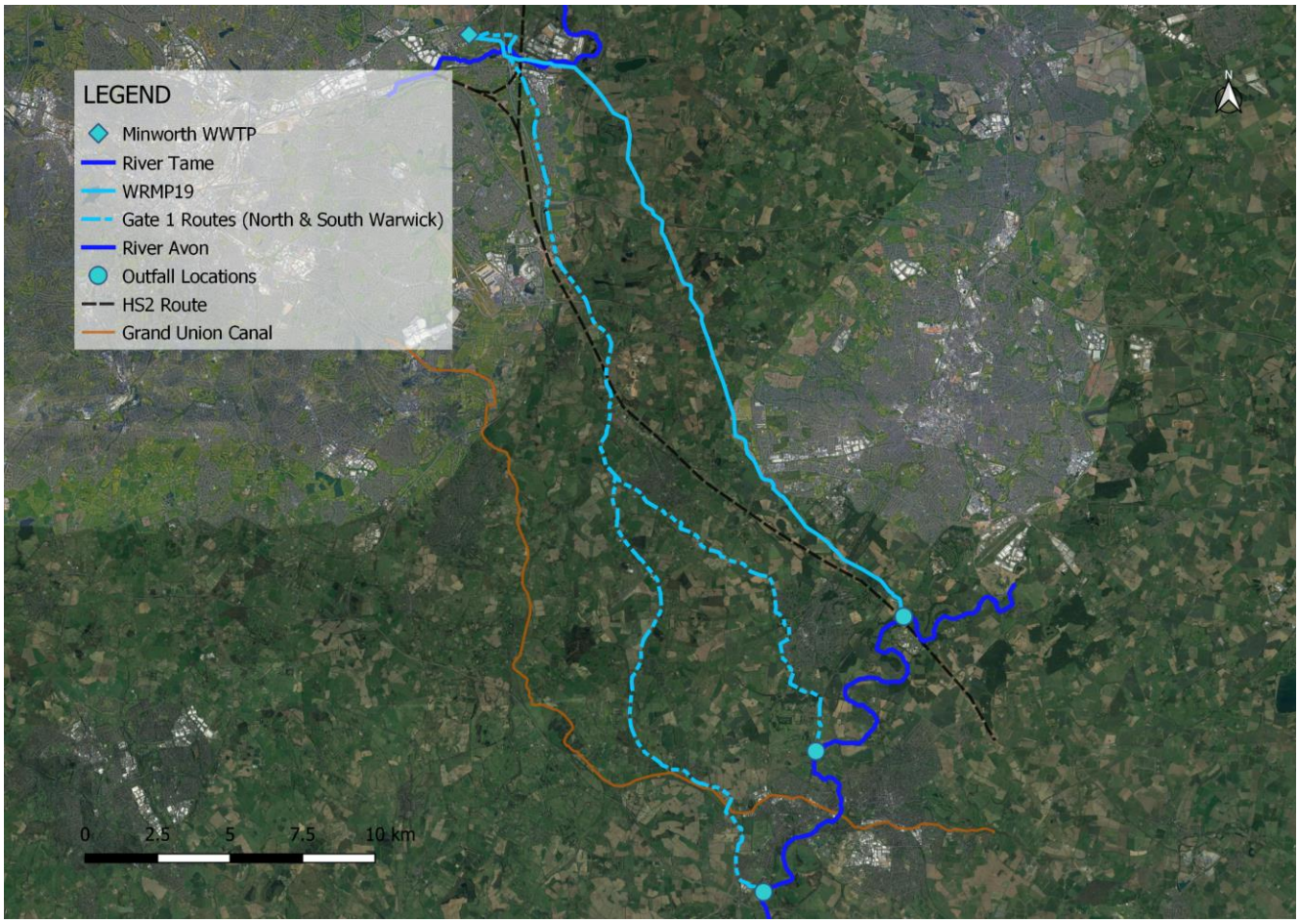


Figure 1-1: Gate 1 and WRMP19 Route Overview

Whilst there are multiple options of discharge location for the GUC SRO the preferred option(s) do not coincide with a route to the River Avon and therefore a combined pipeline option is not being progressed. However, all routes to the outfall South of Warwick cross the GUC.

Three discharge locations were identified in Gate 1, however at this stage results from environmental surveys are still ongoing, as such we have used the Gate 1 discharge locations are as shown above and listed below.

Table 1-1. Discharge locations

SRO	Receiving Waterbody	Pipeline Route	Discharge Location
STT SRO	River Avon	WRMP19	Stoneleigh
		Gate 1 - North Warwick	North Warwick
		Gate 1 - South Warwick	South Warwick
GUC SRO	None considered	n/a	n/a

1.2. Purpose

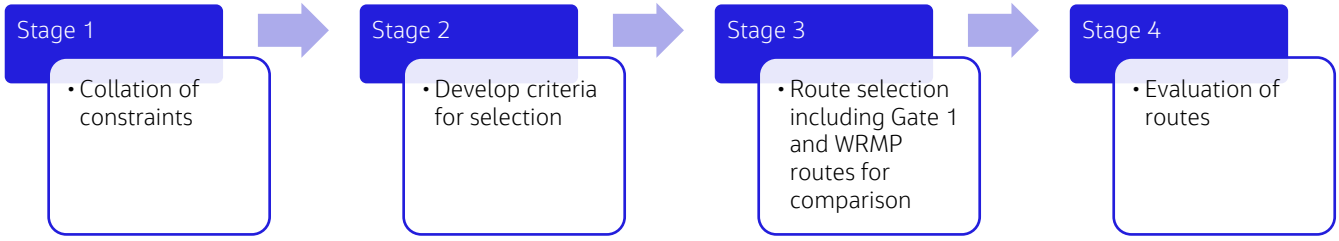
The purpose of this appraisal is to describe the activities undertaken to identify and evaluate pipeline route options to transfer the required flows from Minworth to the River Avon. Alongside the environmental assessment of the discharge locations, the desired outcome is to identify the preferred route option for Gate 2.

This appraisal describes the methodology applied, the details of the analysis carried out and a summary of the findings from the desktop pipeline route appraisal. Issued separately from this report is the accompanying GIS data package of constraints data, see details in Appendix B. Constraints Data. Additionally, this appraisal is a supporting document to the Concept Design Report for Minworth SRO.

1.3. Methodology

The appraisal has been carried out in four stages, shown in Figure 1-2 below and described in the subsequent sections.

Figure 1-2. Staged Methodology



1.3.1. Stage 1 – Collation of Constraints

Opensource datasets have been compiled for the area of interest including Environmental, Geotechnical, Major services, and Ground level data. The output of stage 1 is a list of GIS datasets used and a series of Environmental Constraints Plans. The plans identify environmental features and designations of national and some local importance which the options may have a potential impact on or define the route and design choices.

1.3.2. Stage 2 – Develop Criteria for Selection

To allow comparison of the routes, to identify the preferred option, comparative costs have been developed for both capital expenditure (CAPEX) and operational expenditure (OPEX). In addition to cost comparison, a Multi-Objective Decision Analysis (MODA) has been developed to allow the inclusion of non-monetary factors important in option selection.

1.3.3. Stage 3 – Route Selection

A preliminary steady state hydraulic analysis has been undertaken in this stage and the output is the identification of long-list of potential routes for the pipeline. The general approach in defining the routes/corridors is based on achieving a balance between achieving the shortest distance from the pumping station to the outfall location (River Avon), and ensuring the route is functional in terms of pipeline hydraulics, as well as avoiding environmentally sensitive areas such as ancient woodland, SSSI etc.

1.3.4. Stage 4 – Evaluation of Routes

The routes were assessed against the criteria developed at Stage 2 for inclusion in the multi objective decision analysis tool MODA. To aid transparency of assessment, items included were digitised: either by a point denoting crossing location or a polyline indicating the length of pipeline estimated to be affected. These are included in the GIS data package issued alongside this appraisal.

1.4. Limitations

Limitations of this appraisal include the following:

- The Gate 1 and WRMP19 routes were not available in GIS formats such as Shapefiles or KML/KMZ, and the sole purpose of this appraisal is to assess these routes and recommend a preferred option to be investigated further in the next stage. To account for this, the routes were reproduced based on the information available such as the Gate 1 long sections drawings.
- Pipeline route development criteria are included in Appendix A.
- Information about the constraints considered in this appraisal are included in Appendix B. Constraints Data, as well as their relevant data source.
- Additional constraints may be identified in later stages and may impact the preferred route, such as the major buried services which were not available at this stage. See section 2.2. Constraints Limitations.
- The outfall locations used in this appraisal are the same locations provided in Gate 1, alternative outfall locations are proposed as opportunities for cost savings in section 6.2. Opportunities. These opportunities require further investigation.
- Costing has been limited to the elements available in the Severn Trent Cost Tool Lite - May 2019 Version, whereas the non-monetary elements have been included in Jacobs multi objective decision analysis MODA tool to allow inclusion in the assessment.
- Benefits have not been costed; it is assumed that they will be similar for all of the pipeline routes.
- The operational regime is assumed that the running time is 24 hrs with 90% of the time sweetening flow and 10% of the time peak flow. At this stage, the sweetening flow is assumed to be 10% of peak flow.
- No land referencing has been undertaken.
- Land and property compensation risk has not been considered.
- Transient analysis has not been undertaken at this stage.

2. Stage 1 – Collation of Constraints

2.1. Constraints Data

To assist with determining the environmental scheme feasibility, a series of Environmental Constraints Plans have been produced and are included in the Appendix C. Environmental Constraints Plan and Appendix D. Heritage Constraints Plan. The plans identify environmental features and designations of national and some local importance which the options may have a potential impact on or define the route and design choices.

Assessment of the potential impacts or effects on the environmental features from the proposed SRO options has not been included. The environmental constraints plans are to be used by the Engineering Team for guidance and illustration, to help with the development of the SRO routes and designs, with the initial aim to avoid and/or limit the direct impacts to the environmental features in the first instance.

Due to the amount of data available and to allow for clarity when viewing, the information set out in Appendix B. Constraints Data are split into two plans. The first plans are predominantly general environmental features (Environmental Constraints Plans) with the second set being historical and archaeological data (Heritage Constraints Plans). Note that both sets of constraints were considered during route selection, the split is only for presentation purposes.

Available mapping and aerial imagery were used to identify the visible constraints mentioned below:

- Roads – Motorways, A roads, B roads, minor roads, un-made roads and tracks
- Canals
- Railways
- Abandoned railway lines
- Golf courses
- Buildings
- Private gardens
- Private yards
- Football pitches and sports fields
- Ponds
- Equine facilities
- Field boundaries, hedge rows and trees

Contours were generated from ground level data to identify high ground and steep slopes. The contours were generated at 10m intervals from 40 to 200 m AOD, anything higher than 120 m AOD was considered high was and avoided when possible. Steep slopes were defined as 1 in 10.

2.2. Constraints Limitations

The production of the Environmental Constraints Plans does not construe any statutory or non-statutory environmental assessment that has been undertaken and they are only to be used as illustration and guide of key environmental constraints to aid with the selection and definition of appropriate routes; whereabouts the most significant environmental risks and impacts can be avoided or reduced at an early phase.

Due to the scale of the scheme, the spread of the different options and the zone of influence used, it was necessary to break the plans up to allow for more detail to be provided on the boundaries and locations of features in relation to the proposed alignments. Smaller scale plans have been produced to illustrate the entire area.

The following data was not freely accessible in digital format via public domains and is required to be requested from Local Authorities (Staffordshire County Council, Warwickshire County Council and West Midlands County Council) and may not be digitised:

- Conservation Areas and Tree Preservation Orders
- English Local Authority Green Belt Dataset
- Local Wildlife Sites / SINC / SNCI

Full services searches of the routes have been undertaken. Utilities companies have provided indicative information on the approximate location of their services, but no depth information is available.

Land and property compensation risk has not been considered, and no land referencing has been undertaken.

There will be an abundance of Public Right of Ways (PROWs) in close proximity to the route alignments which would need to be reviewed during the environmental assessment. Due to the scale of the scheme and the current vision of the options it was thought that adding PRoW to the plans would potentially create a cluttered illustration and detract from the constraints that are likely to be more critical to the decision and design process. Therefore, the PROWs were considered but are not shown on plans.

The presence / absence of protected species and their habitats has not been included. This data would require specific surveys to be carried out and the data digitised. Assumptions can be made for certain habitats that could support particular protected species that would require specific mitigation and in some circumstances consent from regulators to disturb i.e., rivers/streams can support riparian species such as otter and water vole, or ponds support populations of Great Crested newt, or trees and buildings can be habitat for bats (noting that the habitats for bats are protected along with the individuals). The data.gov.uk data library (illustrated on Magic.gov.uk) does provide locations for previously held protected species licences. However, as per the PRoW illustration it is likely that this would create a cluttered plan.

Although the historic licence locations provide an indication of where particular species have previously been encountered and licences have been granted to complete works that have some level of disturbance, they are relatively limited as they are only a single point in time and do not allow for the likely movement of species or guarantee that they are still present.

The Green Belt designation has not been included on the plans as it covers a significant area of land and would potentially detract from other constraints that are likely to be more critical to the decision and design process. Paragraph 150, of the National Planning Policy Framework (NPPF) 2021 refers to 'engineering operations' as an acceptable form of development within the Green Belt, providing its openness is preserved and the proposals do not conflict with the purposes of including land within it (see para 138. of NPPF for purpose of Green Belt). Any mitigation would need to demonstrate that the openness of the area was not jeopardised.

Appendix N Environmental Constraints Tech Note includes the Environmental and Heritage Constraints Plans, the sources of data and their limitations.

3. Stage 2 – Develop Criteria for Selection

To allow comparison of the routes to identify the preferred option, comparative costs have been developed for both capital expenditure (CAPEX) and operational expenditure (OPEX). In addition to cost comparison, a Multi-Objective Decision Analysis (MODA) has been developed to allow the inclusion of non-monetary factors important in option selection.

3.1. Comparative Costs

Comparative costs were developed for each route using cost profiles included in Severn Trent Cost Tool Lite - May 2019 Version.

Alternative pipe sizes were considered for the same flow for each route to identify the least cost option, based on the capital and operational costs included.

3.1.1. Pipeline Hydraulics

To allow the capital and operational costs to be developed, steady state hydraulic analysis of the routes has been undertaken. A single diameter for the rising main and a single diameter for the gravity main have been assumed. Note that for the preferred route there is an opportunity for cost savings by reducing the size of gravity main after Westwood Heath hill. This will be proposed in the preferred route appraisal.

The following parameters were used to determine the pipe size and pump lift:

- Pipe material: steel
- Pipe roughness: 0.3mm
- Fittings' losses: 15% of the pipe headloss
- Overall pump efficiency: 65%
- Assumed lift within pumping station: 6m
- Pump run time: 24hrs per day
- Maximum pressure: 16Bar
- Maximum velocity: 2.5m/s

Multiple pipe diameters were tested to determine the most cost-effective pipe diameter for each route. Since the pipeline will operate at the maximum flow rate infrequently, this analysis tended towards a smaller pipe diameter, lower pipeline CAPEX option. Lower flow rates are more usual for constantly operating pipelines. A larger maximum velocity has been selected to minimise the carbon impact of a larger diameter pipeline that would be infrequently used. The maintenance implications of running at a higher velocity are mitigated by the limited operational use at maximum flow for the pipeline. Selection of a smaller pipe is also more appropriate for the "normal" sweetening flow operational condition.

Surge analysis has not been undertaken at this stage.

Twin pipelines have not been considered since there is usually a cost premium for doing this, since two 1.2m diameter pipes are required to replace a 1.6m diameter pipe. In addition, transfer is not required at all times, so maintenance will be possible.

3.1.2. Capital Expenditure

Comparative costs incorporated are identified in Appendix H. Comparative costs. Only costs likely to be differentiators between options have been included in this assessment, for example Break Pressure Tank (BPT) and outfall costs have been excluded as these are considered the same for all options. Risk has not been included, but likely risks have been considered when determining the MODA criteria.

Table 3-1 summarises the costing elements considered used for comparing pipeline options.

Table 3-1. Comparative cost basis

Element	Comments
Pipe	Cost per m based on pipe diameter – Single rising main diameter and single gravity main diameter. Rising main diameter can be different to gravity main diameter. ST Cost Lite Level 3 elements used: ▪ Pressure mains in fields / verges ▪ Pressure mains in rural / suburban highway ▪ Pressure mains in urban highway Any lengths proposed to be within verges will be costed as highway, since for a large diameter trunk main, such as this, working within a small working width of a verge will result in considerable cost uplift.
Crossings (extra over to pipe cost)	Number of crossings of each type calculated with a cost applied to each crossing type. Crossing type, method assumed, and ST Cost Tool Lite Level 3 elements used: ▪ Motorway – trenchless - Major Road (M) crossings ▪ A road – trenchless – Major Road (A/B) crossings ▪ B road – trenchless – Major Road (A/B) crossings ▪ Minor road – open cut – Minor Road (unclassified) crossings ▪ Railway - trenchless – Railway line crossings (Public) ▪ HS2 – trenchless – Railway line crossings (Public) ▪ Main river – trenchless – Watercourse crossings ▪ Ordinary watercourse – open cut (watercourse flumed) – Watercourse crossings ▪ HV – open cut (safe system of work) – Overhead Electric Crossings (Pylons supported) ▪ Canal – trenchless – Canal Crossings Where trenchless see additional cost for trenchless
Trenchless	Trenchless sections have been identified for crossings and to avoid environmental constraints where appropriate. Pipe jacking of one pipe diameter larger has been assumed. ST Cost Tool Lite Level 3 element used: ▪ Tunnelling / pipe jacking
Pumping station	Capital cost based on relationship to power requirements ST Cost Tool Lite Level 3 element used: ▪ Major Water Pumping Station

3.1.3. Operational Expenditure

The various routes have an impact on the hydraulic performance of the pipeline, in particular the pumping head and therefore the operational cost. To enable a comparison to be made on the effect of the various routes on the operational cost of the pumping station, a high-level net present value (NPV) estimate of the pumping costs has been undertaken. The following assumptions have been made:

- OPEX cost over 50 years factored to the Net Present Value
- Discount rate: [redacted] per annum
- Energy cost: £[redacted]/kWh

Commercial information redacted

At this stage the operating regime of the pipeline is not known. The following assumptions have been made:

- Peak flow: 115 Mld
- Sweetening flow: 10% of peak flow
- Percentage of time sweetening flow: 80%
- Percentage of time peak flow: 20%
- Running time: 24hrs per day – both sweetening flow and peak flow

An alternative to sweetening flow would be to drain the entire pipeline. At this stage sweetening flow has been assumed as a conservative assumption.

3.2. Non-Monetary Multi Objective Decision Analysis

A non-monetary multi objective decision analysis tool (Jacobs' MODA) is a method used to rank alternatives based on how well they rate against a chosen set of objectives (evaluation criteria). Criteria are weighted by relative importance, and the overall "decision score" of an alternative is the weighted sum of its rating against each criterion. Criteria are typically derived from critical success factors, shaped by key issues, assumptions, and boundaries from decision process definition

MODA proceeds through a series of defined steps, as follows:

- Establish the decision context
- Identify and specify evaluation criteria
- Develop alternatives
- Develop performance measures (measurement scales) to measure how well alternatives meet each evaluation criterion
- Assign scores that identify how well each alternative meets each evaluation criterion
- Assign weights to the evaluation criteria to reflect the relative importance of the various criteria
- Calculate total value scores and conduct sensitivity analysis

3.2.1. Decision Analysis Methodology

The MODA decision analysis evaluation process is carried out through the following steps:

Table 3-2: MODA Staged Methodology

MODA Defined Steps	Description
STEP 1: Setup	In this step the project purpose is defined and clearly stated, the type of criteria is also defined here, it's also decided whether to assess with high level main criteria only or to create a more detailed assessment which includes sub-criteria to each main criterion. Early on in this stage as well, the preferred weighting method is chosen.
STEP 2: Enter Criteria and Sub-Criteria	The criteria and sub-criteria are defined in this step, the technical team holds a workshop including all the necessary disciplines to define the main criteria, next, sub-criteria are defined to allow more detailed assessment which yields more accurate results.
STEP 3: Define Scales	Each sub-criteria needs a definition for a scale 1 scoring and scale 5 scoring and in anything between, those definitions are decided in this step. The measurement scale is also defined here, in this project a scale of 1 to 5 was defined for all sub-criteria for consistency.
STEP 4: Define Alternatives	In this step the alternatives (options) are defined and given a short and a long name

MODA Defined Steps	Description
STEP 5: Scoring	In this step a scoring is given to each alternative for each sub-criterion. The scoring rational is also explained in this step.
STEP 6: Individuals Providing Weights	The individuals providing the weights are named in this section, client involvement is recommended in this step as well as experts from all disciplines of the project.
STEP 7: Weighting Form	A weighting form is used to collect the weights from the individuals defined in the previous step.
STEP 8: Est. Consensus Weights	In this step the consensus weights are calculated by considering all the weights collected in the previous steps.
Results: Consequence Table	Results are shown in a consequence table format
Results: Consensus Weighting	Consensuses weightings are used to show results in a table format and multiple chart formats
Sensitivity Analysis	Sensitivity analysis is conducted on three levels: Sensitivity to overall weightings and to NPV weights and cost weights. And results are shown in table and chart formats.

3.2.2. Evaluation Criteria

The evaluation criteria and performance measures for this evaluation are shown in Appendix E. MODA Criteria. The principal areas considered are shown in Table 3-3 below. The criteria and sub-criteria are tailored to this project:

Table 3-3: Summary Table of MODA Evaluation Criteria and Sub-Criteria

ID#	Evaluation Criteria	Sub Criteria
1	Constructability	Length with steep slopes (incl. side slopes > 1 in 10) Length within flood zone Length within landfill Length within high groundwater table Likely complexity of trenchless crossings Other geotechnical risks Length within water supply source protection zone Length with narrow working width - where less than 40m available
2	Planning risk	No. of points where available options constrained i.e., pipe corridor width less than 200m Flexibility of BPT site location No. of HS2 crossings Route crosses land where permission likely to be difficult e.g., common land, trenchless beneath houses
3	Operational considerations	Maintenance requirements - likely number of air valves and washouts Hydraulics favourable
4	Customer disruption during construction	Length working within road (including lengths in verge) Ribbon development impact - pipe routed across ribbon development Length of route within 50m of residential properties Traffic disruption during construction

ID#	Evaluation Criteria	Sub Criteria
5	Break Pressure Tank siting	Site access Geotechnical risks
6	Land Costs	Length within high grade agricultural land High value land impacted - sports fields, golf courses, equine Residential properties directly affected i.e., gardens, or trenchless beneath
8	Carbon	Embodied carbon Operational carbon

3.2.3. Scales

Each criterion was scored where possible on a natural scale, based on direct measurement of a criteria. Where this was not possible a 1-5 scale was used, with five being the best outcome and one the worst, see the following Appendices for more details:

- Appendix E. MODA Criteria
- Appendix I. MODA Scoring
- Appendix J. MODA Weightings

4. Stage 3 – Route Selection

Indicative routes were developed to the three STT outfall locations, based on the methodology identified in Section 1.3.3. Constrained sections along the routes where the available working width is narrow have been identified.

4.1. Gate 1 Routes & WRMP19 Route

At Gate 1, two routes were developed, one to the North of Warwick and one to the South of Warwick. In addition to this a further route was developed during WRMP19, to a discharge location downstream of the confluence of River Avon and River Sowe. See Figure 4-1 below. The two routes developed during Gate 1 and WRMP19 have been included in the appraisal to allow comparison with alternative options developed as part of this routing exercise.

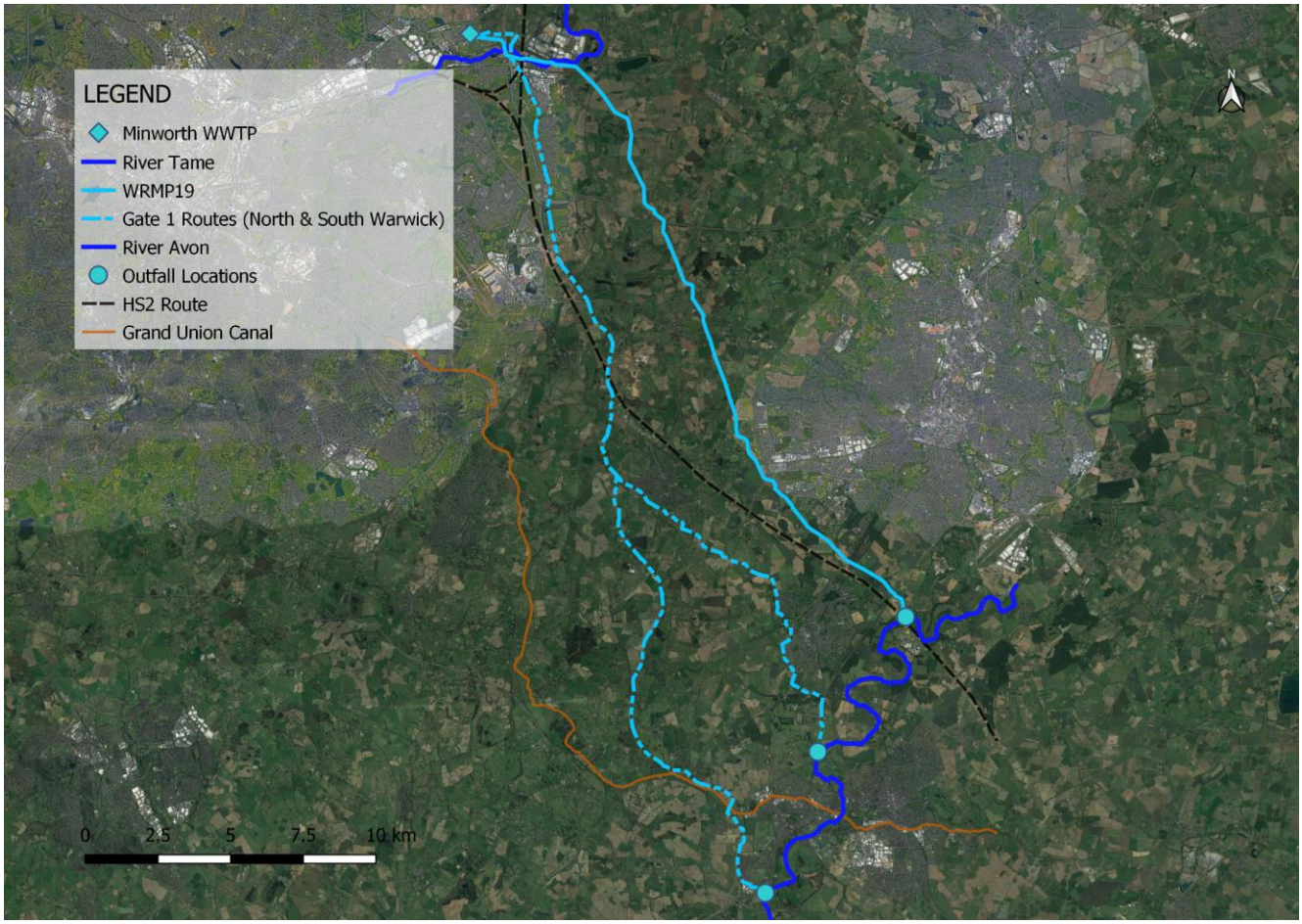


Figure 4-1: Gate 1 Routes and WRMP19 Route

A possible combined route starting on similar alignment to Gate 1 routes then connecting to WRMP19 has been considered and discounted, due to the following two main reasons:

- Gate 1 routes are extended alongside urban highways, which do not have space for the "right of way" trench, or suitable space in amongst existing utilities.
- There is no suitable crossing point to connect Gate 1 routes to WRMP19 because the space in between is a busy built-up area and/or full of constraints such as flood zones, and permitted landfill sites, with limited capacity for tunnelling.

4.2. Gate 2 Routes

The general approach for defining the routes is based on achieving a balance between achieving the shortest distance from the pumping station to the outfall location (River Avon), and ensuring the route is functional in terms of pipeline hydraulics, as well as avoiding environmentally sensitive areas such as ancient woodland, SSSI etc. To support this assessment, a preliminary steady state hydraulic analysis was undertaken at this stage and the output used to identify a shortlist of potential routes for the pipeline as shown in Figure 4-2.

The shortlisted routes described in Section 4.3 will be costed and evaluated against the list of criteria defined in Section 1.3.3 to identify the preferred route.

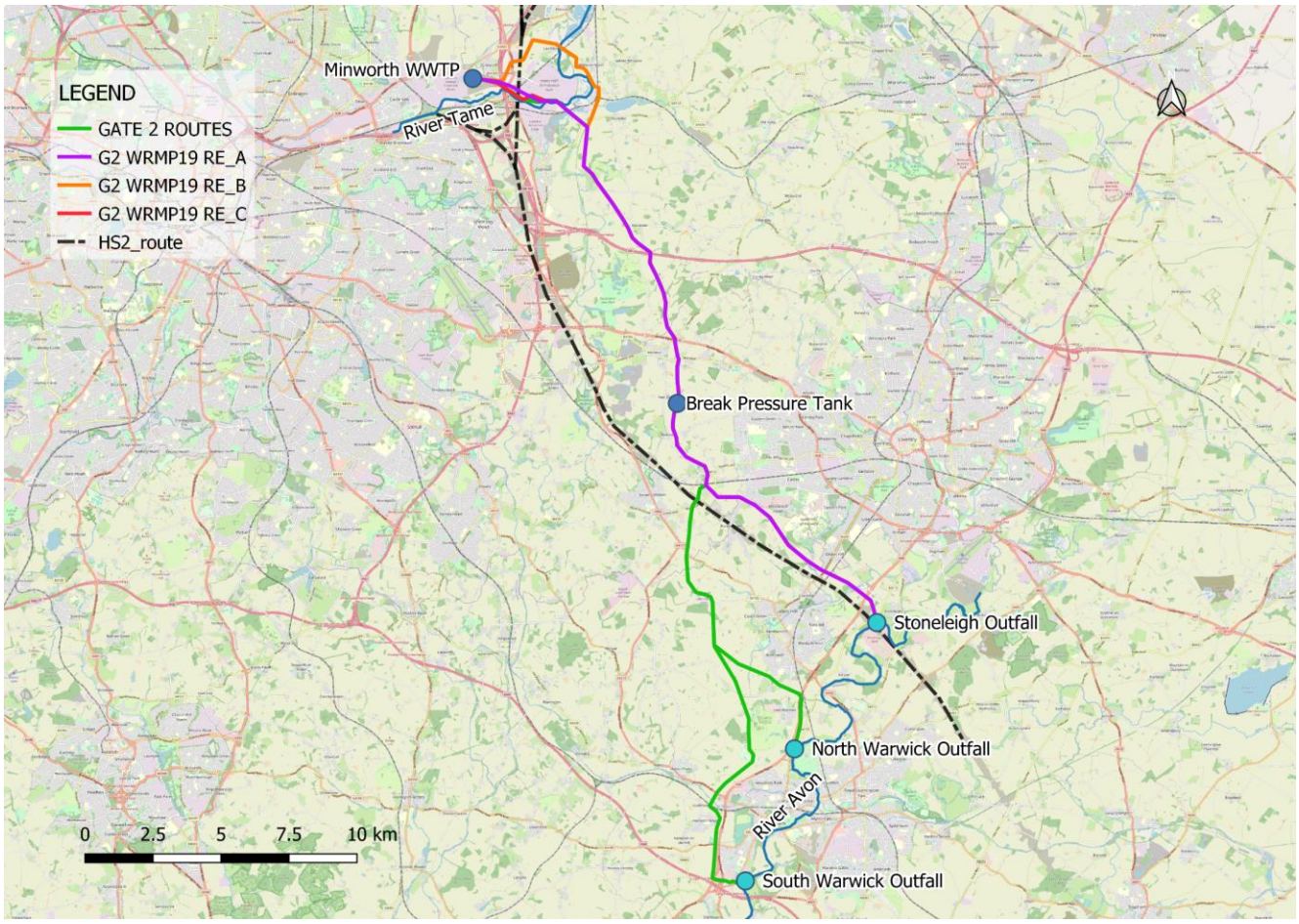


Figure 4-2: Gate 2 Proposed Routes

4.3. Shortlisted Routes

Table 4-1: Shortlisted Routes Lengths Table

Routes Name	Route Short Name	Overall Length (km)	Rising Main Length (km)	Gravity Main Length (km)
WRMP19	WRMP19	27.75	13.29	14.46
Gate 1 North Warwick	G1 NW	32.54	22.77	9.78
Gate 1 South Warwick	G1 SW	36.47	22.22	14.25
Gate 2 WRMP19	G2 WRMP19	28.25	15.91	12.34

Routes Name	Route Short Name	Overall Length (km)	Rising Main Length (km)	Gravity Main Length (km)
Gate 2 North Warwick	G2 NW	32.04	15.91	16.13
Gate 2 South Warwick	G2 SW	37.41	15.19	21.50
Gate 2 WRMP19 RE_ A	G2 WRMP19 RE_A	28.20	16.08	12.12
Gate 2 WRMP19 RE_ B	G2 WRMP19 RE_B	31.45	19.33	12.12
Gate 2 WRMP19 RE_ C	G2 WRMP19 RE_C	28.30	16.18	12.12

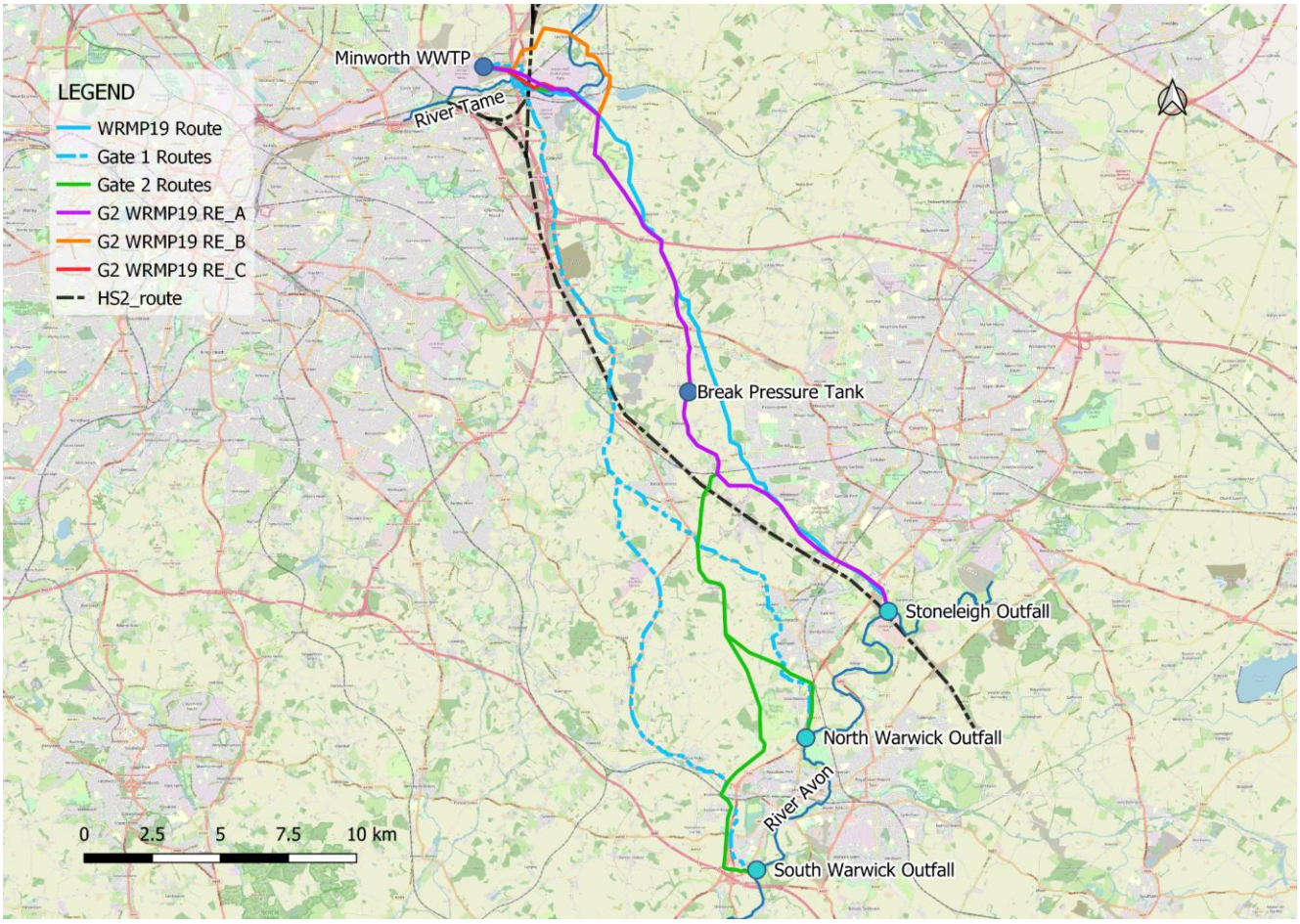


Figure 4-3: Shortlisted Routes Plan Overview - For individual Routes see Appendix F. Pipeline Routes

4.4. Route Constrained Sections – Narrow Working Width

A pipeline with a diameter of between 900mm and 1050mm diameter, will require a construction corridor approximately 40m wide to facilitate its installation. This is considered appropriate to allow sufficient area for the trench width, spoil heaps, pipeline stringing, pipe section storage areas and access tracks along the site. The construction area required can be narrower (to as little as 10m) for short sections, such as along roads or through hedgerows, with a commensurate increase in construction cost. In some areas wider worker areas may be necessary to accommodate side slopes or launch and reception pits / shafts for trenchless crossings.

Identified below are the sections where the constraints are clustered and causing a limited scope for the pipeline route alterations. These are highlighted in Figure 4-4 to Figure 4-7 below.

4.4.1. Constrained Sections A, B and C

Constrained section A affects all routes due to the crossing of M42 and M6 highways as well as the proximity to Beaver metals extractors. Note that Gate 2 Routes avoid this pinch point by crossing from a higher point to the North.

Constrained section B falls under Gate 1 Routes and it's a highly sensitive area due to crossing the HS2 route twice as well as proximity to Auria Solutions and BBV Water Orton compounds.

Constrained section C affects WRMP19 and Gate 2 routes due to proximity to industrial built-up area and multiple River Tame crossings.

Figure 4-4: Narrow working width at Minworth abstraction

4.4.2. Constrained Section D

Constrained section D affects WRMP19 and Gate 2 routes as it crosses a residential built-up area. It is not preferable to re-align the pipeline to the South, avoiding the pinch point, because of elevation constraints. This leave a residual risk that would need to be managed during construction. Gate 2 routes follow a route South of route WRMP19 to minimise as much as possible the residential area crossed by the pipeline, as shown in Figure 4-5.

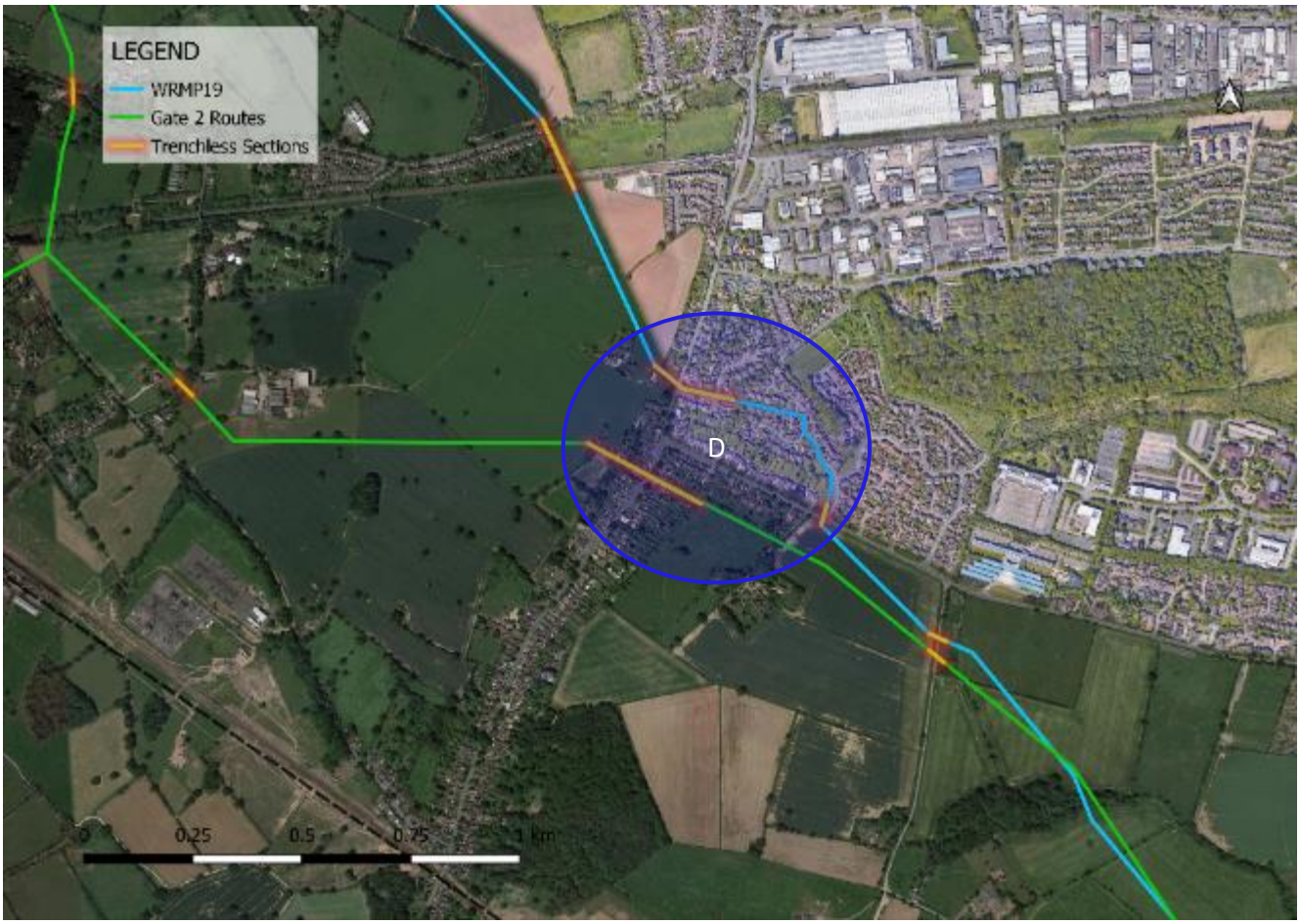


Figure 4-5: Narrow working width at Tile Hill

4.4.3. Constrained Section E

Constrained section E affects Gate 1 South Warwick route and Gate 2 South Warwick route due to proximity to built-up area. Note that an alternative outfall is considered as an opportunity to avoid this pinch point. See more in Section 6.2.2.

Figure 4-6: Narrow working width at South Warwick outfall

4.4.4. Constrained Sections - Gate 1 routes

All of the yellow highlighted sections affecting Gate 1 routes are complicated areas due to extending the pipeline within the urban highway road, Gate 2 routes avoid going through urban or rural highways and instead target open fields. These are highlighted in Figure 4-7.

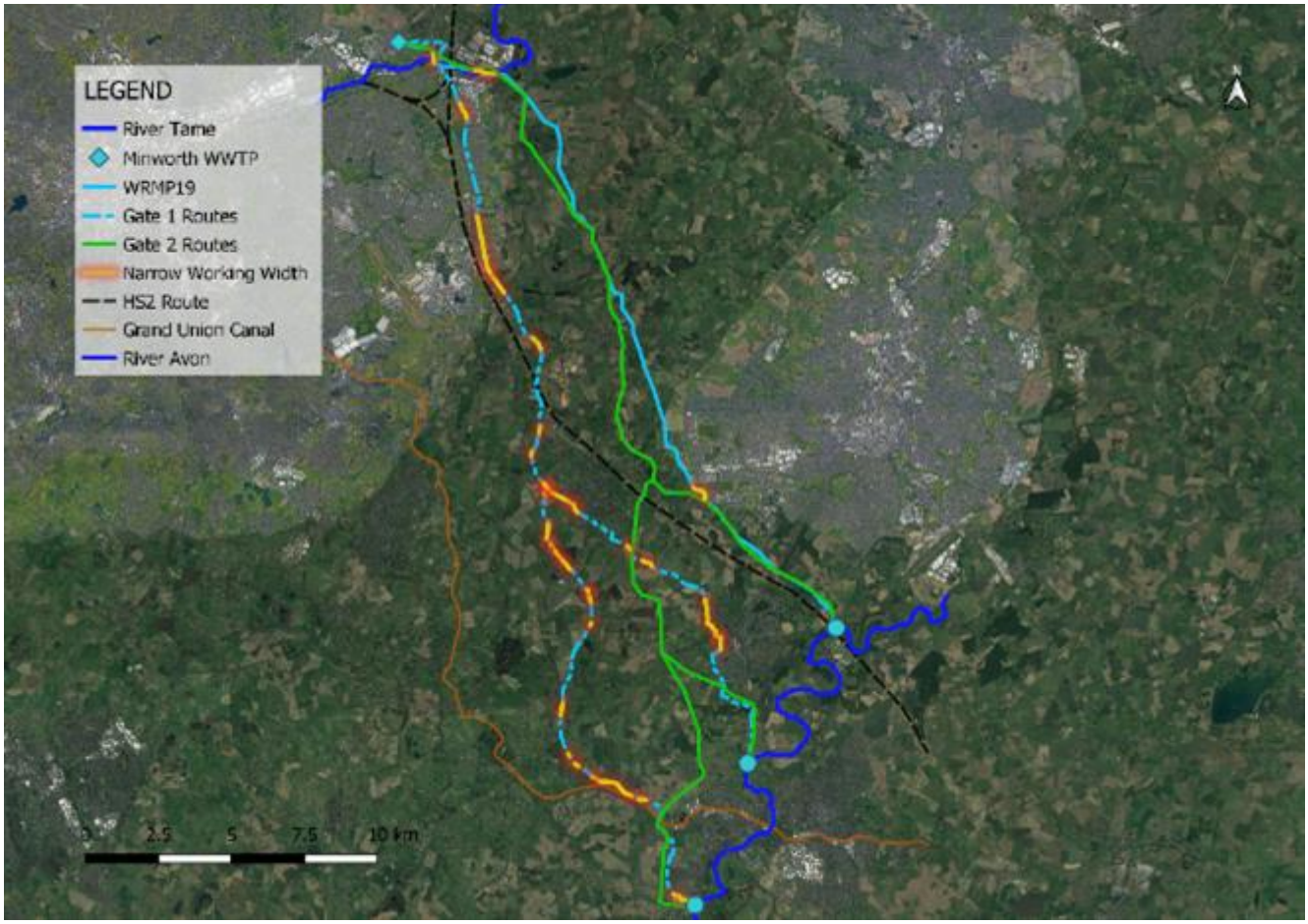


Figure 4-7: Narrow working width for Gate 1 Routes

5. Stage 4 – Evaluation of Routes

The pipeline routes are assessed using the following criteria:

- Ground Conditions
- Constructability
- Crossings
- Hydraulics
- Carbon Impact

The outputs of these assessments are used to create the comparative cost assessment.

5.1. Ground Conditions

5.1.1. Introduction and Resources

The six route options comprise the installation of a shallow buried pipe (≈2.5m depth) in a trench across open ground. However, all routes cross major third party owned / operated infrastructure including Railways (e.g., a future HS2 route), Major roads (Trunk Roads and A Roads), Motorways, Rivers and Canals. These will require the pipeline to be installed at depth under the infrastructure, requiring the drilling of trenchless crossings to install the pipeline.

Trenchless crossings are the main geotechnical obstacle / risk requiring investigation due to the variable ground and groundwater conditions expected to be encountered to determine the most appropriate crossing methods to be employed.

The installation of the pipeline in open ground will be by shallow trenches installed in a construction corridor; however, these will be affected by the ground and groundwater conditions, where temporary works comprising sheet piles / localized dewatering or benching of the excavations may be required to install the pipelines, support excavations and control groundwater.

This geotechnical appraisal has been compiled from the following available information:

British Geological Survey (BGS) on-line database http://mapapps.bgs.ac.uk/geologyofbritain/home.html

BGS online Geological Maps #168 Birmingham, #184 Warwick
https://webapps.bgs.ac.uk/data/maps/maps.cfc?method=listResults&MapName=&series=E50k&scale=&getLatest=Y&pageSize=100

Highways England Geotechnical Data Management System (HAGDMS)
https://www.hagdms.co.uk/

Groundsure enviro data viewer
https://www.groundsure.io/#

5.1.2. Geotechnical Analysis Summary

Below is a geotechnical summary of each route option. For further details please refer to Appendix K. Geotechnical Analysis, and Appendix L. Geotechnical Risk Register.

Table 5-1: Geotechnical Analysis Summary

Route	Trenchless Crossings	Geotechnical Issues – Superficial Deposits	Geotechnical Issues – Bedrock	Comments
WRMP 19	Identified potential individual trenchless crossing locations; however, the number could be	Both granular and cohesive materials are expected along the entire route, which will have potentially	Both granular and cohesive materials typically comprising the weathered upper layers of the bedrock,	The route does not follow highways, therefore is in open ground with potentially limited buried

Route	Trenchless Crossings	Geotechnical Issues – Superficial Deposits	Geotechnical Issues – Bedrock	Comments
	reduced by combining individual crossings into a longer drive.	high groundwater, especially near water courses. These may require groundwater control by trenching and/or dewatering.	are expected along the entire route. These will have the potential for, but limited groundwater where outcropping at ground level.	services, but multiple landowners and potential access issues.
Gate 1 - North Warwick	Identified potential individual trenchless crossing locations; however, the number could be reduced by combining individual crossings into a longer drive.	Both granular and cohesive materials are expected along the entire route, which will have potentially high groundwater, especially near water courses. These may require groundwater control by trenching and/or dewatering.	Both granular and cohesive materials typically comprising the weathered upper layers of the bedrock, are expected along the entire route. These will have the potential for, but limited groundwater where outcropping at ground level.	24km of the 32km are along or adjacent to existing highways. Disadvantages include traffic disruption and numerous buried services. However, fewer potential landowners and access issues.
Gate 1 - South Warwick	Identified potential individual trenchless crossing locations; however, the number could be reduced by combining individual crossings into a longer drive.	Both granular and cohesive materials are expected along the entire route, which will have potentially high groundwater, especially near water courses. These may require groundwater control by trenching and/or dewatering.	Both granular and cohesive materials typically comprising the weathered upper layers of the bedrock, are expected along the entire route. These will have the potential for, but limited groundwater where outcropping at ground level.	27km of the 36km are along or adjacent to existing highways. Disadvantages include traffic disruption and numerous buried services. However, fewer potential landowners and access issues.
Gate 2 - WRMP 19	Identified potential individual trenchless crossing locations; however, the number could be reduced by combining individual crossings into a longer drive.	Both granular and cohesive materials are expected along the entire route, which will have potentially high groundwater, especially near water courses. These may require groundwater control by trenching and/or dewatering.	Both granular and cohesive materials typically comprising the weathered upper layers of the bedrock, are expected along the entire route. These will have the potential for, but limited groundwater where outcropping at ground level.	The route does not follow highways, therefore is in open ground with potentially limited buried services, but multiple landowners and potential access issues.
Gate 2 - North Warwick	Identified potential individual trenchless crossing locations; however, the number could be reduced by combining individual crossings into a longer drive.	Both granular and cohesive materials are expected along the entire route, which will have potentially high groundwater, especially near water courses. These may require groundwater control by trenching and/or dewatering.	Both granular and cohesive materials typically comprising the weathered upper layers of the bedrock, are expected along the entire route. These will have the potential for, but limited groundwater where outcropping at ground level.	The route does not follow highways, therefore is in open ground with potentially limited buried services, but multiple landowners and potential access issues.
Gate 2 - South Warwick	Identified potential individual trenchless crossing locations; however, the number could be reduced by combining individual crossings into a longer drive.	Both granular and cohesive materials are expected along the entire route, which will have potentially high groundwater, especially near water courses. These may require groundwater control by trenching and/or dewatering.	Both granular and cohesive materials typically comprising the weathered upper layers of the bedrock, are expected along the entire route. These will have the potential for, but limited groundwater where outcropping at ground level.	The route does not follow highways, therefore is in open ground with potentially limited buried services, but multiple landowners and potential access issues.
G2 WRMP19 RE_ A	Identified potential individual trenchless crossing locations; however, the number could be reduced by combining individual crossings into a longer drive.	Both granular and cohesive materials are expected along the entire route, which will have potentially high groundwater, especially near water courses. These may require groundwater control by	Both granular and cohesive materials typically comprising the weathered upper layers of the bedrock, are expected along the entire route. These will have the potential for, but limited groundwater where	The route does not follow highways, therefore is in open ground with potentially limited buried services, but multiple landowners and potential access issues.

Route	Trenchless Crossings	Geotechnical Issues – Superficial Deposits	Geotechnical Issues – Bedrock	Comments
		trenching and/or dewatering.	outcropping at ground level.	
G2 WRMP19 RE_ B	Identified potential individual trenchless crossing locations; however, the number could be reduced by combining individual crossings into a longer drive.	Both granular and cohesive materials are expected along the entire route, which will have potentially high groundwater, especially near water courses. These may require groundwater control by trenching and/or dewatering.	Both granular and cohesive materials typically comprising the weathered upper layers of the bedrock, are expected along the entire route. These will have the potential for, but limited groundwater where outcropping at ground level.	The route does not follow highways, therefore is in open ground with potentially limited buried services, but multiple landowners and potential access issues.
G2 WRMP19 RE_ C	Identified potential individual trenchless crossing locations; however, the number could be reduced by combining individual crossings into a longer drive.	Both granular and cohesive materials are expected along the entire route, which will have potentially high groundwater, especially near water courses. These may require groundwater control by trenching and/or dewatering.	Both granular and cohesive materials typically comprising the weathered upper layers of the bedrock, are expected along the entire route. These will have the potential for, but limited groundwater where outcropping at ground level.	The route does not follow highways, therefore is in open ground with potentially limited buried services, but multiple landowners and potential access issues.

Geology / Groundwater

Geotechnically, all routes are similar in regard to the underlying ground conditions, with loose granular and / or soft cohesive superficial deposits which are mainly located in the Northern part of the routes and outfall at the rivers. These are associated with, and in the vicinity of, water courses that require to be crossed, requiring the construction of trenchless crossings. The deposits are likely to have a high groundwater (potentially variable due to seasonal conditions), which may require control by either temporary works to cut off the groundwater (sheet piles if route / access corridors are limited or by the benching of excavations if space is available), combined with localized dewatering where pipeline trenches are being installed across country. There is no single route that avoids these potential issues.

In the central section of all routes there are stretches where there are no superficial deposits recorded, indicating that bedrock outcrops at ground level. This will be either a stiff clay, being the upper weathered layers of the underlying mudstones, or a medium dense to dense granular material comprising sand and / or gravel sized fragments sourced from the various sandstone bedrock types. Groundwater may be present in these but is unlikely to be present in significant volumes requiring temporary works of sheet piles, with localized dewatering from sumps in trenches.

A suitable, specified, ground investigation to determine the ground conditions, i.e., granular, cohesive or bedrock and the strength and groundwater regimes, will be required to determine the best suited methods to be adopted for trenchless crossings.

Trenchless Crossings

All of the option routes are affected by third party infrastructure - railways, roads, rivers, canals and the proposed alignment of the future HS2 route - therefore, these will require trenchless crossings to pass under.

Tanks and Outfall

All of the option routes have break-pressure tanks located at the highest point of the route. These will require deeper excavations of ≈5m for their construction and all options will require an outfall structure to be constructed below ground / river level at the River Avon.

Contaminated Land

There are a number of historic and permitted landfill sites in the area crossed by the pipeline near Minworth/Coleshill. All of the option routes are affected by these landfill sites. Routes that minimise the length of pipeline within known landfill sites have been given a higher score in the route appraisal process.

5.1.3. Consents

The pipeline routes assessed cross key infrastructure and rivers at several locations. This section summarises the requirements for each type of crossing. The number and complexity of these crossing has been considered during the evaluation of the proposed routes using the MODA tool, specifically under criteria 2.4 - Crossing land where permissions likely to be difficult to obtain.

National Highways – Motorways and Trunk Roads

These will require early engagement, with the preparation, issue and approval of the following:

- Statement of Intent (SoI)
- Preliminary Sources Study Appraisal (PSSR)
- Geotechnical Investigation Appraisal (GIR)
- Geotechnical Design Appraisal (GDR), if required, or completed by the Design & Build contractor

County Councils – All other roads

- Geotechnical Investigation Appraisal (GIR)
- Geotechnical Design Appraisal (GDR), if required, or completed by the Design & Build contractor

Network Rail – All railway crossings

These will require early engagement with a signed asset agreement (BAPA) in place before the preparation, issue and approval of the following:

- An asset agreement (BAPA) will be required before any work is undertaken by Network Rail
- Work Package Plan (WPP)
- Approval in Principle (AIP)

Rivers – Environment Agency

Ecological appraisals and environmental surveys / appraisals.

Canals – Canal & River Trust

Ecological appraisals and environmental surveys / appraisals.

Access

Early discussions with all landowners and authorities noted above is advised for obtaining access to undertake any intrusive or non-intrusive ground investigations.

5.2. Constructability

5.2.1. Route Assessment

The construction constraints for a contractor installing the six pipeline routes have been included in the route selection process. Using the design information, geospatial data, and external constraints, the following construction considerations have been considered:

- Access and egress to the works locations

- Spatial constraints to the contractor
- Temporary Works requirements
- Proximity of construction activities to 3rd party assets
- High level environmental factors that could impact on construction

Using the same constraints identified in Section 2. Stage 1 – Collation of Constraints, clash detection has been undertaken to identify interactions between the pipe alignment, construction activities, and physical objects on the ground. This has been completed using satellite imagery and geospatial data from stakeholders such as UKPN and National Highways.

During route assessment several construction opportunities have been identified. These potential construction opportunities have been collated and included in Section 6.2. Opportunities of this appraisal for further assessment during the next stages of the project.

Table 5-2 briefly summaries the routes length, number of crossings, and total length of crossings. From a high-level perspective, a shorter route, with less crossings, has benefits for construction. There is a proportional relationship between the length of pipeline, number of crossings, and the overall project cost and schedule. Construction schedules have not been produced for each of the route during this stage of the project but will be developed once a preferred route has been selected. Costings for each of the routes are discussed in detail in Section 5.6.

Table 5-2: The overall length of the routes, number of and overall length of crossings.

Ranked routes (shortest to longest)	Route	Overall length (m)	No of Crossings	Overall Length of crossings
1	WRMP19	27585	26	3260
2	G2 WRMP19 RE_A	28202	24	2838
3	G2 WRMP19	28242	25	3360
4	G2 WRMP19 RE_C	28302	25	3920
5	G2 WRMP19 RE_B	31454	28	2680
6	G2 NW	32041	19	3100
7	G1 NW	32630	32	3810
8	G1 SW	36566	41	4140
9	G2 SW	37408	25	3553

To better understand the geography of the routes and to assist in differentiating each route, they can be identified and coupled by their discharge locations. WRMP19, Gate 2 WRMP19, Gate 2 WRMP19 RE_A, Gate 2 WRMP19 RE_B and Gate 2 WRMP19 RE_C discharge at the most upstream location at Stoneleigh, East of Kenilworth. Gate 1 and Gate 2 North Warwick routes discharge at Old Milverton whilst the Gate 1 and Gate 2 South Warwick routes discharge furthest downstream adjacent to the M40. Figure 5-1 shows the outfall discharge locations for all routes.

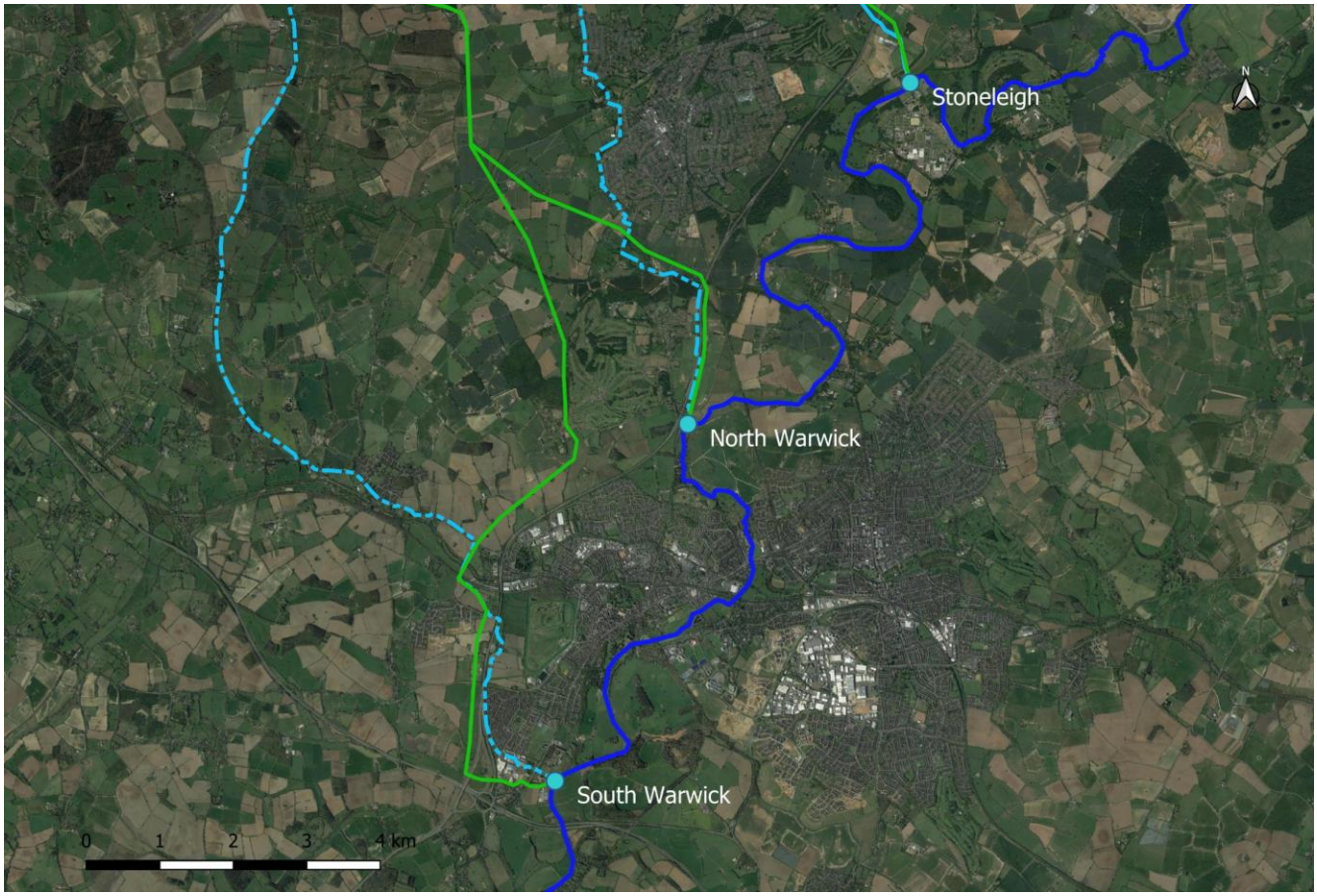


Figure 5-1: Outfall discharge locations.

For all current route options, the pipeline's initial 4.7km from the inlet at Minworth to the starred location identified in Figure 5-2 below has a number of complex constraints and interfaces to overcome. The pipeline routes intersect with the M6, A446, HS2 alignment, 2 separate railways, a historic landfill site and a permitted landfill site.

The Gate 1 North and South Warwick routes intersects with HS2's delta junction and crosses both the Birmingham and Crewe lines. This is a significant interface which will require complex and lengthy collaboration with HS2. The line then follows adjacent to and within the A446 highway which is an arterial route to the strategic road network connection at Junction 9 M42 and the M6 toll. Cognisant of the impact from HS2 and compounding nature of multiple major infrastructure projects in a relatively constrained area, this route has the potential to cause significant traffic disruption to the local area and access to the SRN.

Gate 1 WRMP, Gate 2 North and South Warwick and Gate 2 WRMP RE_B routes roughly follows the River Tame alignment. This section is spatially constrained by the river itself, Hams Hall industrial estate, a rail freight terminal, and its associated railway.

Gate 2 WRMP RE_A follows the existing outfall channel that runs from Minworth under the M4 motorway.

Gate 2 WRMP RE_C follows a longer route around the north end of Hams Hall Industrial Estate. This route avoids the constraint land south of the industrial estate but increases the required number of crossings, including and additional railway crossing.

An overview of all environmental constraints can be found in Appendix C.

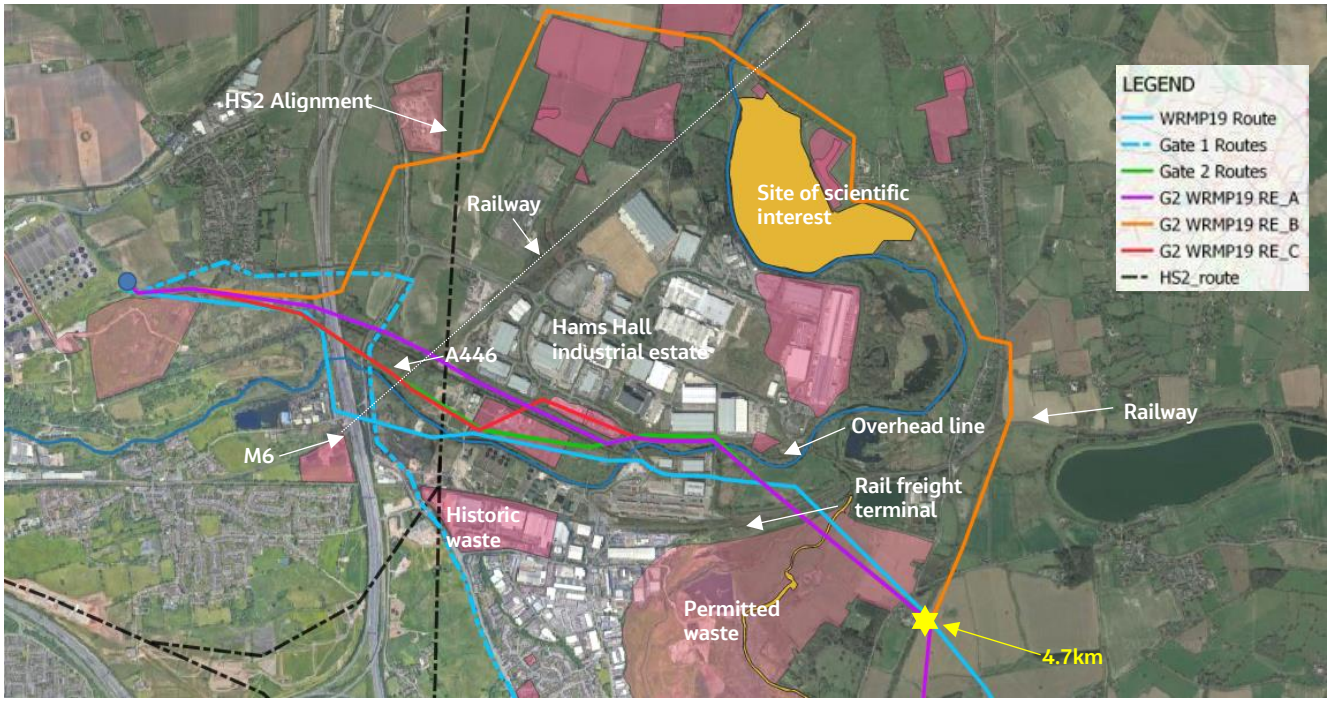


Figure 5-2: A map of the route alignment and the key interfaces in the first 4.7km

5.2.2. **WRMP19**

WRMP 19 is the shortest of all of the route options and on plan is the straightest route. From its inlet location at Minworth, it briefly follows the alignment of the North-South M6, before an East-West intersect under the motorway and HS2 where it follows the alignment of the River Tame before turning in a South, South-Easterly direction into the outfall approximately 8.5km upstream of Warwick.

The key observed interfaces after the identified constraints in Section 4.4 is Maxstoke golf course at CH7.200. The M6 intersection at CH10.600. A45 and railway crossings between CH14.000 and CH15.000 and a road and railway crossing at CH25.000.

From satellite mapping data, the crossing's South of the River Tame appear to have adequate spatial areas to construct the necessary drive and reception chambers required for trenchless construction. Between the River Tame and the inlet at Minworth, spatial and access constraints exist which will require site visits and surveys in which to validate their appropriateness.

The route alignment navigates through a residential development at Tile Hill, where trenchless techniques have been identified to mitigate disruption. The impact from ground settlement around the envelope of the pipeline on residential properties along this chainage must be considered.

From a construction perspective, the break pressure tank is positioned at CH13.130 on an open field and local disturbance will be minimal throughout the operation and maintenance lifespan. Access for construction however will have to be considered as the location is not directly served from the local highway.

From the available GIS information, WRMP19 does not appear to have significant environmental impact and avoids SSSI's and environmentally sensitive areas. The route is however subject to environmental impact assessments.

Accessibility along the route is served relatively well by the local highway network and the project can be segmented to minimise environmental impact from the construction of long temporary haul roads.

5.2.3. Gate 2 WRMP19

Gate 2 WRMP19 is the second shortest pipeline option and outfalls at the same location as WRMP19, 8.8km upstream of Warwick at Stoneleigh Park.

The initial 3km length of the route is positioned to the North of the River Tame and interfaces with a number of constraints, including HS2, M6 and a historic landfill site. This route option is spatially constrained between the River Tame and industrial units at Hams Hall, the alignment however is served via a road network serving the freight terminal. On-site surveys will be required to ensure the land and spatial conditions are adequate for construction.

From chainage 5.00 the route turns South and navigates around Maxstoke Golf course, subsequently eliminating any impact. The alignment continues South Easterly past the scheduled monument at Maxstoke priory and doesn't require significant deviation unlike other routes.

The location of the break pressure tank is at CH15.900 and positioned approximately 50m off the public highway which aids constructability, however, the tanks at their nearest points are 15m away from residential/business units. Construction methods and the associated spatial requirements need to be accounted for in this location. The proximity, serviceability requirements and any operational effects of the break pressure tank also needs to be considered on stakeholders.

At CH 19.686m the route crosses a Network Rail over bridge. This structure which will require further investigation to understand the associated feasibility and constraints.

Similarly, with WRMP19, the alignment interacts with residential properties (CH21.200). Unlike WRMP19, Gate 2 WRMP19 is more direct and there are no alignment deviations. From a constructability perspective, this is a more favourable route as only one drive and one reception pit is required. However, the route directly passes underneath residential properties and settlement assessments must be completed. There is an opportunity to amend the alignment of the route to utilise Westwood heath road, subsequently mitigating risk to properties.

5.2.4. Gate 1 North Warwick

From its inlet at Minworth, Gate 1 North Warwick largely follows the alignment of the current road network. The alignment crosses the delta junction of HS2 which is a significant structure and would require significant collaboration with HS2. Major project interactions are often particularly intensive and require detailed coordination through design and construction phases.

The alignment predominantly uses the highway network and alignment as a transportation conduit. Whilst this option has significant environmental benefits, the lengthened construction programme associated with highway works and impact on the road users would be significant. The particular highways impacted with this route serve as arterial routes to the strategic road networks, Birmingham airport and HS2. Based on these factors, this route is deemed not as favourable as other routes.

The break pressure tank location has one of the furthest along the route of all 6 options which would potentially require a more intensive pumping strategy and associated infrastructure. The break pressure tank is situated either side of the A452 and is logistically well served for construction.

A key factor to be considered on the route is the alignment directly between the two scheduled monuments of Kenilworth castle and Kenilworth Abbey. The road between the two is a key route which serves the town and the Historic England sites. The current route would heavily impact or sever access to these sites.

5.2.5. Gate 1 South Warwick

For the first 18km of this option, the option follows the alignment of Gate 1 North Warwick and is therefore subject to the same constraints and interfaces. At CH18.100, the alignment deviates in a more Southerly direction to the most downstream outlet option between South Warwick and the M40. The route is second longest at 36566m and has the most and longest crossings, 41 and 4140m respectively.

Similarly with Gate 1 North Warwick, the highway network has been used as an influencer in the route development and it largely follows the alignment of existing highway infrastructure. As before, this has environmental benefits but construction disadvantages.

Having the highest number of crossings will require the most amount of drive and reception chambers. The number of crossings has a tendency to drive up the risk and complexity profile of the option as well as having a negative impact on time and cost.

5.2.6. Gate 2 North Warwick

Gate 2 North Warwick follows the alignment of WRMP19 for the first 26.4km of the route before it heads South and navigates around the Western perimeter of Kenilworth, before aligning with the Eastern side of the A446 to the discharge location at the River Avon meander at Old Milverton.

The route crosses HS2 at CH20.440 which would require re-interface with a separate HS2 team due to the segmentation of the HS2 construction. This additional crossing is unnecessary given the other route options avoid an additional crossing.

The route has the least number of crossings and shortest length of trenchless construction which would positively impact the complexity profile of the project.

Logistically the route is well served by the transport network which would aid constructability and reduce impact on the local environment.

The alignment largely avoids any interaction with residential developments which subsequently reduces stakeholder impact.

5.2.7. Gate 2 South Warwick

Gate 2 South Warwick is the longest of all 6 routes and has a length of 37.408km. The first 19km of the route follow Gate 2 WRMP19's alignment and then shares the same alignment of Gate 2 North Warwick between CH19.800 and CH26.300. Upon deviation for Gate 2 North Warwick the alignment detours around the West of Warwick before discharging adjacent to the M40.

The deviation from G2 NW incurs an additional two crossings across the Warwick bypass. However, the alignment to the East of the Warwick bypass avoids interaction with the residential community.

The final 10km of the route largely utilises green belt and farmland which aren't well served by the highway network. A more intensive temporary access network would be required for this section have a greater impact on the local environment and driving up temporary works costs.

5.2.8. Gate 2 WRMP19 RE_ A

Gate 2 WRMP RE_A is the second shortest route with a length of 28.2km. The route follows Gate 2 WRMP19's alignment for most of its length except for the first 2.7km of route G2 WRMP RE_A, where it follows the existing outfall channel that runs from Minworth to the River Tame. The route crosses under the M42 and M6 toll motorways, the A446 and the HS2 alignment. Overall, this re-designed route requires the shortest length of crossings.

The route option can be accessed via access points from Minworth STW, Marsh Lane, Curdworth and an access road off the A446.

This route option appears to have topographical and spatial constraints along the adjacent section to Hams Hall industrial estate. On-site surveys will be required to ensure the land and spatial conditions are adequate for construction.

Most of the first 3km of the route are within flood zones.

5.2.9. Gate 2 WRMP19 RE_ B

Gate 2 WRMP RE_ B has total length of 31.4km. The route follows Gate 2 WRMP19's alignment for most of its length except for the first 7.8km of route G2 WRMP RE_B.

Gate 2 WRMP RE_ B is longer than other routes sharing the same outfall (WRPM19, G2 WRMP 19, G2 WRMP 19 RE_A and G2 WRMP 19 RE_C). Gate 2 WRMP RE_C follows a longer route around the north end of Hams Hall Industrial Estate. The alignment requires an increased number of crossings, including an additional railway crossing. However, the overall length of crossings required is the second shortest. This route option avoids the spatial constraints between watercourses and industrial units at Hams Hall.

The route avoids the permitted and historic landfill sites located south and south-west of Hams Hall Industrial Estate. It also minimises the length of pipeline within the flood zones along River Tame.

The additional 7.6km will extend the programme duration and increase the environmental impacts associated with logistics, vehicle movements, and compound and access road construction.

5.2.10. Gate 2 WRMP19 RE_ C

Gate 2 WRMP RE_ C has a total length of 28.3km. The route follows Gate 2 WRMP19's alignment for most of its length except for a 500m section within Hams Hall Industrial Estate.

The route requires a significant trenchless crossing underneath HS2, the M42 and M6 toll motorways, industrial use land within Hams Hall Industrial Estate, Minworth outfall channel and a car park. The impact from ground settlement around the envelope of the pipeline on industrial properties along this chainage must be considered

The total length of the crossing exceeds 500m, it's alignment would require a number of shafts to be constructed along the route to enable changes in alignment. On-site surveys will be required to ensure the land and spatial conditions are adequate for the location of the shafts.

5.2.11. Construction Conclusion

Following review of the routes from a constructability perspective each of the routes has been ranked. Table 5-3 Below shows this ranking with justification.

Table 5-3: Route ranking for constructability

Ranking	Route	Overall length (m)	Number of Crossings	Overall Length of crossings (m)	Justification
1	G2 WRMP19	28242	25	3360	Third shortest route. Least impact on residential properties and 3rd parties. Close positioning of BPT to local road network. Potential for highway optimisation during next stage of project. Good access and working room at outfall location.
2	G2 WRMP19 RE_B	31454	28	2680	Second shortest overall length of crossings required. This route avoids the spatial constraints between the River Tame and industrial units at Hams Hall. The route avoids the landfill sites located south and south-west of Hams Hall Industrial Estate. It also minimises the length of pipeline within the flood zones along River Tame.

Ranking	Route	Overall length (m)	Number of Crossings	Overall Length of crossings (m)	Justification
					Potential for alignment optimisation to minimise impact on agricultural land.
3	WRMP19	27585	26	3260	Shortest route. Shortest length of crossings. Second lowest impact on residential properties and 3rd party assets. Closest proximity to the suburbs of Coventry. BPT location not served by local highway network. Potential for refinement during next stages of project. Good access and working room at outfall location.
4	G2 NW	32041	19	3100	Least number of crossings. Follows highway alignment minimising environmental impact but incurs working constraints. Outfall access is across field.
5	G2 SW	37408	25	3553	Multiple HS2 crossings. Longest overall length. Significant crossing under Grand Union Canal and M40 Longbridge Interchange. Good access to outfall however approach is constrained.
6	G2 WRMP19 RE_A	28202	24	2838	Second shortest route and shortest overall length of crossings. Approximately 1km of the route is within a narrow stretch of land between Minworth outfall channel and Hams Hall industrial estate. Most of the first 3km of this route are within flood zones.
7	G2 WRMP19 RE_C	28302	25	3920	Significant trenchless crossing required, including underneath industrial properties and a car park currently in use. Potential shaft locations need to be confirmed adequate.
8	G1 NW	32630	32	3810	High number of crossings, Crosses HS2 delta spur. Utilises arterial roads which aids construction logistics but incurs working constraints. Close proximity to Kenilworth and Castle Green. Outfall access is across field.
9	G1 SW	36566	41	4140	Highest number and length of crossings. Multiple HS2 crossings. Significant crossing under Grand Union Canal. Utilises arterial roads which aids construction logistics but incurs working constraints. Close proximity to the suburbs and industrial estates of Warwick. Good access to outfall.

5.3. Major Crossings

5.3.1. Surface Features and Infrastructure

All existing surface features such as railway lines, canals, motorways, highways, and other watercourses have been identified and assumptions made as to whether they will be crossed by means of trenchless construction or

not, these assumptions are used in the comparative cost calculations, for details see crossings section in Appendix H. Comparative costs. More detailed desk studies will be undertaken once preferred routes have been identified to determine the appropriate method of trenchless construction and associated risks and costs.

5.3.2. Buried Services

All of the pipeline routes avoided the national gas transmission system and the high-pressure gas installations. More detailed desk studies will be undertaken once preferred routes have been identified to locate all buried services and the appropriate method of construction and associated risks and costs. This shall include the gas distribution network pipelines, and Severn Trent water assets.

5.4. Hydraulics

The range of pipe diameters that have been considered are 900mm to 1300mm.

Since the pipeline is to be operated infrequently, operating costs do not have a significant bearing on the pipe size selection. Selection is driven more by the delivery pressure of the pumps, and the available head at the Break Pressure Tank.

The pipeline is comprised of two sections, rising main and gravity main. The rising main diameter for all options is 900mm, a rising main of 800mm wasn't considered to keep the velocity in the pipe below 2.5 m/s. currently the velocity in the 900mm rising main is at 2.13 m/s. The available head in the rising main is made always higher than the head at the break pressure tank. After the BPT, the water flows in the pipe due to gravity with enough pressure to reach the chosen outfall locations.

Preliminary steady state hydraulic analysis has been undertaken for the design flow rate for each of the route options, with a variety of pipe sizes being considered. The hydraulic profiles resulting from these analyses are presented in Appendix G. Hydraulic Profiles. The parameters used are detailed in Section 3.1.1. Pipeline Hydraulics. The results of this hydraulic analysis are used to give scores for the pipeline routes options on the hydraulic criteria in the MODA analysis tool.

5.5. Carbon Impact

Carbon calculators for each option are provided in Appendix M. Carbon Calculator Record Sheets and summarised in Table 5-4 below. The assessment concluded that:

- WRMP19 and G2 WRMP19 has the smallest embodied carbon footprint followed by G1 North Warwick.
- G1 North Warwick and G1 South Warwick has the smallest operational carbon footprint (considering 50 years) followed by G2 WRMP19.
- Gate 1 North Warwick has the smallest life carbon footprint followed by G2 WRMP19.

Table 5-4: Carbon Impact Analysis Summary Table

	WRMP19	G1 NW	G1 SW	G2 WRMP19	G2 NW	G2 SW	G2 WRMP19 RE_A	G2 WRMP19 RE_B	G2 WRMP19 RE_C
Total Life Cycle Carbon Cost £ NPV (£[redacted]/tCO2)	35,381,231	29,160,448	37,959,887	35,168,088	38,740,165	43,436,788	35,347,826	39,069,477	34,875,671
Life Cycle - Total tCO2	141,928	116,974	152,272	141,073	155,402	174,242	141,794	156,723	139,900

Commercial information redacted

	WRMP19	G1 NW	G1 SW	G2 WRMP19	G2 NW	G2 SW	G2 WRMP19 RE_A	G2 WRMP19 RE_B	G2 WRMP19 RE_C
Embodied Carbon - Total tCO2	69,388	81,634	113,212	79,693	94,022	112,861	80,414	89,763	78,519
Sewer Pipes - Rising Main (tCO2)	28,987	38,072	34,899	37,965	38,276	38,276	39,953	49,511	37,200
Sewer Pipes - Rising main rural / suburban highway (tCO2)	0	1,822	6,096	0	0	0	0	0	0
Sewer Pipes - Rising main Urban highway (tCO2)	27,19	14,436	12,263	0	0	0	0	0	0
Sewer Pipes - Gravity main (tCO2)	34,363	19,159	45,393	40,237	54,153	72,990	39,445	39,445	39,445
Sewer Pipes - Gravity main rural / suburban highway (tCO2)	0	1,191	2,517	0	0	0	0	0	0
Sewer Pipes - Gravity main urban highway (tCO2)	17,96	5,536	10,619	0	0	0	0	0	0
Sewer Pipes - Trenchless Rising main (tCO2)	943	1,259	1,243	922	1,218	1,218	627	406	1,485
Sewer Pipes - Trenchless Gravity main (tCO2)	461	96	111	454	259	262	275	275	275
Sewage Pumping Stations (tCO2)	116	60	67	112	112	112	112	123	112
Operational Carbon tCO2 (50 years)	72,540	35,340	39,060	61,380	61,380	61,380	61,381	66,961	61,381

The assessment has been undertaken using the Severn Trent internal carbon tool. The main criteria for developing this assessment are carbon emission ratios per metre of pipeline built, average depth, and type of work area (Field or highway). This evaluation has not considered carbon emissions from maintenance, repair, and replacement activities.

For further assessment, it is recommended to consider maintenance, repair, and replacement carbon, which would increase the operational carbon for option G1 North and South Warwick due to the amount of work required in rural and urban areas where the pipeline would be located.

Key potential opportunities for carbon efficiencies include using:

- Low carbon concrete, substituting cement with other materials/ additives
- Novel alternatives to steel reinforcement in reinforced concrete (e.g., fibre-reinforced polymer bars).
- reduce demolition trough trenchless techniques and avoid infrastructures such as railway lines, canals, motorways, highways, and urban areas.
- re-use demolished material.
- re-use existing available materials, e.g., processing, re-use of excavated material as fill.
- sustainable construction materials.

- efficient methods of work, e.g., more sustainable transport solutions.

The results of the Carbon Impact analysis are used to give scores for the pipeline routes options on the Carbon criteria in the MODA analysis tool.

5.6. Comparative Cost

For each of the routes, alternative pipeline sizes were tested to identify the optimum pipeline size based on the information available at this stage. Note that different pipeline routes have different optimum pipeline sizes which impact the capital costs. Section 3.1 provides a breakdown of the information used in the cost build up. Please refer to Appendix H. Comparative costs for full table.

Table 5-5 and Figure 5-3 summarise the cost CAPEX and OPEX for all options assessed.

Table 5-5: Comparative Cost includes CAPEX + OPEX (NPV over 50 years) (£m)

Criteria			WRMP19	G1 NW	G1 SW	G2 WRMP19	G2 NW	G2 SW	G2 WRMP19 RE_A	G2 WRMP19 RE_B	G2 WRMP19 RE_C
CAPEX (£m)	Pipe	Length (km)	27.8	32.5	36.5	28.2	32.0	37.4	28.2	31.5	28.3
		Total pipe cost (£m)	35.9	44.3	58.4	39.5	45.5	53.8	39.4	43.5	39.5
	Total crossing / trenchless cost (£m)		37.8	50.7	54.2	30.2	33.5	38.7	28.4	28.8	37.5
	Pumping Station	Power (MW)	3.1	1.5	1.7	2.9	2.9	2.9	2.9	3.2	2.0
		Pumping station Cost	5.8	3.8	4.0	4.7	4.7	4.7	4.7	5.2	4.8
	Total CAPEX (£m)		79.4	98.7	116.6	74.5	83.6	97.2	72.5	77.5	81.8
Total OPEX (NPV over 50 years) (£m)			13.2	6.5	7.3	11.7	11.7	11.7	11.7	12.8	11.8
Grand Total CAPEX + OPEX (NPV) (£m)			92.5	105.2	123.9	86.2	95.3	109.0	84.2	90.2	93.5

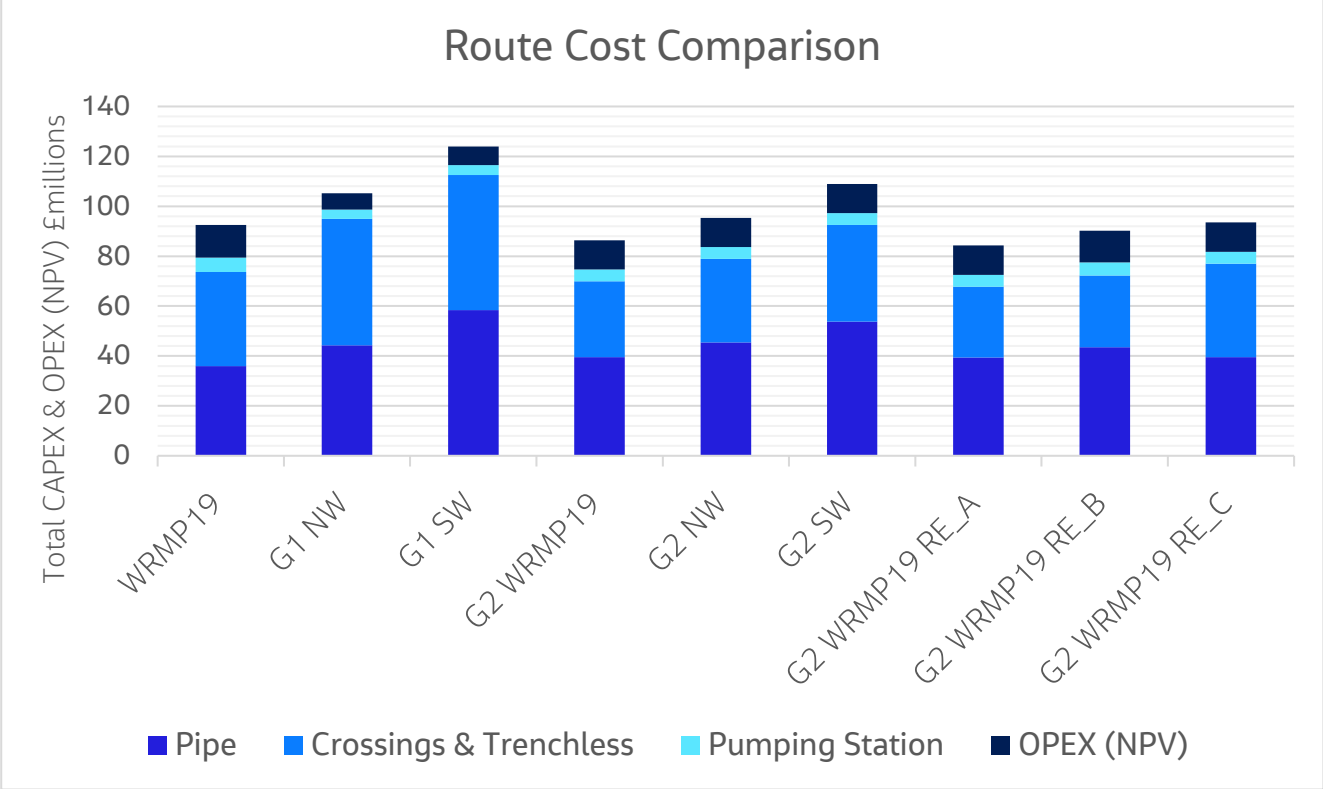


Figure 5-3: Comparative Cost Chart

5.7. Non-Monetary Multi Objective Decision Analysis - MODA Jacobs Tool

5.7.1. Scoring Alternatives against Criteria

Scores for each route option were assigned against the set of criteria, including a written rationale for each score provided where not a direct measurement, these are provided in Appendix E. MODA Criteria and Appendix I. MODA Scoring Rationale. The scores are listed in Table 5-6 and shown in Figure 5-4.

5.7.2. Weights

In MODA, weights are used to express the relative value of one criterion versus another within the context of the decision being made. Thus, they reflect both the inherent importance of a criterion and its variability in that particular context. A concept called “swing weighting” was used to develop weights with a focus on understanding trade-offs among the evaluation criteria. Swing weighting is a technique that uses the endpoints of the measurement scales to help people consider the variability of criteria when assessing their relative value in making a decision.

Six engineers with a range of experience of pipeline routing has given weightings for the assessment criteria, included participation from Severn Trent. The average weights developed by this group are called consensus weightings. The consensus and individual weightings are shown in Appendix J. MODA Weightings. The individual weights of team members were retained to test the sensitivity of results to changes in weighting preference, see Section 5.7.5. Sensitivity Analysis below.

5.7.3. **Results**

Table 5-6: MODA Results after applying the Consensus Weighting in table format

ID#	Evaluation Criteria	WRMP19	G1 NW	G1 SW	G2 WRMP19	G2 NW	G2 SW	G2 WRMP19 RE_A	G2 WRMP19 RE_B	G2 WRMP19 RE_C
Total Score		63.9	50.2	44.4	73.7	64.7	63.5	63.1	71.0	60.8
1	Constructability	17.5	20.2	18.3	19.2	17.9	18.9	12.9	21.1	11.2
2	Planning risk	15.7	2.2	2.2	17.8	14.3	14.3	14.7	14.5	13.7
3	Operational considerations	6.5	1.8	0.0	4.7	3.7	2.6	4.7	4.7	4.7
4	Customer disruption during construction	11.3	5.9	6.0	12.6	11.8	12.6	12.6	12.6	11.9
5	Break Pressure Tank siting	3.0	6.3	6.3	4.7	4.7	4.7	4.7	4.7	4.7
6	Land Costs	5.3	6.9	6.9	10.1	10.1	9.1	10.1	10.1	10.1
8	Carbon	4.7	7.0	4.7	4.7	2.3	1.2	3.5	3.5	4.7

- The results of the multi objective decision analysis show that Pipeline Route G2 WRMP19 has the highest total score.
- Route G2 WRMP19 achieved the highest score because it has low elevations giving it a more favourable hydraulic profile, and its overall alignment go through open field grounds avoiding environmental and social constraints. This option also has a suitable break pressure tank (BPT) location with available access, positioned approximately 50m off the public highway which aids constructability.
- Route G2 WRMP19 was followed closely by Route G2 WRMP19 RE_B. These two options follow the same route for most of their length, between Coleshill and the discharge point, and therefore share most of their benefits.
- Route G2 WRMP19 RE_B follows a longer route around the north end of Hams Hall Industrial Estate rather than cutting across it through the land between the WwTP and the industrial development. This allows minimising the length of the route within flood zones and historic landfill sites and improve constructability.

The MODA results are shown below in chart format, a higher score indicates a preferable scheme.

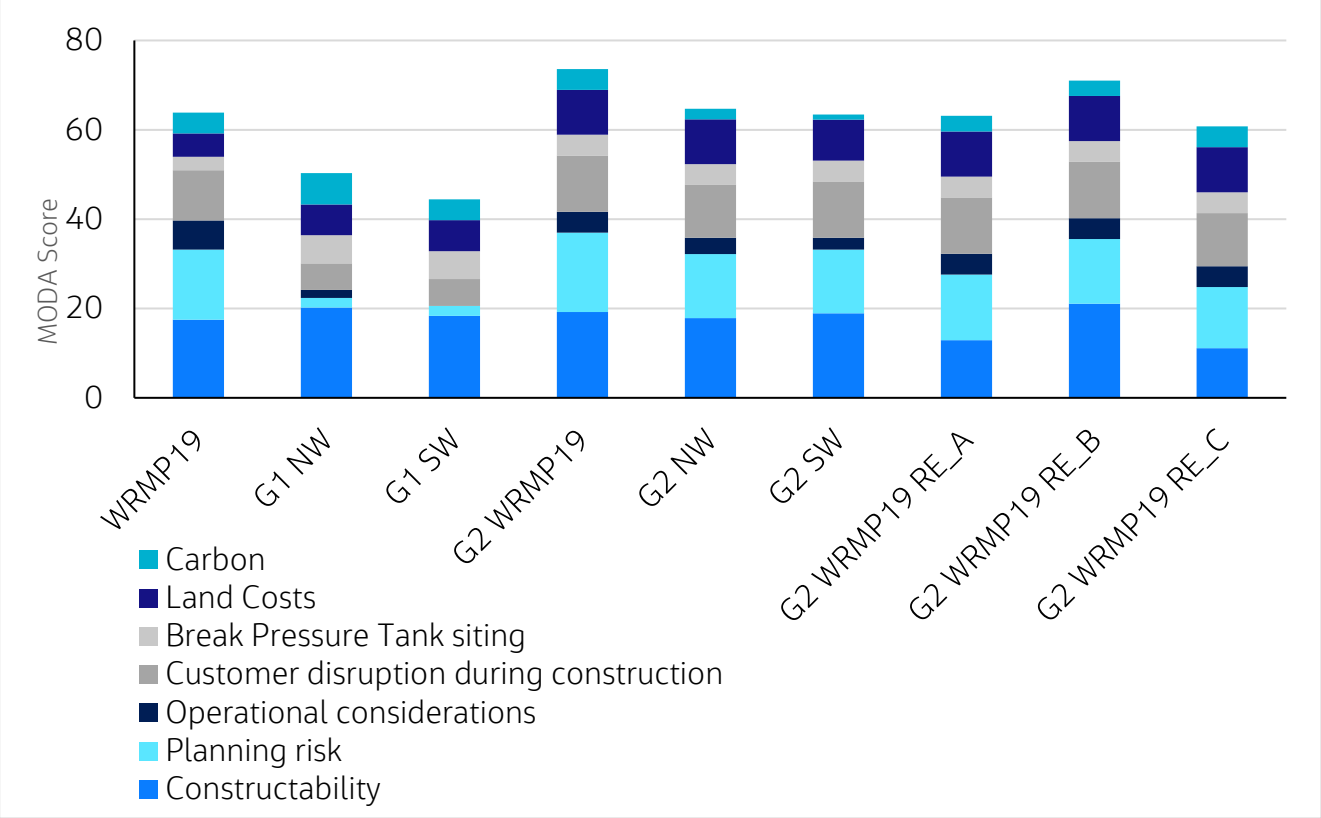


Figure 5-4: MODA Results for Consensus Weighting in Chart Format

5.7.4. Comparison of Cost & non-Monetary MODA Values

The MODA scoring results do not include a weighting for cost. The graph shown in Figure 5-5 plots the estimated costs for each option against their MODA score. The preferred options (higher MODA score and lower costs) are at the top left corner of the chart. G2 WRMP19 route is the best performing option, followed by G2 WRMP19 RE_B.

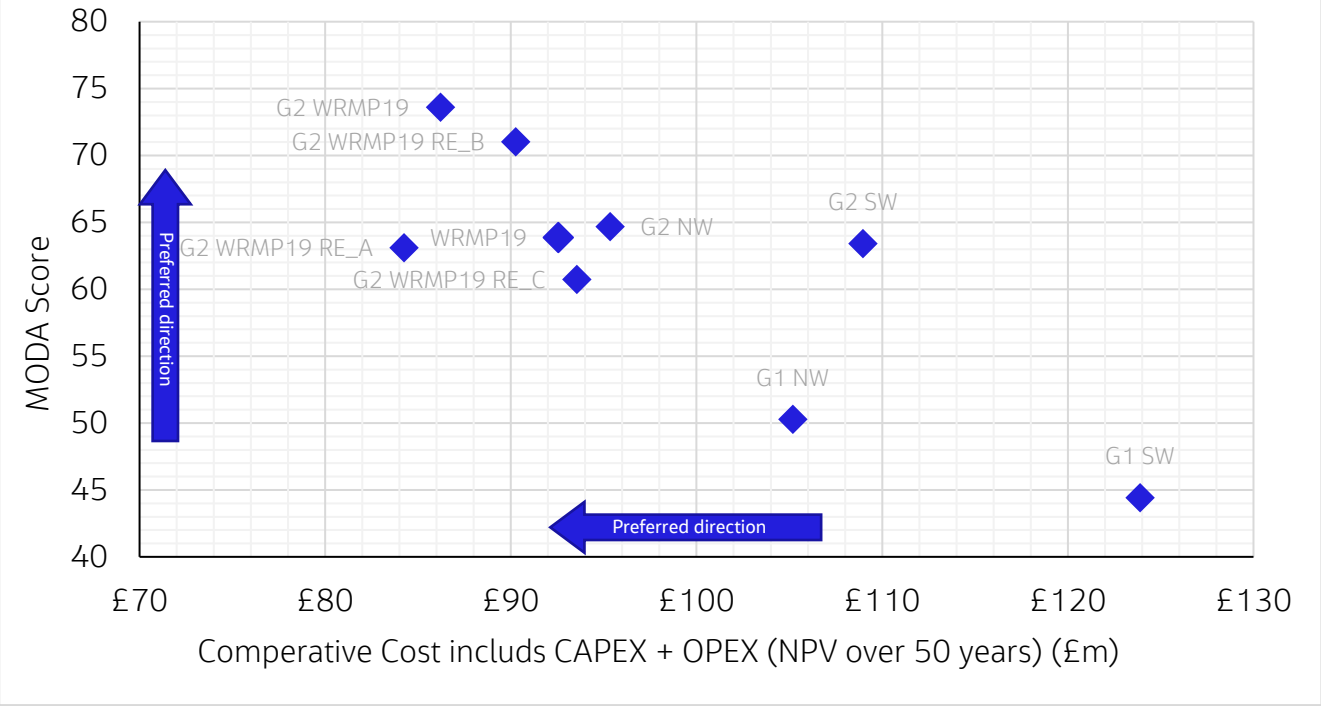


Figure 5-5: MODA Value to Cost Comparison

5.7.5. Sensitivity Analysis

The sensitivity of the results has been tested by changing the weighting preferences. The results shown in Table 5-7: Sensitivity to Weighting demonstrates that Route G2 WRMP19 remains ranked number 1 across the weightings of all members, followed by G2 WRMP19 Re_B in all scenarios.

Table 5-7: Sensitivity to Weighting

Weights	WRMP19	G1 NW	G1 SW	G2 WRMP19	G2 NW	G2 SW	G2 WRMP19 RE_A	G2 WRMP19 RE_B	G2 WRMP19 RE_C
MODA Score									
Consensus	63.9	50.2	44.4	73.7	64.7	63.5	63.1	71.0	60.8
Member 1	63.2	51.0	44.9	72.7	64.1	63.1	61.4	70.9	59.8
Member 2	65.9	50.1	44.8	74.0	64.6	63.0	64.1	70.6	61.0
Member 3	61.3	49.9	44.2	72.8	64.5	63.0	63.3	60.5	60.5
Member 4	65.1	46.7	41.0	74.7	64.2	62.4	65.6	71.4	62.0
Member 5	64.9	52.2	46.1	75.2	66.9	66.0	63.8	71.9	61.7
Member 6	63.2	51.0	44.9	72.7	64.1	63.1	61.4	70.9	59.8
Rank, Highest Valued Alternative = 1									
Consensus	4	8	9	1	3	5	6	2	7
Member 1	4	8	9	1	3	5	6	2	7

Weights	WRMP19	G1 NW	G1 SW	G2 WRMP19	G2 NW	G2 SW	G2 WRMP19 RE_A	G2 WRMP19 RE_B	G2 WRMP19 RE_C
Member 2	3	8	9	1	4	6	5	2	7
Member 3	6	8	9	1	3	5	4	2	7
Member 4	4	8	9	1	5	6	3	2	7
Member 5	5	8	9	1	3	4	6	2	7
Member 6	4	8	9	1	3	5	6	2	7

The original MODA scoring results presented at Section 5.7.3 Results do not include a weighting for cost, however in this section the results sensitivity to cost is presented,

Figure 5-6 below shows the results changing as the weighting for cost increases from 0 to 100 percent. Notice at 0% sensitivity to cost you will see the original MODA scoring results as previously shown in section 5.7, and at 100% sensitivity to cost you will see the comparative cost results as previously shown in section 5.6.

Route G2 WRMP19 remains ranked number 1 except when the comparison is 80% or above cost related in which case it becomes ranked number 2 with a minor gap with route G2 WRMP19 Re_A.

Route G2 WRMP19 RE_B remains ranked number 2 whilst costs account for 40% or less of the total score, being overtaken by route G2 WRMP19 Re_A from that point.

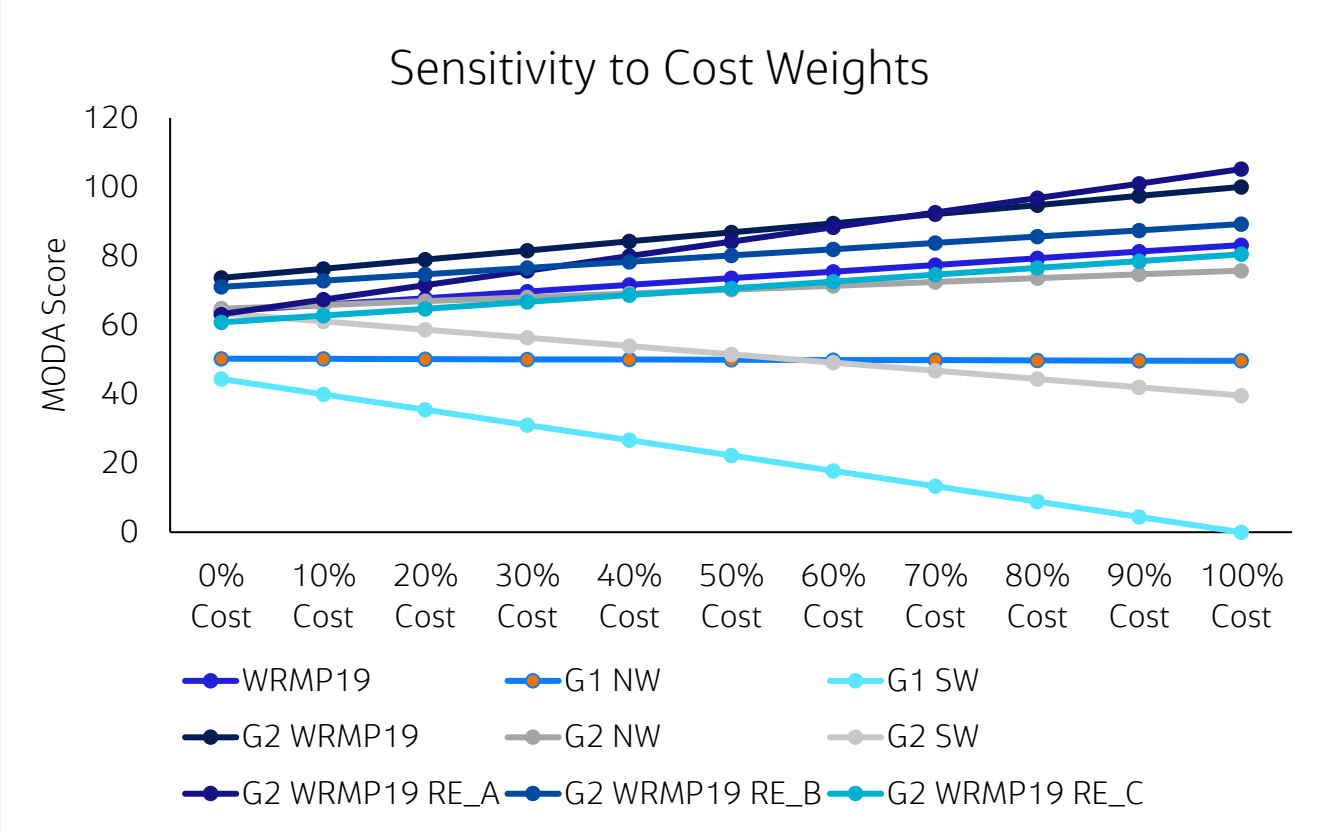


Figure 5-6: Sensitivity to Cost Weights

5.8. Land availability

After the first submission of the route appraisal report, it was determined that the land within the red boundary area shown in Figure 5-7, located between the industrial units at Hams Hall and the existing Minworth WwTW outfall canal, cannot be access for construction. The preferred route should avoid this piece of land and any routes passing through it must be discarded.

Table 5-8 summarises the intersection of the assessed routes with the highlighted land to be avoided and the routes discarded as result.

Figure 5-7: Land not available for construction

Table 5-8: Routes intersection with land to be avoided

Route	Within highlighted zone?	Comments
WRMP 19	Yes	Route discarded
Gate 1 -North Warwick	No	-
Gate 1 - South Warwick	No	-
Gate 2 -WRMP 19	Yes	Route discarded
Gate 2 -North Warwick	Yes	Route discarded
Gate 2 -South Warwick	Yes	Route discarded
G2 WRMP19 RE_ A	No	-
G2 WRMP19 RE_ B	No	-
G2 WRMP19 RE_ C	No	-

6. Conclusions and Recommendations

6.1. Conclusions

A summary of the options considered during this assessment and suggested ranking of those options based on the information included is provided in Table 6-1: Pipeline Routes Ranking. The ranking given is based on the output of the comparative cost and the non-monetary multi objective decision analysis. The ranking has been adjusted to reflect the routes discarded in Section 5.8.

Table 6-1: Pipeline Routes Ranking

Route	Status
G2 WRMP19 RE_ B	Rank 1 - Preferred Option
G2 WRMP19 RE_ A	Rank 2
G2 WRMP19 RE_ C	Rank 3
Gate 1 -North Warwick	Rank 4
Gate 1 - South Warwick	Rank 5
WRMP 19	Route discarded
Gate 2 -WRMP 19	Route discarded
Gate 2 -North Warwick	Route discarded
Gate 2 -South Warwick	Route discarded

The conclusion of the appraisal is the result of the routes assessment as described in Stage 4 – Evaluation of Routes. The evaluation of routes considered the following: Ground Conditions, Constructability, Major Crossings, Hydraulics, Carbon Impact, Land Availability and Comparative Cost.

The conclusion of the appraisal is that pipeline Route G2 WRMP19 RE_ B is ranked 1. Route G2 WRMP19 RE_ B is the preferred option because it has low elevations giving it a more favourable hydraulic profile, and its overall alignment goes through open field grounds avoiding environmental and social constraints. This option also has a suitable break pressure tank (BPT) location with available access, the location is at chainage 15.900 and positioned approximately 50m off the public highway which aids constructability.

As highlighted in Section 5.8, Route G2 WRMP19 RE_ B avoids the land located between the industrial units at Hams Hall and the existing Minworth WWTW outfall canal which cannot be accessed for construction. Route Gate 2 -WRMP 19, the higher scoring route in the MODA analysis, passes through this land and was therefore discarded.

The preferred option Gate 2 WRMP19 RE_ B has total length of 31.4km and has the second shortest overall length of crossings required. The route outfalls at the same location as the original WRMP19 route, which is at Stoneleigh Park 9km upstream of Warwick. The initial 7.5km length of the preferred option is slightly complicated because interfaces with a number of constraints, including HS2, M6 and two rail crossings. However, trenchless solutions are proposed to overcome these constraints.

This preferred option avoids the spatially constrained between the River Tame and industrial units at Hams Hall, as well as the permitted and historic landfill sites located south and south-west of Hams Hall Industrial Estate. It also minimises the length of pipeline within the flood zones along River Tame.

Similarly, with original WRMP19 route, the preferred option alignment interacts with residential properties. But unlike other routes option, the preferred option is more direct and there are no alignment deviations.

On the other hand, Pipeline routes G1 North Warwick and G1 South Warwick are ranked least favourable due to their high cost of construction and low rating on the MODA criteria, this aligns with common sense since these routes are long routes that go through a high number of crossings (including crossing the HS2 three times), also,

long sections of these routes are along or adjacent to existing highways, this creates a high-risk construction process due to traffic disruption and numerous buried services.

6.2. Opportunities

The following opportunities have been identified which can be further investigated during the refinement of the preferred option.

6.2.1. North Warwick Alternative Outfall Location

An alternative outfall location for North Warwick route can be used to shorten the route and avoid extending the pipeline parallel to built-up areas. The alternative location shown as a blue dot in Figure 6-1 below is further away to North of Warwick and is surrounded by open fields away from the busy highway. Please note that outfall location requires further investigation.

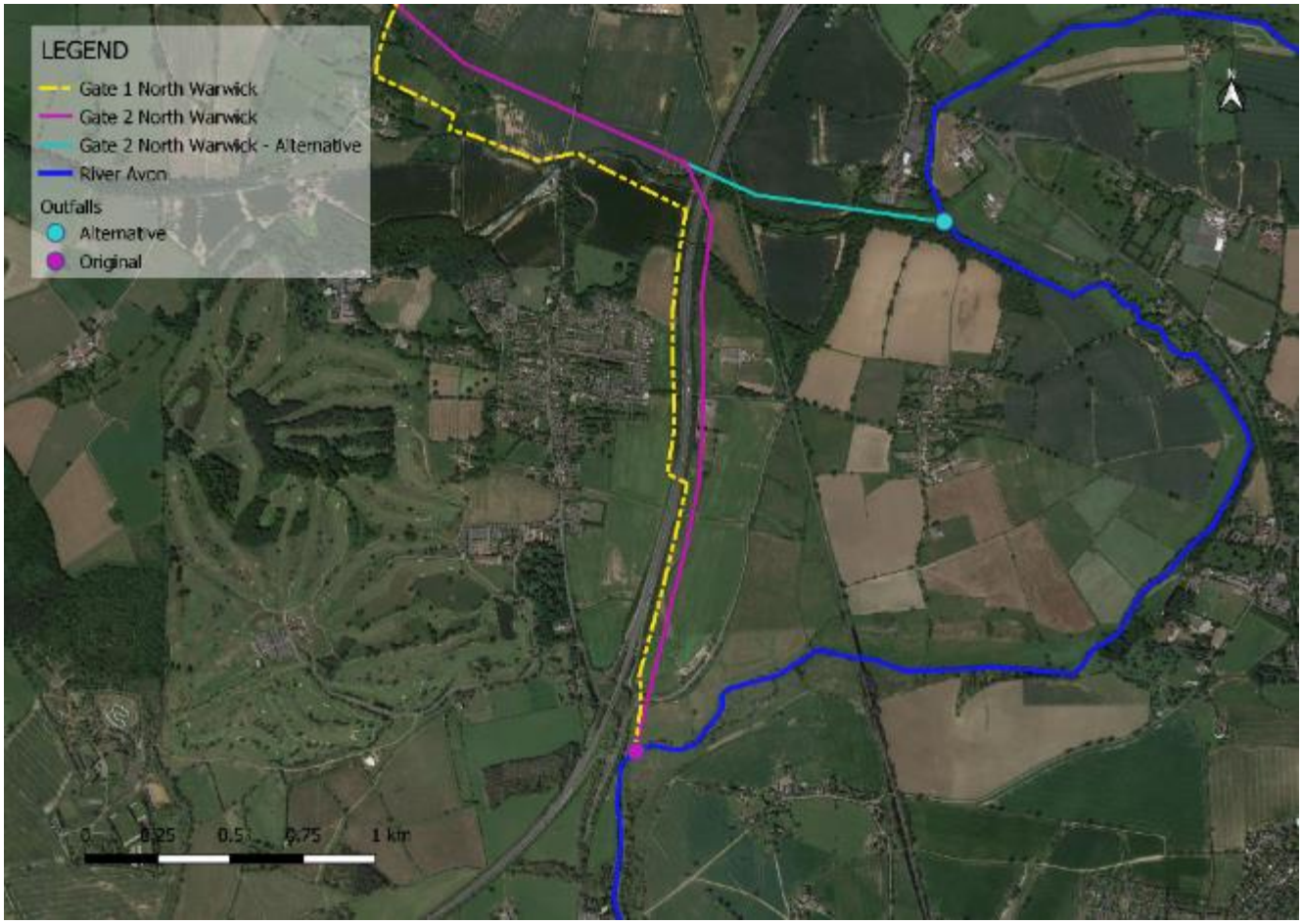


Figure 6-1: Opportunity for alternative outfall location at North Warwick

6.2.2. South Warwick Alternative Outfall Location

An alternative outfall location for South Warwick route can be used to improve the route and avoid extending the pipeline through a busy built-up area. The alternative location shown as a blue dot in Figure 6-2 below is further down to South of Warwick and is surrounded by open fields away from the busy highway. Please note that outfall location requires further investigation.

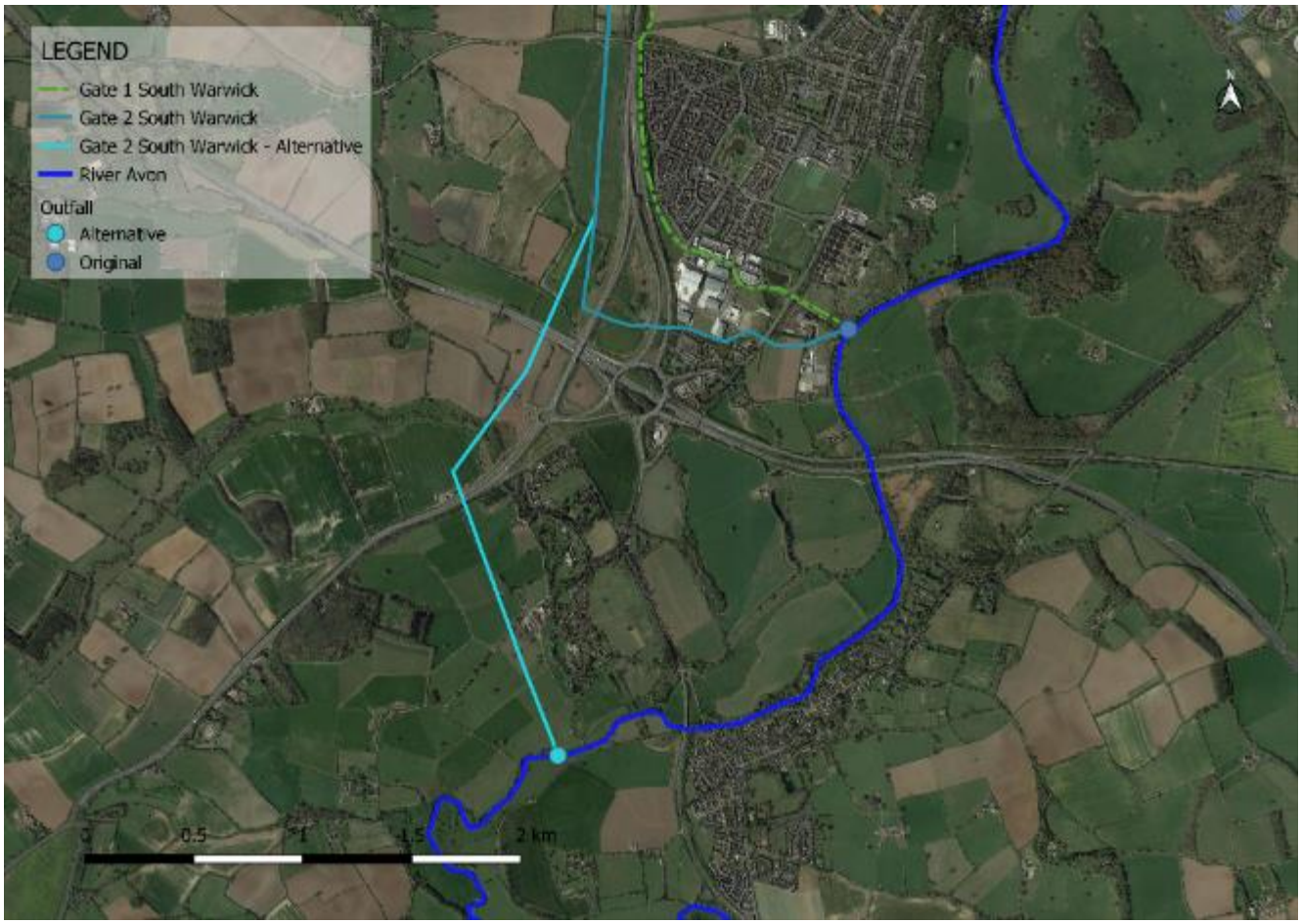


Figure 6-2: Opportunity for alternative outfall location at South Warwick to avoid built-up area crossings

6.2.3. **Pipeline Diameter Reduction after Tile Hill**

Please note that there is an opportunity to optimise the preferred pipeline route by reducing the size of the gravity main after crossing Tile hill peak. This will improve the hydraulic profile of the pipeline and will also reduce the CAPEX cost considerably. Approximate the last 7 km of the pipeline can be reduced to 900mm instead of the current 1050mm.

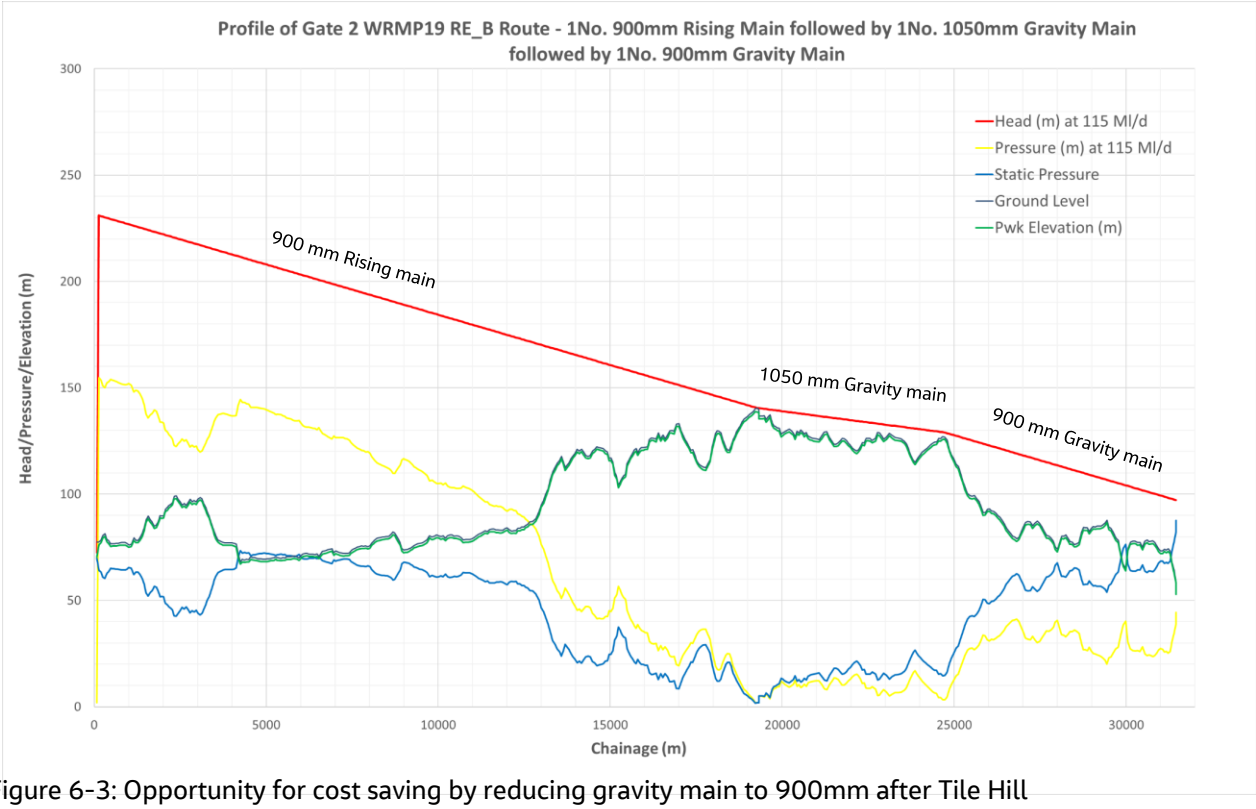


Figure 6-3: Opportunity for cost saving by reducing gravity main to 900mm after Tile Hill

6.2.4. **Route Refinement to Utilise 'Grey Belt' Land**

To mitigate potential structural disturbances associated with trenchless construction, realignment of the routes should be considered to use highway corridors. This is particularly relevant with WRMP19 and Gate 2 WRMP19 routes which intersect with the Burton Green/Tile Hill community.

There are further opportunities along the route to limit environmental disturbance by utilising highway corridors and or reserves. These route refinements can be assessed at detailed design stage.

Figure 6-4: Route refinement to utilise 'grey belt' land

6.2.5. **Route pipeline through the existing discharge channel - G2 WRMP19 RE_A**

There is a construction opportunity for Route G2 WRMP19 RE_A. It has been suggested to utilise the route of, or the discharge channel structure itself, to convey the pipeline. This opportunity would mitigate increases in length, materials, vehicle movements, spoil, land possessions and eliminate interfaces with HS2 and National highways at this location. This solution is considered to have benefit cost, programme and be less impactful on the environment assuming that the existing infrastructure is capable of supporting the pipeline. This opportunity has not been studied further due to uncertainty regarding the installation through the channel area, the impact on operations and the feasibility of the construction adjacent to a live final effluent outfall channel.

There are a number of potential installation methods which could be considered, such as clamping the pipe to the wall of the concrete channel, or by laying the pipeline in the base of the channel secured to the concrete with clamps or ballast. Alternatively, the pipe could be suspended above the channel by steelwork as indicated in Figure 6-6.

Figure 6-5: Route G2 WRMP19 RE_A modified route to pass along the length of the discharge channel

Figure 6-6: Example of a type of pipe clamp arrangement

Figure 6-7: Photo of the existing discharge channel

Appendices

A. Pipeline Route Development Criteria

Feature	Description	Requirement	Source of data	Preference Scale
Below hydraulic grade line (HGL)	Total head or static head less pipe losses	-	OS Terrain 50 used to develop hydraulic profile	N/A
Uncultivated open space	E.g. fields not used for crops	Preferred route	Aerial photography	3
Low grade cultivated open space	Lower grade cultivated open space	Preferred route	Agricultural Land Classification Grade 3 and below Agricultural Land Classification Post 1988 England	2
Cultivated open fields	High value agriculture		Agricultural Land Classification Grade 1 & 2 Agricultural Land Classification Post 1988 England	1
Football pitches and sports fields		Avoid if possible	Aerial photography	0
Railway Embankment		Cross Railway Embankment at right angles	Aerial photography / topography	0
Un-made roads and tracks		Need to provide alternative access	Aerial photography	0
Ponds		Clearance of 250m	Aerial photography	0
Abandoned railway lines	Generally comprising embankments, cuttings, earthworks	Working width is very constricted – not ideal for pipe laying	Aerial photography	-1
AONB and National Park		Avoid where possible but as these are large scale designations can be difficult - but will increase sensitivity of impacts on habitats and landscape features such as trees.	N/A to this area	-1
Flood plain		Avoid where possible (may be difficult to avoid completely as usually along rivers etc)	Flood Map for Planning (Rivers and Sea) - Flood Zone 2 Flood Map for Planning (Rivers and Sea) - Flood Zone 3	-1
Equine facilities		Avoid where possible as the compensation may be high	Aerial photography	-1
Landfill	-	Avoid where possible as this will lead to requirements for containment, capping, tunnelling	Environment Agency	-1
Nature Reserves Local (and non statutory wildlife sites)	-	Avoid traversing	Natural England	-1

Feature	Description	Requirement	Source of data	Preference Scale
Railway Cutting		Cross Railway cuttings at right angles	Aerial photography / LiDAR / contours	-1
Steep slopes – including side slopes	-	Avoid where possible Cross perpendicular to contours where possible – i.e. straight up slope	LiDAR	-1
Water Supply Source Protection Zones		Avoid where possible	Source Protection Zones	-1
Aerial photography	Areas where the aerial imagery/photography is obscured	Avoid routing through these areas unless you have confirmed knowledge of what is in the area. In many cases the Aerial Imagery is blurred because it is a defence facility or some other top secret area where you would not be allowed to route a pipeline through.	Aerial photography	-2
A Road		Avoid routing pipeline along the carriageway of an 'A' Road	Mapping	-2
Common land		Avoid traversing – permission difficulties, likely to have multiple owners	CRoW Act 2000 - Access Layer	-2
Golf courses		Avoid if possible, if not possible to avoid then very early stakeholder management required	Aerial photography	-2
Historic underground mine workings		Avoid		-2
Priority habitat wetland sites and chalk grasslands	Habitats that could be irreversibly affected/or difficult to reinstate	Avoid traversing		-2
Public parks	Various designations	Avoid if possible	Aerial photography / mapping	-2
Ribbon/Linear Residential or commercial Developments	Crossing	Avoid crossing in the middle of ribbon development. Where a pipeline route has to cross ribbon development, identify at least 2 or 3 gaps in the development where the pipe can be threaded through	Aerial photography / mapping	-2
Allotments		Avoid	Aerial photography	-3
Ancient Woodland	-	Avoid traversing	Natural England	-3

Feature	Description	Requirement	Source of data	Preference Scale
Buildings	Residential and commercial buildings	Apply a 15m wide exclusion zone around all buildings (except where pipeline in road)	Aerial photography / mapping	-3
Canal		Avoid traversing	Aerial photography / mapping	-3
Cemetery		Avoid – not even with trenchless	Aerial photography?	-3
Cultural heritage sites	Scheduled Monuments, Registered parks and gardens, Battlefields, World Heritage Sites, Conservation Areas, listed buildings	Avoid	Historic England	-3
Environmental designations – national and international	SSSI / SAC / SPA / NNRs / Ramsar's	Avoid traversing	Natural England	-3
Motorways	-	Do not route pipeline along the carriageway of a motorway	Aerial photography	-3
Private Property Gardens		Avoid	Aerial photography	-3
Private Yards	Residential and commercial yards	DO not route pipeline working width within a yard	Aerial photography	-3
Rivers & watercourses	Where pipeline runs along watercourses	Appy a 10m wide exclusion zone adjacent to rivers and other watercourses. Do not allow the pipeline working width to be within 10m of a watercourse or water body. This is to avoid need for Flood Defence Permit applications	Statutory Main River Map Mapping	-3

B. Constraints Data

Extracted on 16/11/21

Dataset title	Dataset Responsible Party	Source Publication Date	Comment
Environmental Designations			
Air Quality Management Areas	DEFRA	01/10/21	
Flood Map for Planning (Rivers and Sea) – Areas Benefiting from Defences	Environment Agency	05/11/21	
Flood Map for Planning (Rivers and Sea) - Flood Storage Areas	Environment Agency	05/11/21	
Flood Map for Planning (Rivers and Sea) - Flood Zone 2	Environment Agency	05/11/21	
Flood Map for Planning (Rivers and Sea) - Flood Zone 3	Environment Agency	05/11/21	
Source Protection Zones	Environment Agency	05/11/21	
Statutory Main River Map	Environment Agency	11/11/21	
Battlefields	Historic England	20/08/21	
Listed Buildings	Historic England	08/11/21	
Registered Parks and Gardens	Historic England	20/08/21	
Scheduled Monuments	Historic England	08/11/21	
World Heritage Sites	Historic England	20/08/21	N/A to area
Agricultural Land Classification Post 1988 England	Natural England	20/05/20	
Ancient Woodlands (England)	Natural England	30/04/21	
Areas of Outstanding Natural Beauty (AONB)	Natural England	01/09/20	N/A to area
Biosphere Reserves (England)	Natural England	20/05/20	N/A to area
Country Parks (England)	Natural England	01/09/20	
CRoW Act 2000 - Access Layer	Natural England	20/05/20	
Local Nature Reserves (England)	Natural England	12/10/21	
National Nature Reserves (England)	Natural England	28/10/21	
National Parks	Natural England	01/09/20	
National Trails	Natural England	20/05/20	
Priority River Habitat - Rivers	Natural England	20/05/20	N/A to area
Ramsar (England)	Natural England	22/10/20	N/A to area
Sites of Special Scientific Interest (England)	Natural England	28/10/21	
Special Areas of Conservation (England)	Natural England	12/10/21	
Special Protection Areas (England)	Natural England	03/08/21	

Dataset title	Dataset Responsible Party	Source Publication Date	Comment
Special Area of Conservation (SAC)	Natural England	05/01/22	
Site of Special Scientific Interest (SSSI)	Natural England	05/01/22	
Drinking Water Safeguard Zone	Department for Environment, Food and Rural Affairs (DEFRA)	05/01/22	
Priority Habitats	Department for Environment, Food and Rural Affairs (DEFRA)	05/01/22	
Permitted waste sites	Environment Agency/Permitted Waste Sites Authorised Landfill Site Boundaries	05/01/22	
Noise Important Area (NIA)	Department for Environment, Food and Rural Affairs (DEFRA)	05/01/22	
Registered Battlefields	Historic England	05/01/22	
Historic landfill sites	Environment Agency/Historic Landfill Map Server	05/01/22	
Services			
National Grid Cable	National Grid	Extracted – 02/12/2021	
National Grid Gas Pipe – 2m Buffer	National Grid	Extracted – 02/12/2021	
National Grid OHL	National Grid	Extracted – 02/12/2021	
National Grid Substations	National Grid	Extracted – 02/12/2021	
National Grid Towers	National Grid	Extracted – 02/12/2021	
High pressure gas mains	Unavailable data		
Trunk sewers	Unavailable data		
Trunk mains	Unavailable data		
Sewer rising mains	Unavailable data		
Oil pipelines	Unavailable data		
Aviation fuel pipelines	Unavailable data		
Geotechnical			
Geological mapping	British Geological Society		
National landslide database	British Geological Society		
Hydrogeology	British Geological Society		
Non coal mining plans	Coal Authority datasets		
Coal mine appraisal ing areas	Coal Authority datasets		
Surface Coal Resource Area	Coal Authority datasets		
Abandoned Mine Catalogues	Coal Authority datasets		
Other			
Ground level data	OSTerrain50	Extracted – 02/12/2021	
HS2 rail and depot details	Unavailable data		
Crown land	Unavailable data		
Future development areas	Unavailable data		

Dataset title	Dataset Responsible Party	Source Publication Date	Comment
MOD land	Unavailable data		
Land owned by other statutory undertakers	Unavailable data		

C. Environmental Constraints Plan

Full details included in Appendix N

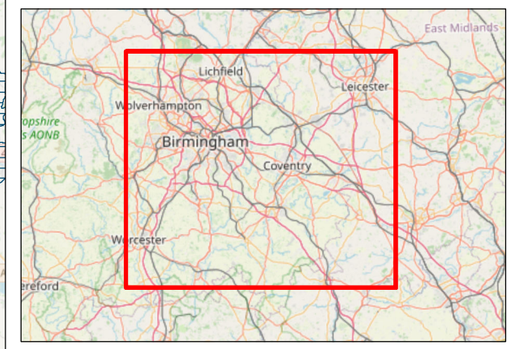
Author names redacted

FIGURE 1.1

SHEET 1 OF 10
SHEET 2 OF 10
SHEET 3 OF 10
SHEET 4 OF 10
SHEET 5 OF 10
SHEET 6 OF 10
SHEET 7 OF 10
SHEET 8 OF 10
SHEET 9 OF 10
SHEET 10 OF 10

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study Area
- 20km Study Area
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
- Special Areas of Conservation
- Ancient Woodland
- Permitted Landfill Site
- Flood Zone 3
- Flood Zone 2
- Drinking Water Safeguard Zone
- Source Protection Zone



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	JAN 2021	Initial Issue	[redacted]			

Jacobs
5 First Street, Manchester, M15 4GU, UK.
Tel: +44(0)161 235 6000
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Project: MINWORTH STRATEGIC RESOURCE OPTION (SRO)

Drawing Title: ENVIRONMENTAL CONSTRAINTS PLAN
OVERVIEW SHEET

Drawing Status: FOR ISSUE

Scale @ A3	1:275,000	DO NOT SCALE
Jacobs No.	B19589CF	
Client No.		

Drawing No.: B19589CF_Env_Constraints

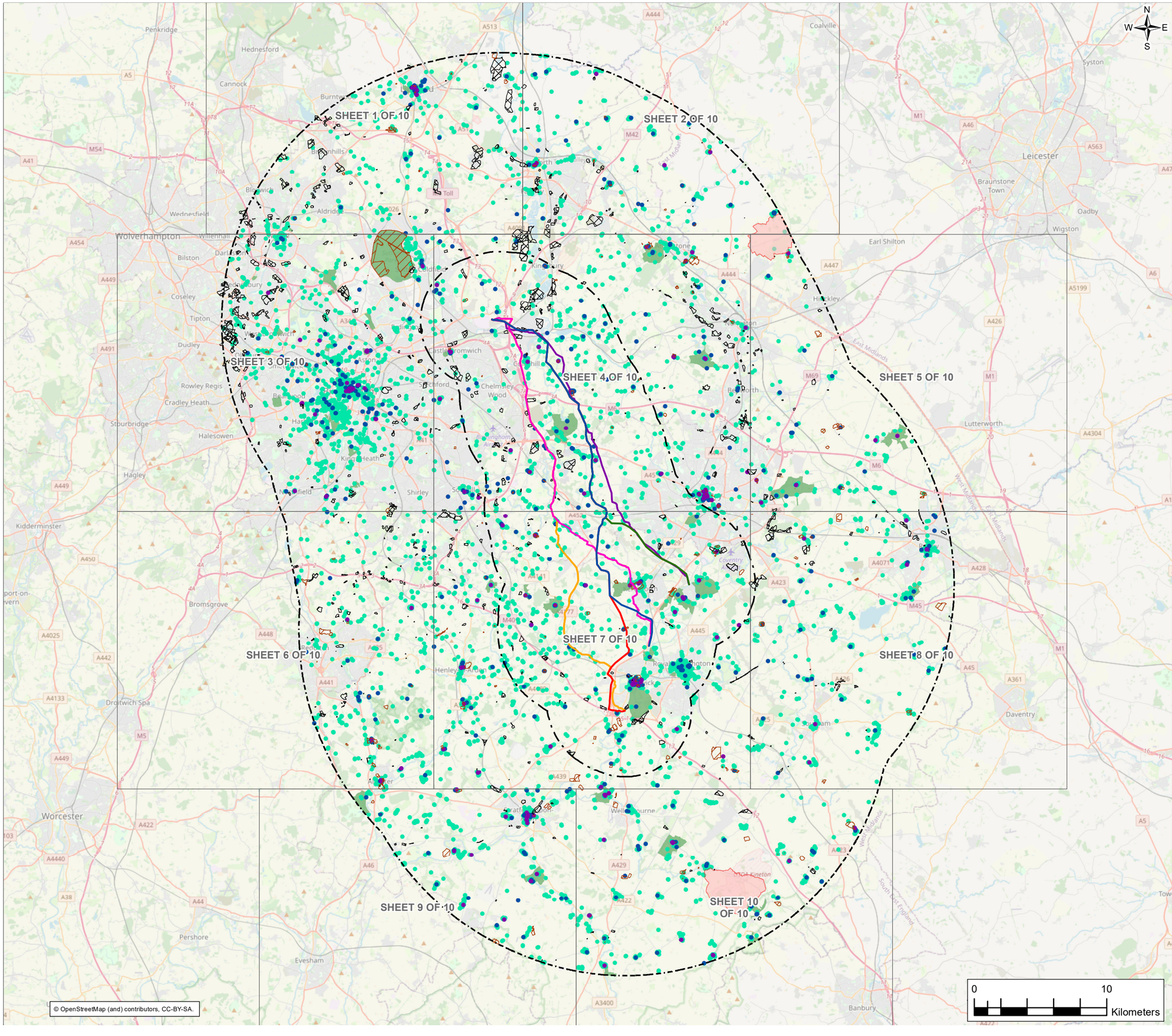
0 10 Kilometers

D. Heritage Constraints Plan

Full details included in Appendix N

Author names redacted

FIGURE 2.1



Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	JAN 2021	Initial Issue	[redacted]			

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Client: SEVERN TRENT

Project: MINWORTH STRATEGIC RESOURCE OPTION (SRO)

Drawing Title: HERITAGE CONSTRAINTS PLAN
OVERVIEW SHEET

Drawing Status: FOR ISSUE

Scale @ A3	1:275,000	DO NOT SCALE
Jacobs No.	B19589CF	
Client No.		
Drawing No.	B19589CF_Her_Constraints	

E. MODA Criteria

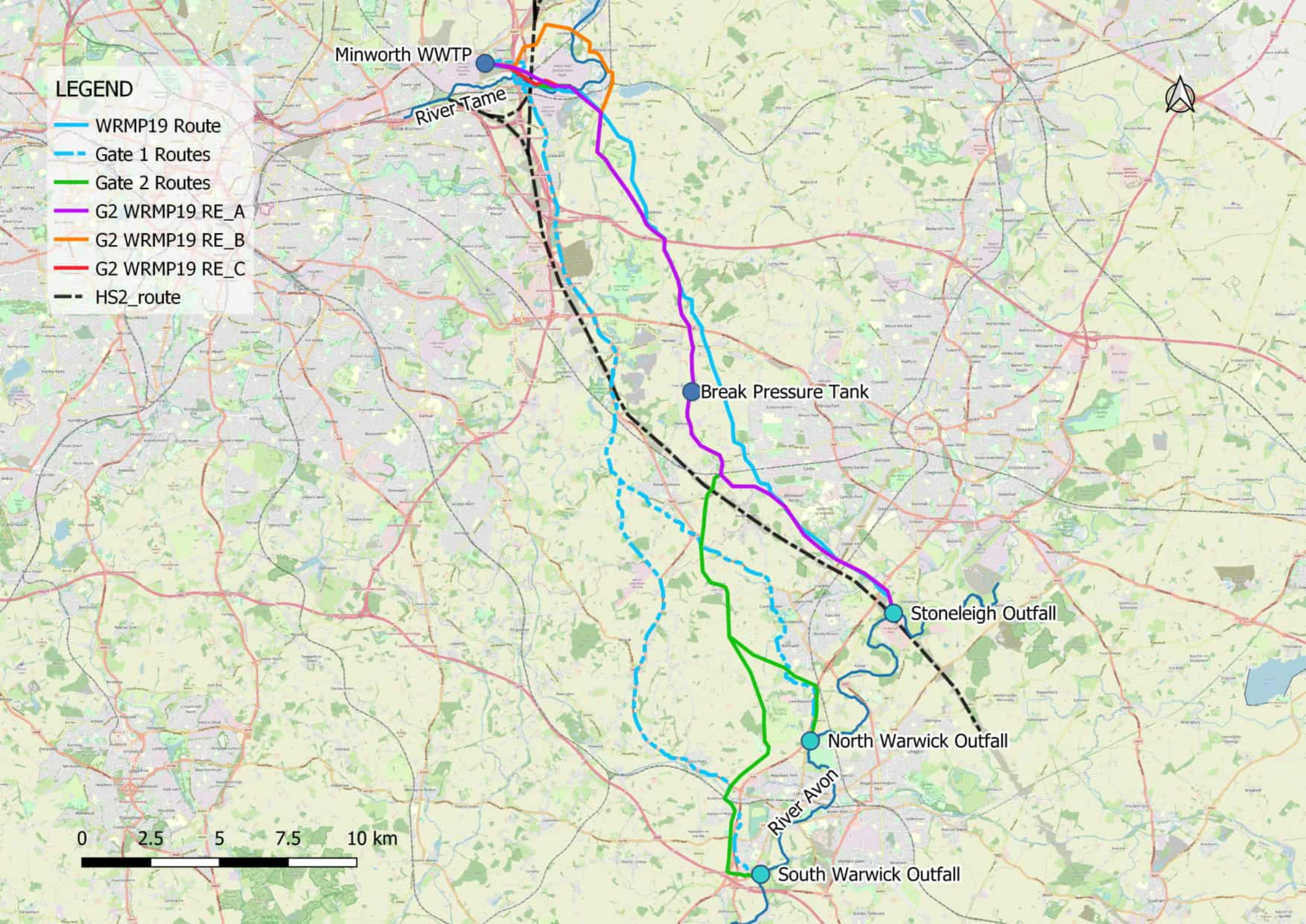
STEP 7: Criteria

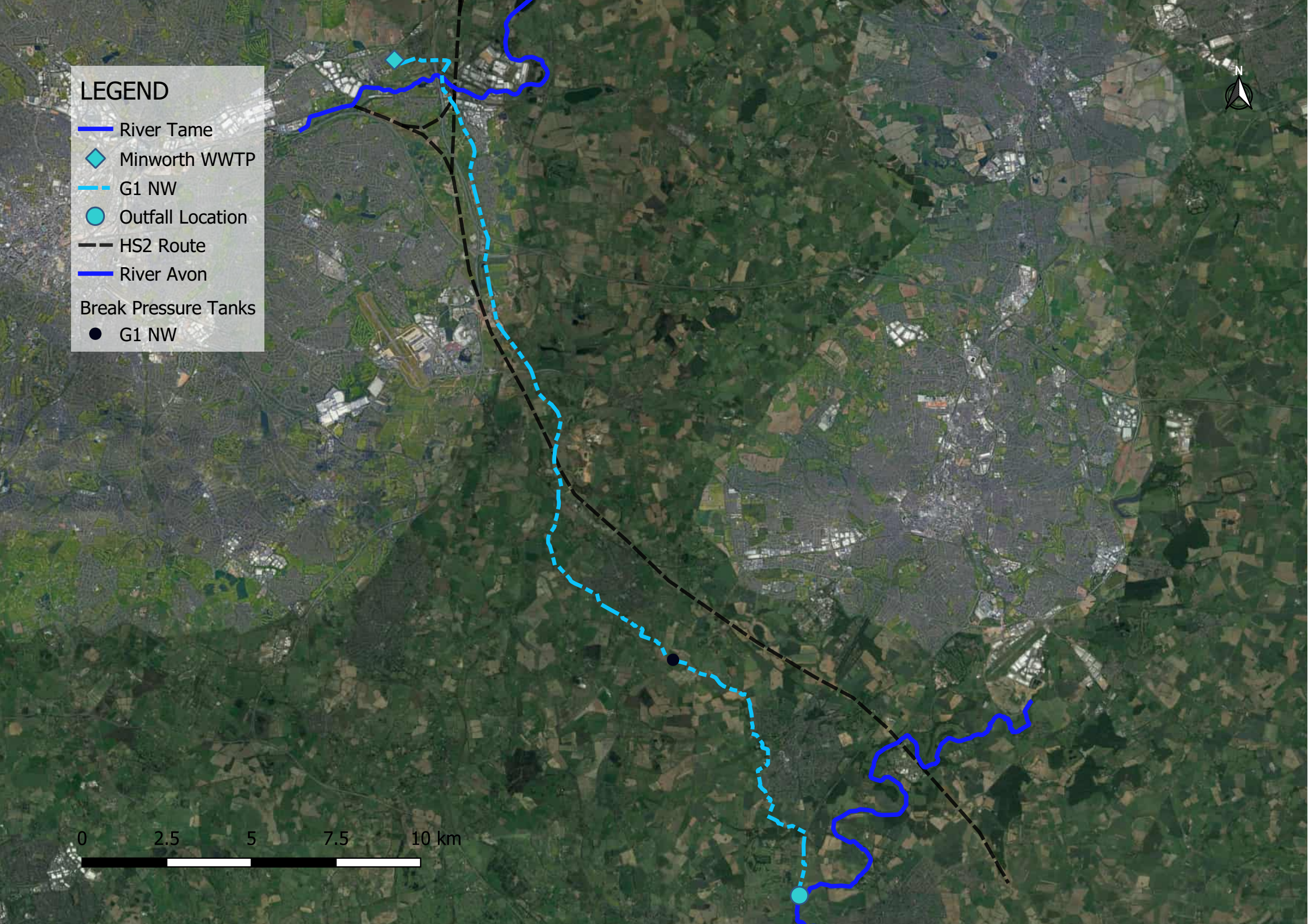
Minworth SRO

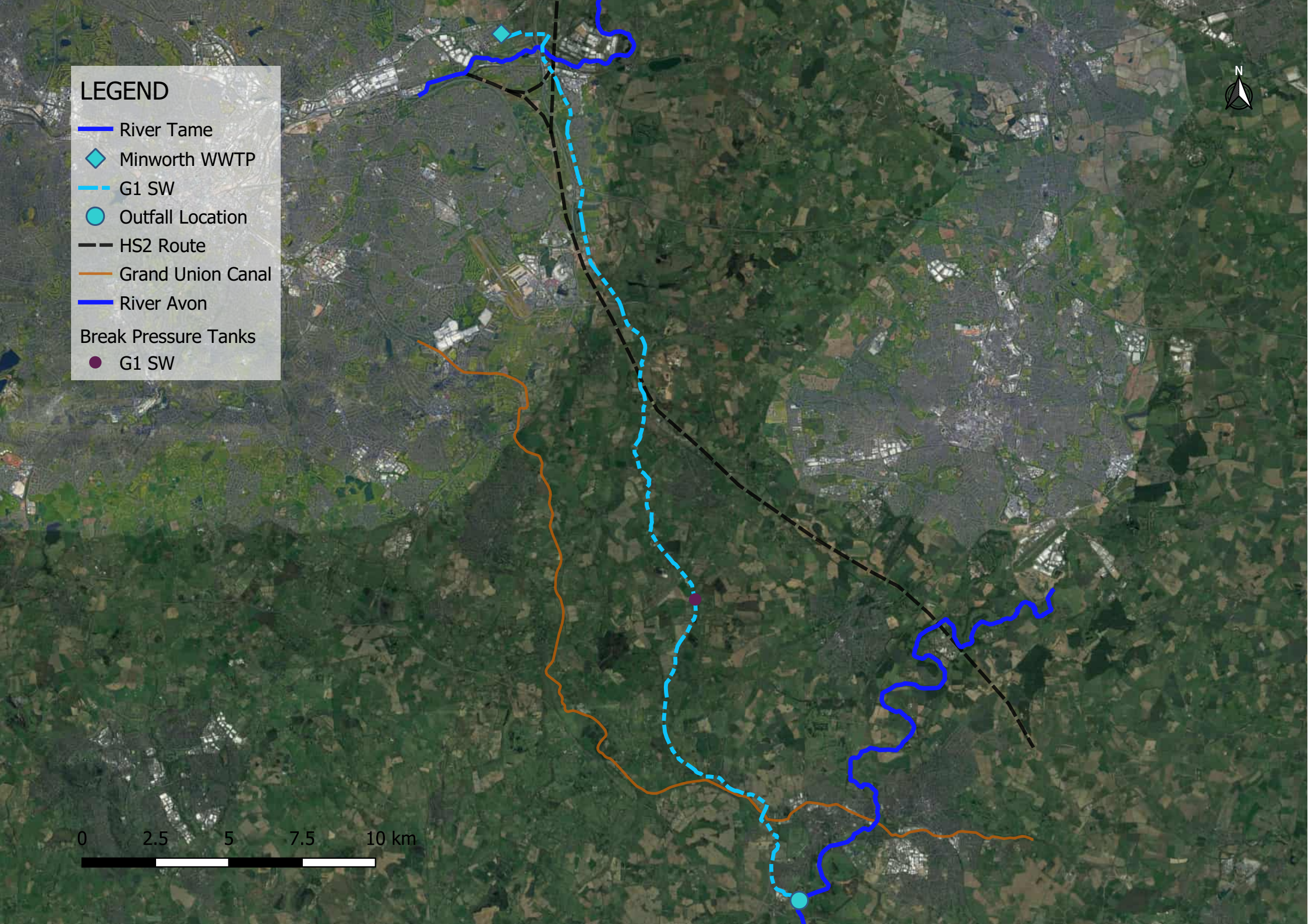
To appraise multiple pipeline route options to transfer flows from Minworth WwTW to the River Avon for use by STT SRO

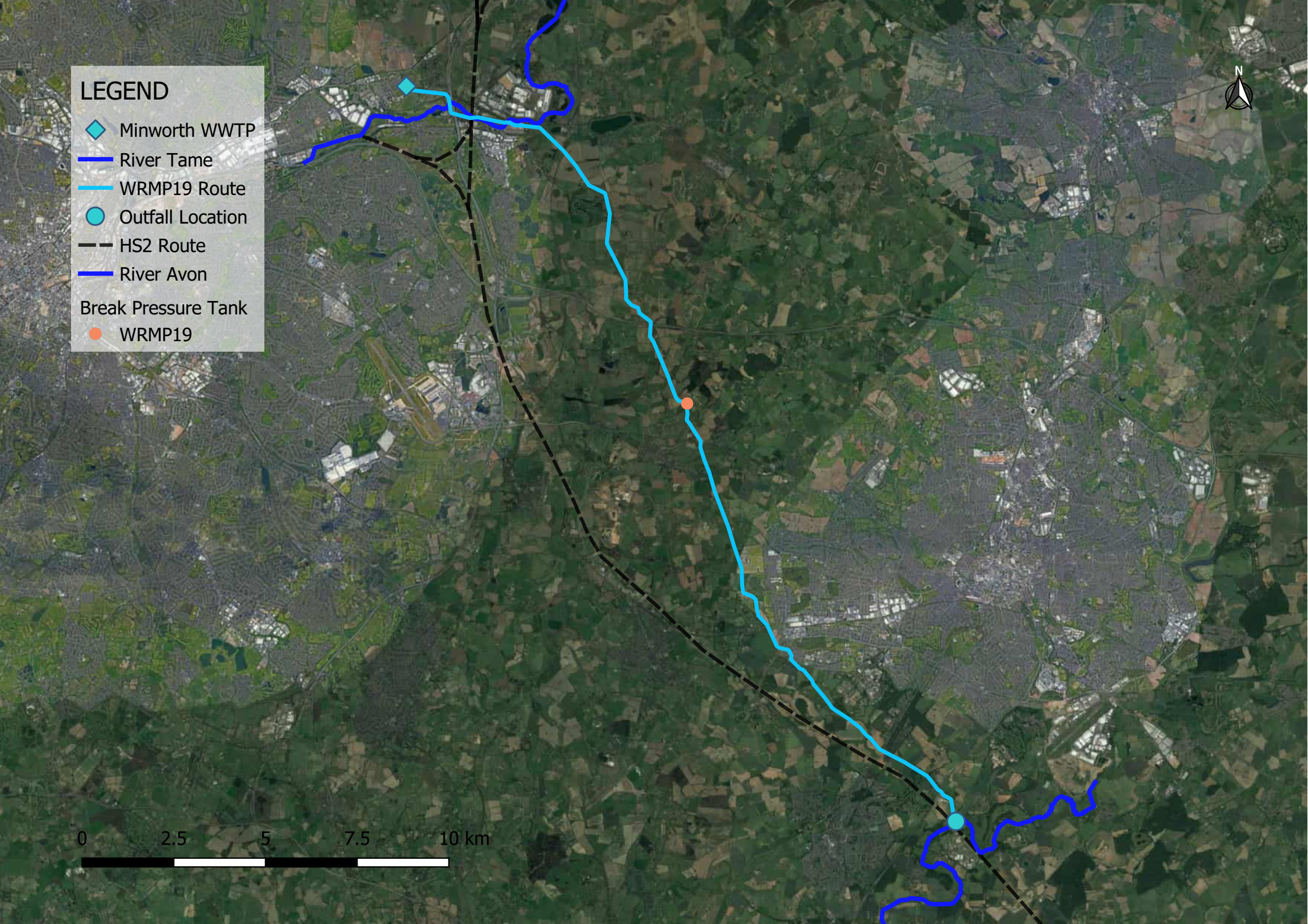
ID#	Evaluation Criteria	Worst Feasible Outcome	Best Feasible Outcome
1	Constructability		
1.1	Length with steep slopes (incl. side slopes > 1 in 10)	If more than 500 m of pipeline is in a 10% slop areas	If less than 100 m of pipeline is in a 10% slop areas
1.2	Length within flood zone	More than 4500 m of pipeline is in flood zone areas	Less than 3000 m of pipeline is in flood zone areas
1.3	Length within landfill	More than 1200 m of pipeline is in landfill areas	Less than 300 m of pipeline is in landfill areas
1.5	Length within high groundwater table	More than 5000 m of pipeline goes through high groundwater table areas	Less than 500 m of pipeline goes through high groundwater table areas
1.6	Likely complexity of trenchless crossings	-Access good - Lengths well within 500m	- Access poor - Long crossings identified - Shafts within floodplains - Within landfill site
1.7	Other geotechnical risks	High occurrence of other geotechnical risks	Low occurrence of other geotechnical risks
1.8	Length within water supply source protection zone	More than 8000 m of pipeline is in source protection zone	Less than 3500 m of pipeline is in source protection zone
1.9	Length with narrow working width - where less than 40m available	More than 1000 m of pipeline is in narrow working width areas	Less than 500 m of pipeline is in narrow working width areas
2	Planning risk		
2.1	No. of points where available options constrained i.e. pipe corridor width less than 200m	More than 10 pinch points	Less than 5 pinch points
2.2	Flexibility of BPT site location	- Single site option - Close proximity to residential properties - access poor	- Multiple site options - Natural screening available - No local receptors that would be impacted
2.3	No. of HS2 crossings	3 times crossing HS2	Crossing HS2 once or none
2.4	Route crosses land where permission likely to be difficult e.g. common land, trenchless beneath houses	More than 10 occasions	Less than 5 occasions
3	Operational considerations		
3.1	Maintenance requirements - likely number of air valves and washouts	Ground profile constantly changing, likely to result in a large number of air valves and washouts	Profile minimises number of air valves and washouts required
3.3	Hydraulics favourable	Long flat high point, likely to result in the requirement for deep dig to ensure stable hydraulics	Distinct high point
4	Customer disruption during construction		
4.1	Length working within road (including lengths in verge)	More than 9000 m of pipeline is in narrow working width areas	Less than 1000 m of pipeline is in narrow working width areas
4.2	Ribbon development impact - pipe routed across ribbon development	More than 4 occasions	1 occasion or none
4.3	Length of route within 50m of residential properties	More than 8000 m of route within 50m of residential properties	Less than 1000 m of route within 50m of residential properties
4.4	Traffic disruption during construction	- Route along in fields - X No. of roads crossings - X No. of ribbon development crossed	- Route in fields - X No. of road crossings - X No. of ribbon development crossed
5	Break Pressure Tank siting		
5.1	Site access	Remote location, single track roads	Close proximity to A/B road
5.2	Geotechnical risks	High geotechnical risks at BPT location	Low geotechnical risks at BPT location
6	Land Costs		
6.1	Length within high grade agricultural land	More than 5000 m of route is in high grade agricultural land	Less than 500 m of route is in high grade agricultural land
6.2	High value land impacted - sports fields, golf courses, equine	More than 300 m of route is in high value land	Less than 50 m of route is in high value land
6.3	Residential properties directly affected i.e. gardens, or trenchless beneath	More than 5 occasions	Less than 1 occasion
8	Carbon		
8.1	Embodied carbon	Embodied Carbon produced to build the pipeline higher than 20,000 tCO2e	Embodied Carbon produced to build the pipeline lower than 15,000 tCO2e
8.2	Operational carbon	Operational Carbon produced to build the pipeline higher than 145,000 tCO2e	Operational Carbon produced to build the pipeline lower than 75,000 tCO2e

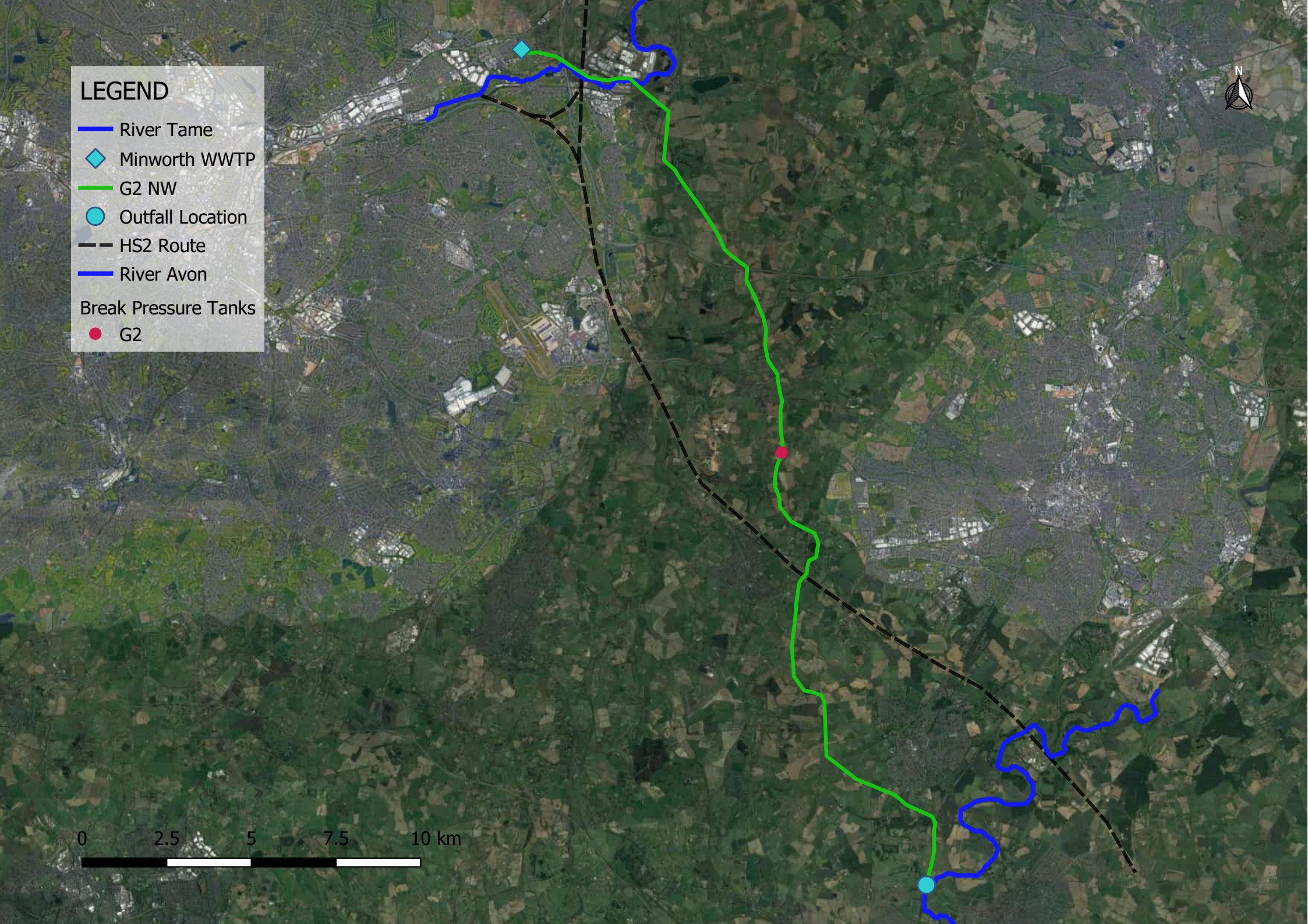
F. Pipeline Routes

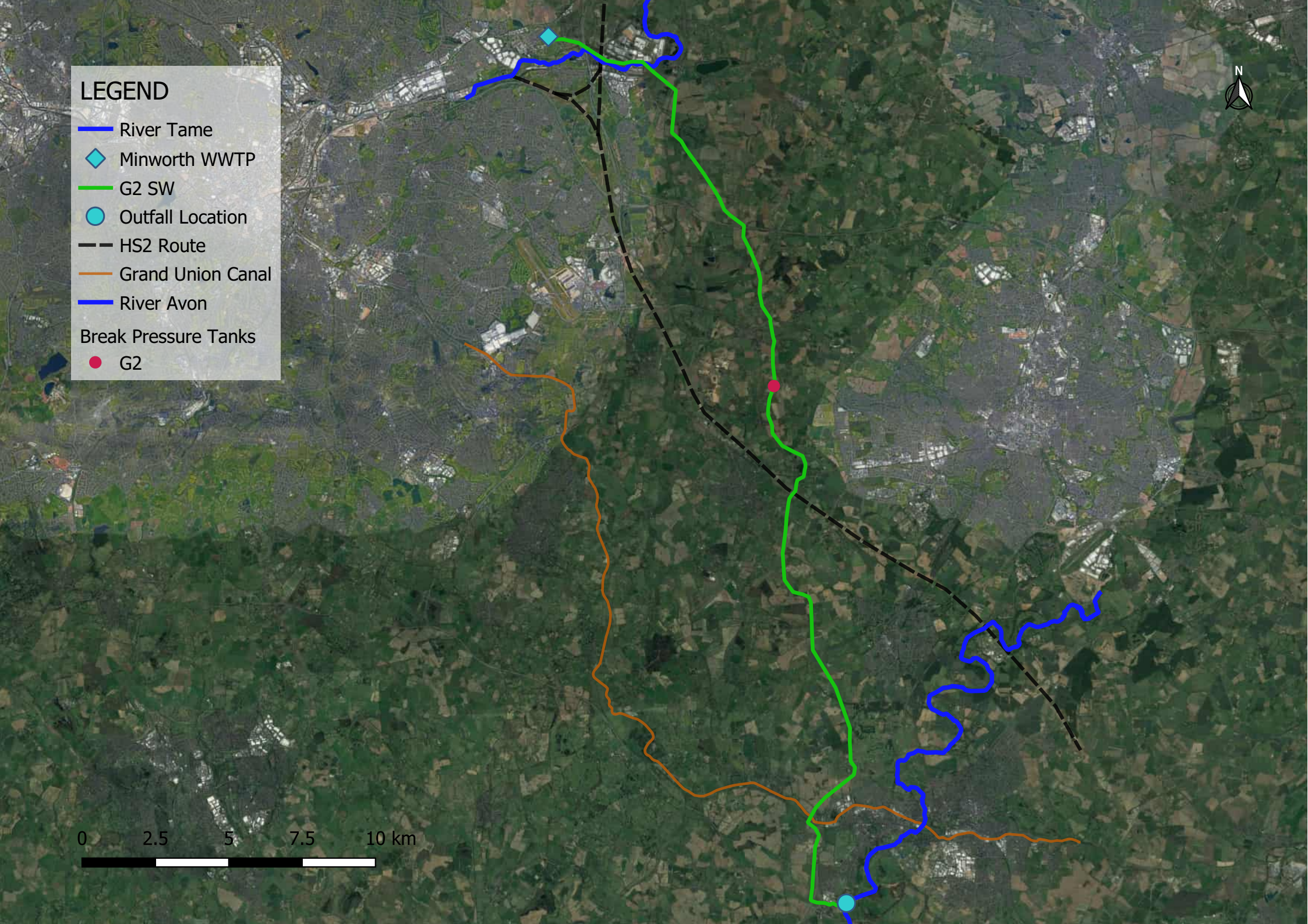

LEGEND
WRMP19 Route
Gate 1 Routes
Gate 2 Routes
G2 WRMP19 RE_A
G2 WRMP19 RE_B
G2 WRMP19 RE_C
HS2_route
Minworth WWTP
River Tame
Break Pressure Tank
Stoneleigh Outfall
North Warwick Outfall
River Avon
South Warwick Outfall
0
2.5
5
7.5
10 km


LEGEND
River Tame
Minworth WWTP
G1 NW
Outfall Location
HS2 Route
River Avon
Break Pressure Tanks
G1 NW
N
0
2.5
5
7.5
10 km


LEGEND
River Tame
Minworth WWTP
G1 SW
Outfall Location
HS2 Route
Grand Union Canal
River Avon
Break Pressure Tanks
G1 SW
N
0
2.5
5
7.5
10 km


LEGEND
Minworth WWTP
River Tame
WRMP19 Route
Outfall Location
HS2 Route
River Avon
Break Pressure Tank
WRMP19
N
0
2.5
5
7.5
10 km


LEGEND
River Tame
Minworth WWTP
G2 NW
Outfall Location
HS2 Route
River Avon
Break Pressure Tanks
G2
N
0
2.5
5
7.5
10 km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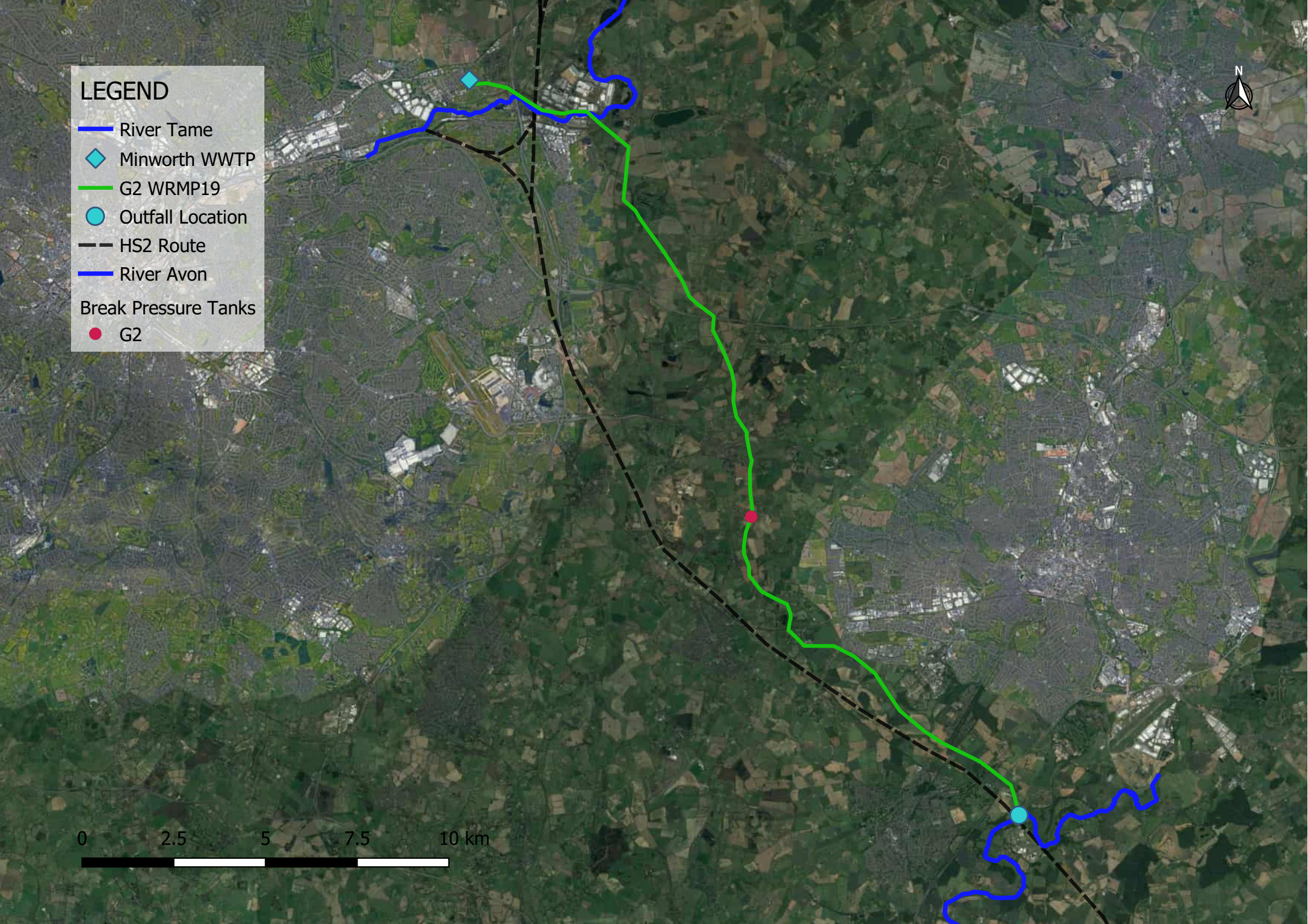
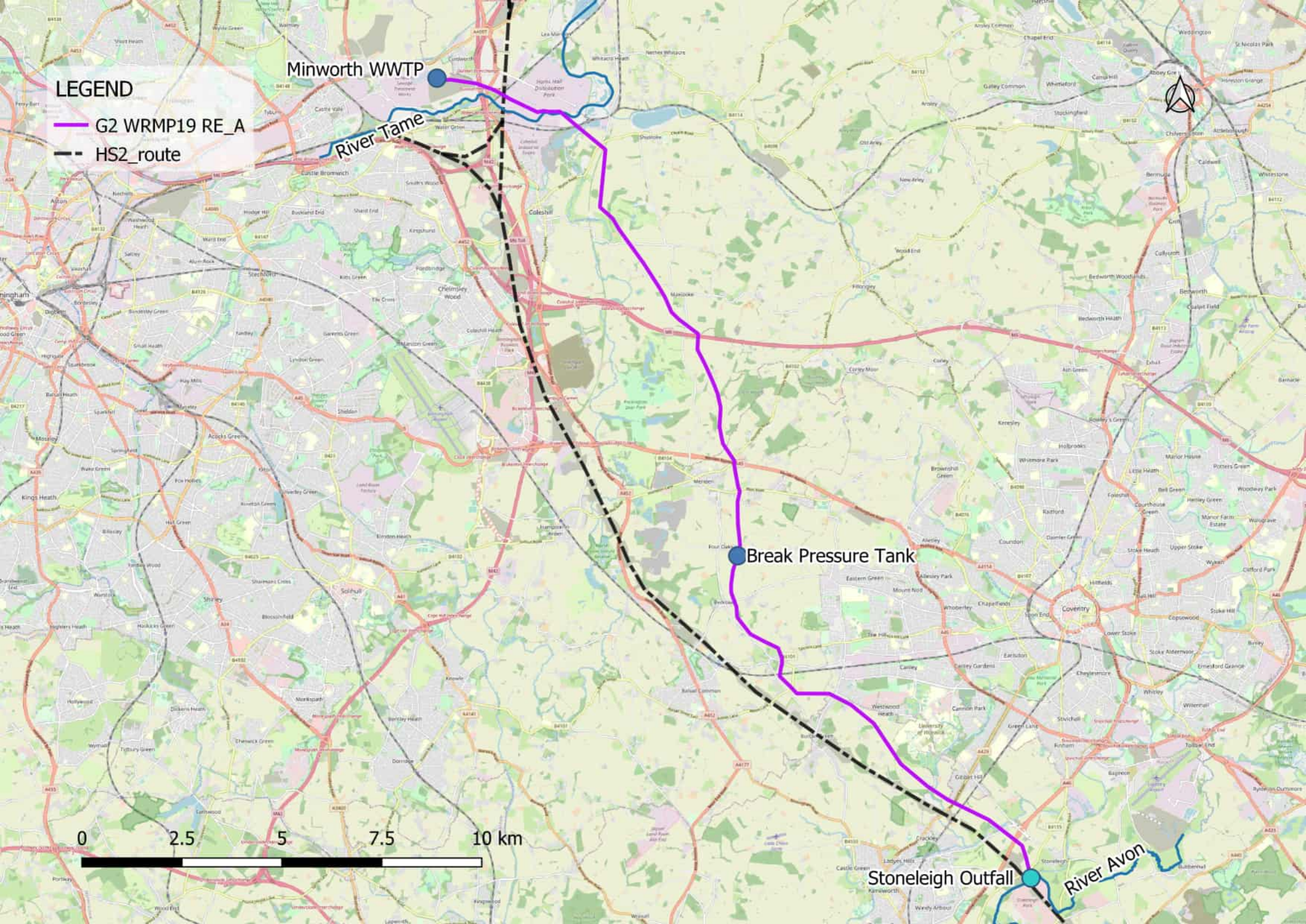
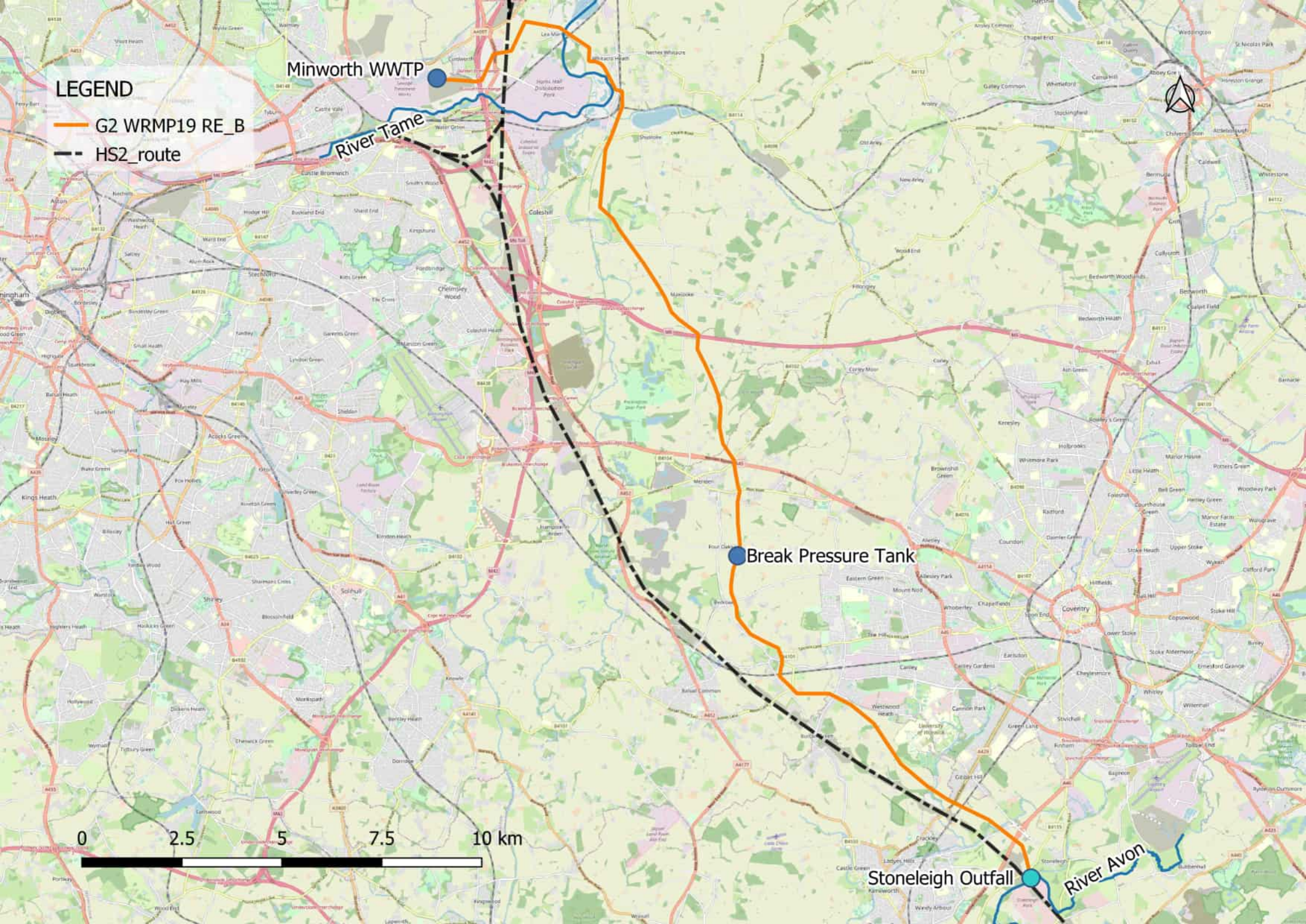
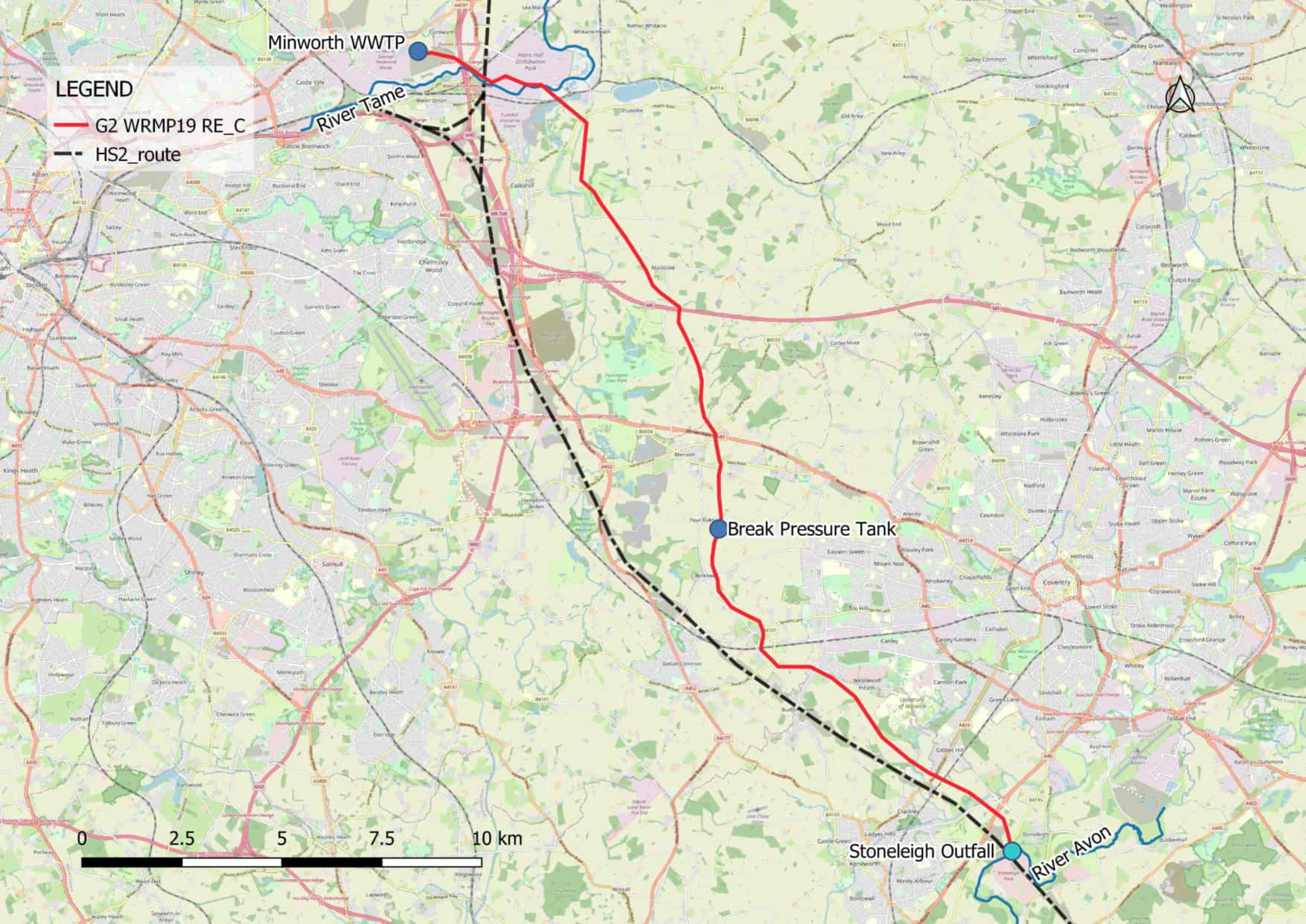
River Tame
Minworth WWTP
G2 SW
Outfall Location
HS2 Route
Grand Union Canal
River Avon
Break Pressure Tanks
G2
N
0
2.5
5
7.5
10 km


LEGEND
River Tame
Minworth WWTP
G2 WRMP19
Outfall Location
HS2 Route
River Avon
Break Pressure Tanks
G2
N
0
2.5
5
7.5
10 km


LEGEND
G2 WRMP19 RE_A
HS2_route
Minworth WWTP
River Tame
Break Pressure Tank
Stoneleigh Outfall
River Avon
0
2.5
5
7.5
10 km


LEGEND
G2 WRMP19 RE_B
HS2_route
Minworth WWTP
River Tame
Break Pressure Tank
Stoneleigh Outfall
River Avon
0
2.5
5
7.5
10 km


Minworth WWTP
River Tame
LEGEND
G2 WRMP19 RE_C
HS2_route
Break Pressure Tank
Stoneleigh Outfall
River Avon
0
2.5
5
7.5
10 km

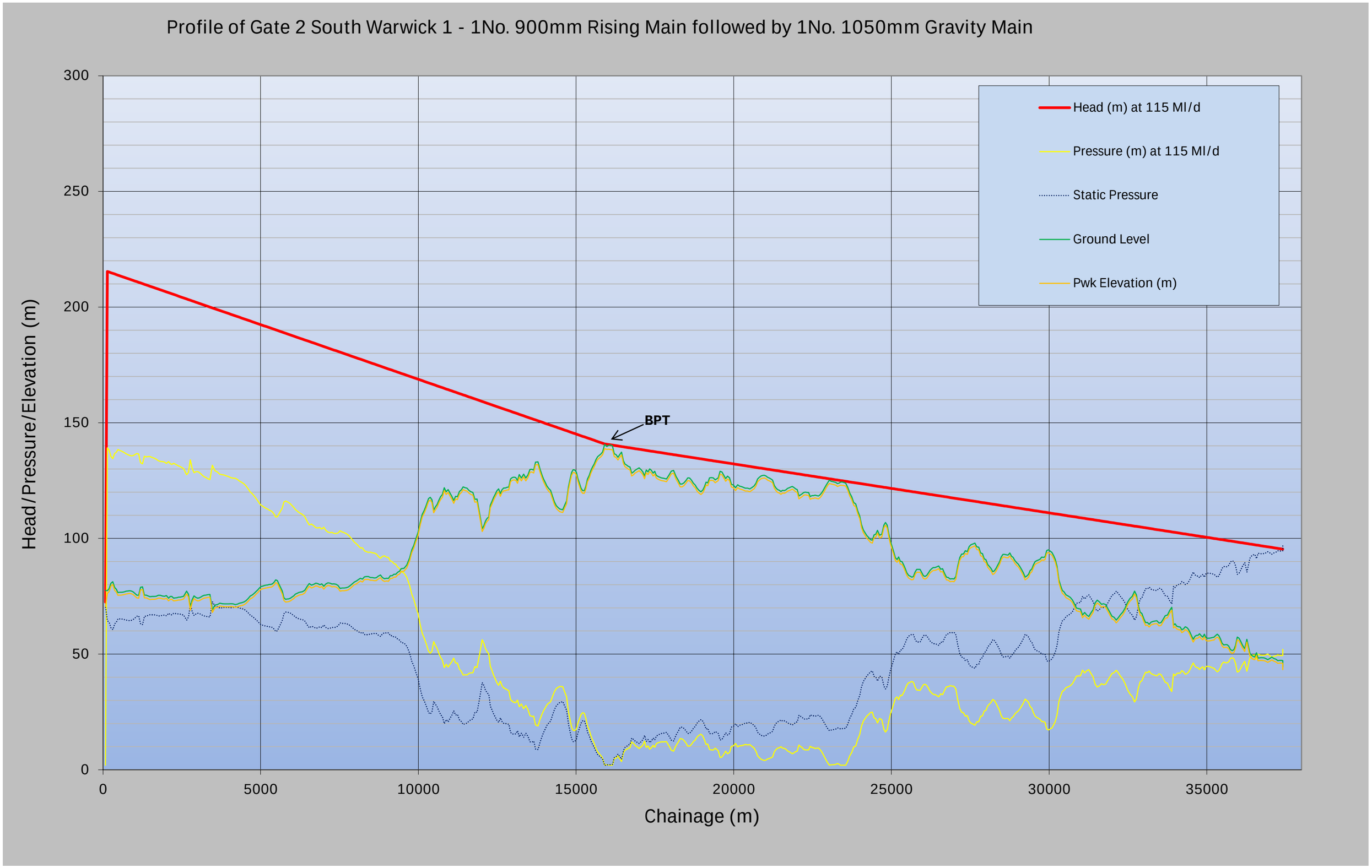
G. Hydraulic Profiles

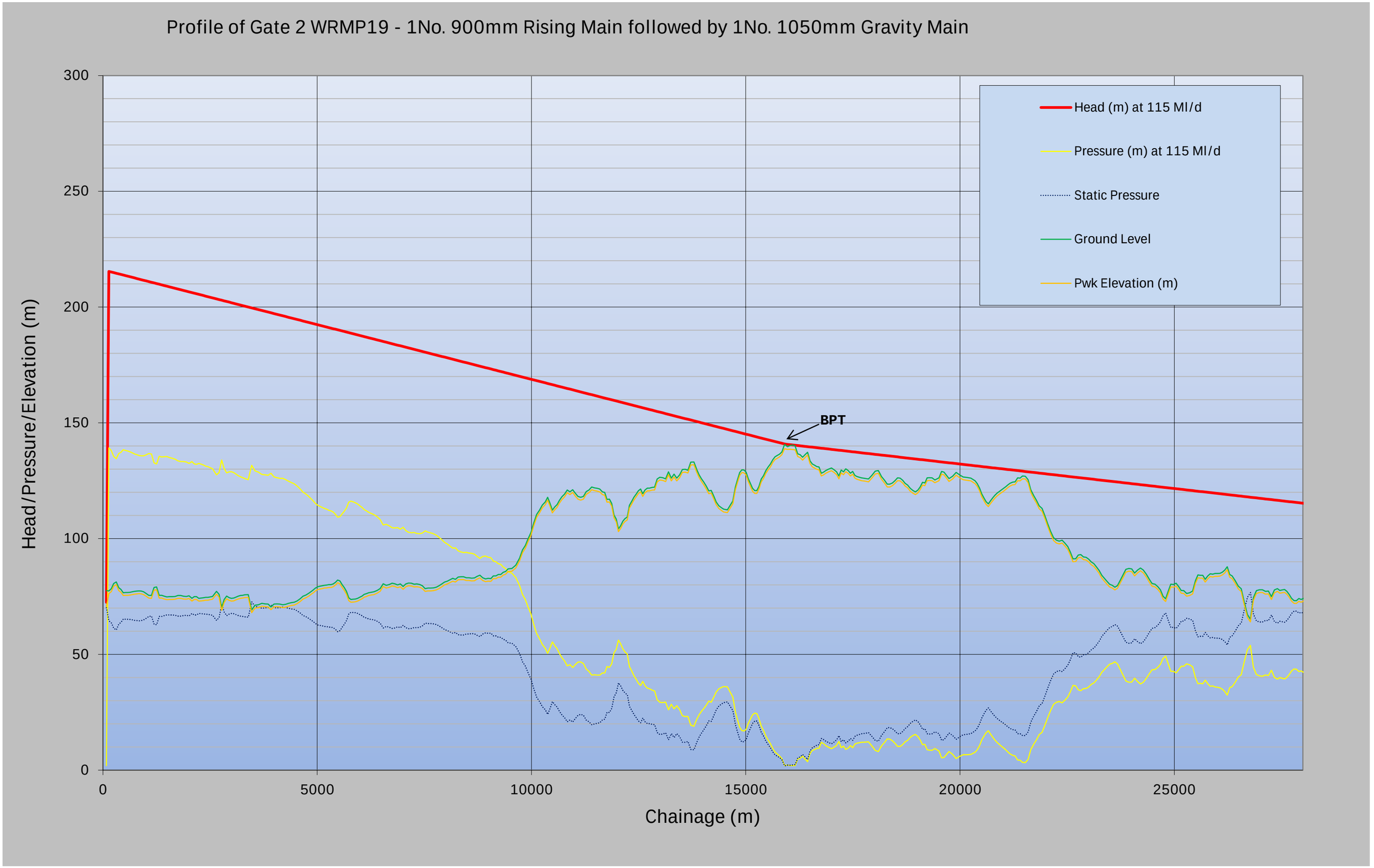
Profile of Gate 1 North Warwick - 1No. 900mm Rising Main followed by 1No. 900mm Gravity Main

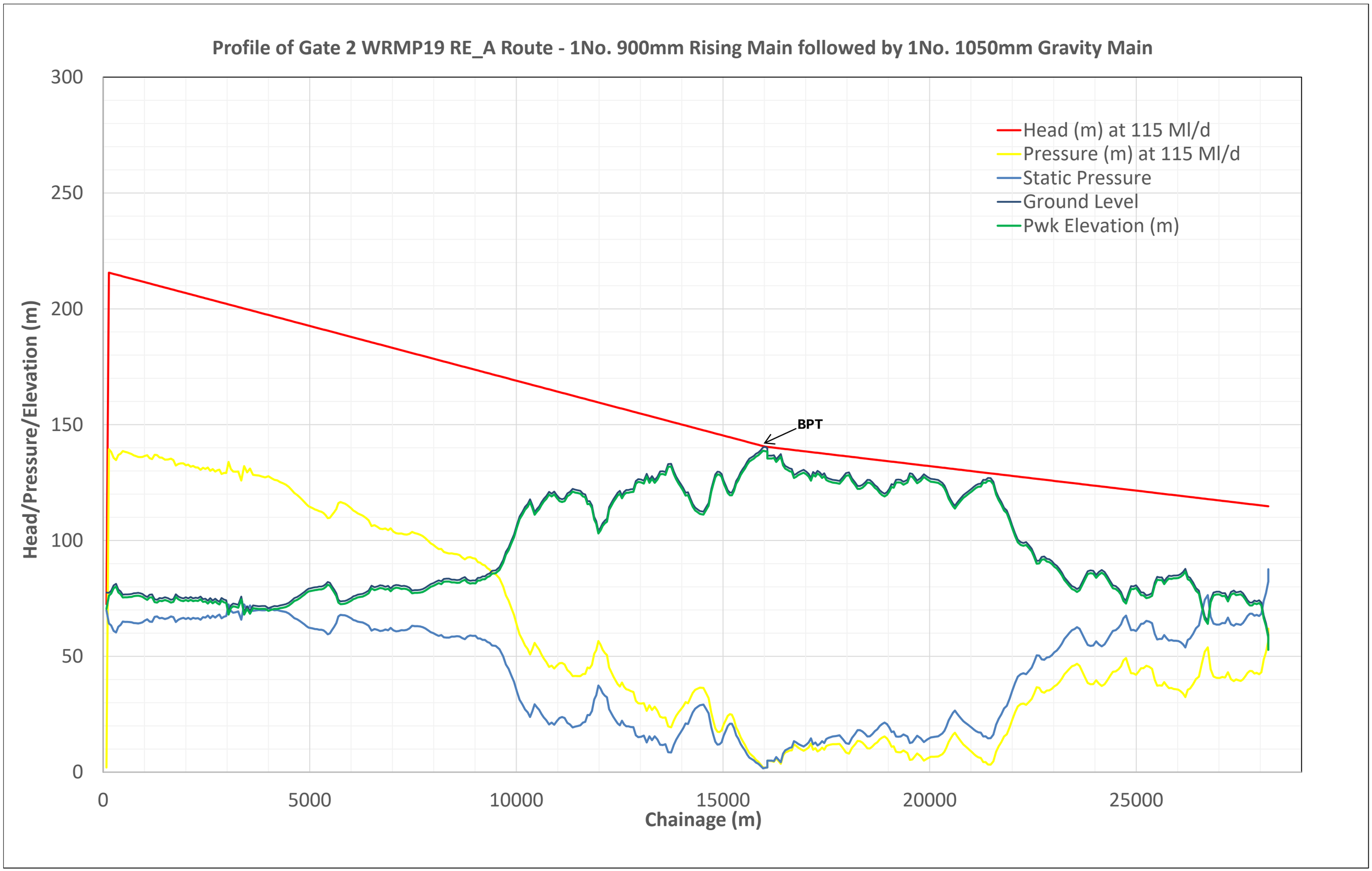

Profile of Gate 1 South Warwick - 1No. 900mm Rising Main followed by 1No. 1200mm Gravity Main
Head/Pressure/Elevation (m)
250
200
150
100
50
0
0
5000
10000
15000
20000
25000
30000
35000
40000
Chainage (m)
BPT
Head (m) at 115 Ml/d
Pressure (m) at 115 Ml/d
Static Pressure
Ground Level
Pwk Elevation (m)


Profile of WRMP19 - 1No. 900mm Rising Main followed by 1No. 900mm Gravity Main
Head/Pressure/Elevation (m)
300
250
200
150
100
50
0
0
5000
10000
15000
20000
25000
Chainage (m)
BPT
Head (m) at 115 Ml/d
Pressure (m) at 115 Ml/d
Static Pressure
Ground Level
Pwk Elevation (m)

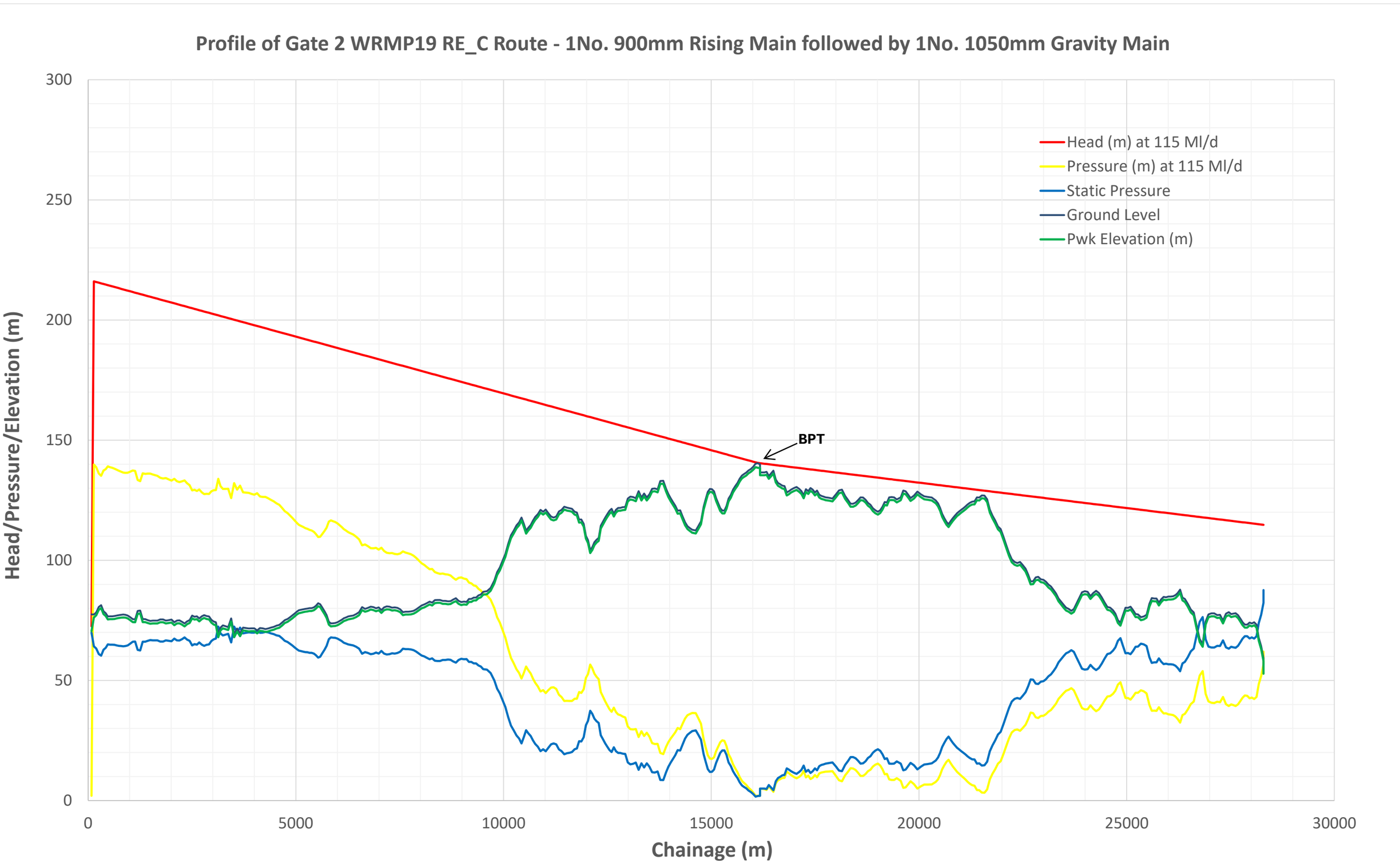

Profile of Gate 2 North Warwick 1 - 1No. 900mm Rising Main followed by 1No. 1050mm Gravity Main
Head/Pressure/Elevation (m)
300
250
200
150
100
50
0
0
5000
10000
15000
20000
25000
30000
Chainage (m)
BPT
Head (m) at 115 Ml/d
Pressure (m) at 115 Ml/d
Static Pressure
Ground Level
Pwk Elevation (m)


Profile of Gate 2 South Warwick 1 - 1No. 900mm Rising Main followed by 1No. 1050mm Gravity Main
Head/Pressure/Elevation (m)
300
250
200
150
100
50
0
0
5000
10000
15000
20000
25000
30000
35000
Chainage (m)
BPT
Head (m) at 115 Ml/d
Pressure (m) at 115 Ml/d
Static Pressure
Ground Level
Pwk Elevation (m)

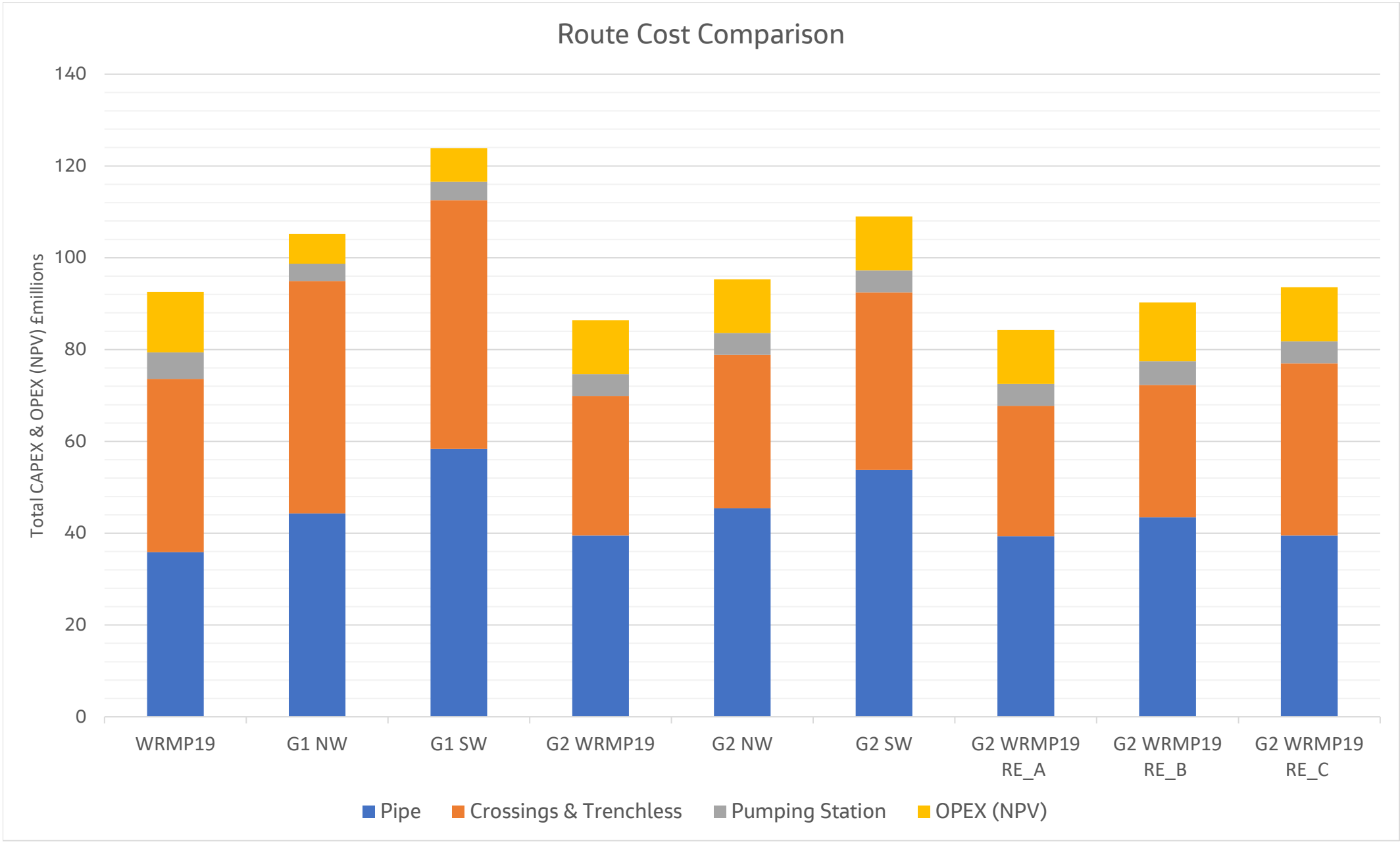

Profile of Gate 2 WRMP19 - 1No. 900mm Rising Main followed by 1No. 1050mm Gravity Main
Head/Pressure/Elevation (m)
300
250
200
150
100
50
0
0
5000
10000
15000
20000
25000
Chainage (m)
BPT
Head (m) at 115 Ml/d
Pressure (m) at 115 Ml/d
Static Pressure
Ground Level
Pwk Elevation (m)


Profile of Gate 2 WRMP19 RE_A Route - 1No. 900mm Rising Main followed by 1No. 1050mm Gravity Main
Head/Pressure/Elevation (m)
300
250
200
150
100
50
0
0
5000
10000
15000
20000
25000
Chainage (m)
Head (m) at 115 Ml/d
Pressure (m) at 115 Ml/d
Static Pressure
Ground Level
Pwk Elevation (m)
BPT

Profile of Gate 2 WRMP19 RE_B Route - 1No. 900mm Rising Main followed by 1No. 1050mm Gravity Main


Profile of Gate 2 WRMP19 RE_C Route - 1No. 900mm Rising Main followed by 1No. 1050mm Gravity Main
Head/Pressure/Elevation (m)
300
250
200
150
100
50
0
0
5000
10000
15000
20000
25000
30000
Chainage (m)
Head (m) at 115 Ml/d
Pressure (m) at 115 Ml/d
Static Pressure
Ground Level
Pwk Elevation (m)
BPT

H. Comparative costs


Route Cost Comparison
Total CAPEX & OPEX (NPV) £millions
140
120
100
80
60
40
20
0
WRMP19
G1 NW
G1 SW
G2 WRMP19
G2 NW
G2 SW
G2 WRMP19 RE_A
G2 WRMP19 RE_B
G2 WRMP19 RE_C
Pipe
Crossings & Trenchless
Pumping Station
OPEX (NPV)

Commercial information redacted

Route				WRMP19	G1 NW	G1 SW	G2 WRMP19	G2 NW	G2 SW	G2 WRMP19 RE_A	G2 WRMP19 RE_B	G2 WRMP19 RE_C	ST Cost Tool Lite	Cost element	Assumption
Capital cost (£m)	Pipeline	Pipe	Length (km)												
			Rising main: Rising main length (km)												
			Rising main: Rising main diameter (mm)												
			Rising main: Length within field (m)												
			Rising main: Cost per m										Dependent on diameter	Pressure mains in fields / verges	
			Rising main: Length with rural / suburan highway (m)												Minor road
			Rising main: Cost per m										Dependent on diameter	Pressure mains in rural / suburban highway	
			Rising main: Length with urban highway (m)												Motorway, A road, b-road
			Rising main: Cost per m										Dependent on diameter	Pressure mains in urban highway	
			Rising main cost (£m)												
			Gravity main: Gravity main length (km)												
			Gravity main: Gravity main diameter (mm)												
			Gravity main: Length within field (m)												
			Gravity main: Cost per m										Dependent on diameter	Pressure mains in fields / verges	
			Gravity main: Length with rural / suburan highway (m)												
			Gravity main: Cost per m										Dependent on diameter	Pressure mains in rural / suburban highway	
			Gravity main: Length with urban highway (m)												
			Gravity main: Cost per m										Dependent on diameter	Pressure mains in urban highway	
			Gravity main cost (£m)												
			Total cost pipe (£m)												
		Crossings / Trenchless (Extra over)	Motorway (No.)											Major Road (M) crossings	
			A road (No.)											Major Road (A) crossings	
			B road (No.)											Major Road (B) crossings	
			Minor road (No.)											Minor Road (uncl) crossings	
			Railway incl. HS2 (No.)											Railway line crossings (Public)	
			Main river (No.)											Watercourse crossings (River)	
			Ordinary watercourse (No.)											Watercourse crossings	
			Canal (no.)											Canal Crossings	
			HV (No.)											Overhead Electric Crossings (Pylons supported)	
			Crossings cost (£m)												
			Rising main: Rising main - Diameter (mm)												Size one size bigger than pipe diameter
			Rising main: Rising main - Trenchless total length (m)												
			Rising main: Cost per m										Dependent on diameter	Micro-tunnelling / pipe jacking	
			Rising main: Rising main - Trenchless number (No.)												
			Rising main: Cost per item										Dependent on diameter	Micro-tunnelling / pipe jacking	
			Rising main: Trenchless Rising main cost (£m)												
			Gravity main: Gravity - Diameter (mm)												Size one size bigger than pipe diameter
			Gravity main: Gravity - Trenchless total length (m)												
			Gravity main: Cost per m										Dependent on diameter	Micro-tunnelling / pipe jacking	
			Gravity main: Gravity - Trenchless number (No.)												
			Gravity main: Cost per item										Dependent on diameter	Micro-tunnelling / pipe jacking	
			Gravity main: Trenchless Gravity main cost (£m)												
			Total trenchless cost												
			Total cost crossings & trenchless (£m)												
		CAPEX (£m)													
	Pumping station		Static lift (m)												
			Pump lift (m)												
			Power (MW)										See formula	Major Water Pumping Station	
			CAPEX (£m)												
	Total														
OPEX (£m)	Peak		Cost per year (£m)												
	Sweetening		Pump lift (m) (assumes static lift - due to minimal losses at sweetening flow)												
			Power (MW)												
			Cost per year (£m)												
	Total		Per year (£m)												
			Cumulative cost over 50 years without NPV (£m)												
			Cumulative cost over 50 years with NPV (£m)												
	Total CAPEX & OPEX (NPV)														

I. MODA Scoring Rationale

Commercial information redacted

STEP 5: Scoring

Minworth SRO

To appraise multiple pipeline route options to transfer flows from Minworth WwTW to the River Avon for use by STT SRO

ID#	Evaluation Criteria	Measurement Scale	Worst Feasible Outcome	Best Feasible Outcome	WRMP19	G1 NW	G1 SW	G2 WRMP19	G2 NW	G2 SW	G2 WRMP19 RE_A	G2 WRMP19 RE_B	G2 WRMP19 RE_C
N/A	**Long-term Lifecycle Cost (50-year NPV)**	PV Cost											
1	**Constructability**												
1.1	Length with steep slopes (incl. side slopes > 1 in 10)	1-5 scale											
1.2	Length within flood zone	1-5 scale											
1.3	Length within landfill	1-5 scale											
1.5	Length within high groundwater table	1-5 scale											
1.6	Likely complexity of trenchless crossings	1-5 scale											
1.7	Other geotechnical risks	1-5 scale											
1.8	Length within water supply source protection zone	1-5 scale											
1.9	Length with narrow working width - where less than 40m available	1-5 scale											
2	**Planning risk**												
2.1	No. of points where available options constrained i.e. pipe corridor width less than 200m	1-5 scale											
2.2	Flexibility of BPT site location	1-5 scale											
2.3	No. of HS2 crossings	1-5 scale											
2.4	Route crosses land where permission likely to be difficult e.g. common land, trenchless beneath houses	1-5 scale											
3	**Operational considerations**												
3.1	Maintenance requirements - likely number of air valves and washouts	1-5 scale											
3.3	Hydraulics favourable	1-5 scale											
4	**Customer disruption during construction**												
4.1	Length working within road (including lengths in verge)	1-5 scale											
4.2	Ribbon development impact - pipe routed across ribbon development	1-5 scale											
4.3	Length of route within 50m of residential properties	1-5 scale											
4.4	Traffic disruption during construction	1-5 scale											
5	**Break Pressure Tank siting**												
5.1	Site access	1-5 scale											
5.2	Geotechnical risks	1-5 scale											
6	**Land Costs**												
6.1	Length within high grade agricultural land	1-5 scale											
6.2	High value land impacted - sports fields, golf courses, equine	1-5 scale											
6.3	Residential properties directly affected i.e. gardens, or trenchless beneath	1-5 scale											
8	**Carbon**												
8.1	Embodied carbon	1-5 scale											
8.2	Operational carbon	1-5 scale											

... Scoring Rationale ...	... Scoring Rationale ...	... Scoring Rationale ...	... Scoring Rationale ...	... Scoring Rationale ...	... Scoring Rationale ...	... Scoring Rationale ...	... Scoring Rationale ...	... Scoring Rationale ...	... Sc
WRMP19	G1 NW	G1 SW	G2 WRMP19	G2 NW	G2 SW	G2 WRMP19 RE_A	G2 WRMP19 RE_B	G2 WRMP19 RE_C	
None of the routes do go through steep slope areas (smaller than 1 in 10), therefore, all routes were given the score of 5, the best possible outcome on this sub-criteria.									
4672m of this route goes through flood zone areas, therefore, the route is given the score of 1 for this sub-criteria	3393m of this route goes through flood zone areas, therefore, the route is given the score of 4 for this sub-criteria	2850m of this route goes through flood zone areas, therefore, the route is given the score of 5 for this sub-criteria	4353m of this route goes through flood zone areas, therefore, the route is given the score of 2 for this sub-criteria	4231m of this route goes through flood zone areas, therefore, the route is given the score of 2 for this sub-criteria	4527m of this route goes through flood zone areas, therefore, the route is given the score of 1 for this sub-criteria	4717m of this route goes through flood zone areas, therefore, the route is given the score of 1 for this sub-criteria	3497m of this route goes through flood zone areas, therefore, the route is given the score of 3 for this sub-criteria	4234m of this route goes through flood zone areas, therefore, the route is given the score of 1 for this sub-criteria	
1299m of this route goes through a landfill sites, therefore, the route is given the score of 1 for this sub-criteria	279m of this route goes through a landfill sites, therefore, the route is given the score of 5 for this sub-criteria	279m of this route goes through a landfill sites, therefore, the route is given the score of 5 for this sub-criteria	1153m of this route goes through a landfill sites, therefore, the route is given the score of 2 for this sub-criteria	1153m of this route goes through a landfill sites, therefore, the route is given the score of 2 for this sub-criteria	1153m of this route goes through a landfill sites, therefore, the route is given the score of 2 for this sub-criteria	655m of this route goes through a landfill sites, therefore, the route is given the score of 3 for this sub-criteria	135m of this route goes through a landfill sites, therefore, the route is given the score of 5 for this sub-criteria	1353m of this route goes through a landfill sites, therefore, the route is given the score of 1 for this sub-criteria	
The area surrounding the abstraction point at Minworth is the only area with a high groundwater table, all the routes go equally through that area, therefore, all the routes were give a similar score of 4 for this sub-criteria.									
A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.6 was given to this route, equivalent to 5 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.7 was given to this route, equivalent to 4 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.8 was given to this route, equivalent to 3 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.7 was given to this route, equivalent to 4 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.8 was given to this route, equivalent to 3 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.7 was given to this route, equivalent to 4 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.8 was given to this route, equivalent to 3 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.7 was given to this route, equivalent to 4 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 2.5 was given to this route, equivalent to 1 here	
Short route across open country avoiding industrial and residential developments	Long route with 24km along or adjacent to highways, causing construction issues/traffic disruption, narrow corridor working and numerous buried services	Long route with 25km along or adjacent to highways, causing construction issues/traffic disruption, narrow corridor working and numerous buried services	Short route across open country avoiding industrial and residential developments	Long route across open county with numerous infrastructure crossings	Long route across open county with numerous infrastructure crossings	Short route across open country avoiding industrial and residential developments. The route crosses a narrow streatch of land between a canal and a industrial development.	Long route across open country avoiding industrial and residential developments	Short route across open country. Extended tunnelling to avoid industrial developments, including tunnleing across flood plains.	
7925m of this route goes through water supply source protection zone, therefore, the route is given the score of 2 for this sub-criteria	3177m of this route goes through water supply source protection zone, therefore, the route is given the score of 5 for this sub-criteria	4653m of this route goes through water supply source protection zone, therefore, the route is given the score of 3 for this sub-criteria	8183m of this route goes through water supply source protection zone, therefore, the route is given the score of 1 for this sub-criteria	4399m of this route goes through water supply source protection zone, therefore, the route is given the score of 3 for this sub-criteria	3616m of this route goes through water supply source protection zone, therefore, the route is given the score of 4 for this sub-criteria	8183m of this route goes through water supply source protection zone, therefore, the route is given the score of 1 for this sub-criteria	8183m of this route goes through water supply source protection zone, therefore, the route is given the score of 1 for this sub-criteria	8183m of this route goes through water supply source protection zone, therefore, the route is given the score of 1 for this sub-criteria	
Between 500-1000 m of pipeline is in narrow working width areas	More than 1000m of pipeline is in narrow working width areas	More than 1000m of pipeline is in narrow working width areas	Less than 500m of pipeline is in narrow working width areas	Less than 500m of pipeline is in narrow working width areas	Less than 500m of pipeline is in narrow working width areas	More than 1000m of pipeline is in narrow working width areas	Less than 500m of pipeline is in narrow working width areas	Less than 500m of pipeline is in narrow working width areas	
This route has between 5-10 pinch points	This route has more than 10 pinch points	This route has more than 10 pinch points	This route has less than 5 pinch points	This route has less than 5 pinch points	This route has less than 5 pinch points	This route has between 5-10 pinch points	This route has between 5-10 pinch points	This route has more than 10 pinch points	
BPT has multiple site options, and natural screening available, and No local receptors that would be impacted	BPT has more than one site option with Moderate proximity to residential properties, and Manageable access	BPT has more than one site option with Moderate proximity to residential properties, and Manageable access	BPT has more than one site option with Moderate proximity to residential properties, and Manageable access	BPT has more than one site option with Moderate proximity to residential properties, and Manageable access	BPT has more than one site option with Moderate proximity to residential properties, and Manageable access	BPT has more than one site option with Moderate proximity to residential properties, and Manageable access	BPT has more than one site option with Moderate proximity to residential properties, and Manageable access	BPT has more than one site option with Moderate proximity to residential properties, and Manageable access	
This route crosses HS2 once, therefore, it is given the score of 5	This route crosses HS2 three times, therefore, it is given the score of 1	This route crosses HS2 three times, therefore, it is given the score of 1	This route crosses HS2 once, therefore, it is given the score of 5	This route crosses HS2 twice, therefore, it is given the score of 3	This route crosses HS2 twice, therefore, it is given the score of 3	This route crosses HS2 once, therefore, it is given the score of 5	This route crosses HS2 once, therefore, it is given the score of 5	This route crosses HS2 once, therefore, it is given the score of 5	
This route crosses land where permissions likely to be difficult between 5-10 times	This route crosses land where permissions likely to be difficult more than 10 times	This route crosses land where permissions likely to be difficult more than 10 times	This route crosses land where permissions likely to be difficult less than 5 times	This route crosses land where permissions likely to be difficult less than 5 times	This route crosses land where permissions likely to be difficult less than 5 times	This route crosses land where permissions likely to be difficult less than 5 times	This route crosses land where permissions likely to be difficult less than 5 times	This route crosses land where permissions likely to be difficult less than 5 times	
Profile mostly minimises number of air valves and washouts required	Ground profile constantly changing, resulting in a large number of air valves and washouts	Ground profile constantly changing, resulting in a large number of air valves and washouts	Ground profile changing in some parts and smooth in others, resulting in a moderate number of air valves and washouts	Ground profile changing, resulting in a high number of air valves and washouts	Ground profile constantly changing, resulting in a large number of air valves and washouts	Ground profile changing in some parts and smooth in others, resulting in a moderate number of air valves and washouts	Ground profile changing in some parts and smooth in others, resulting in a moderate number of air valves and washouts	Ground profile changing in some parts and smooth in others, resulting in a moderate number of air valves and washouts	
This route has a distinct high point	This route has multiple high points and low points	This route has a long flat high point, resulting in requirement for deep dig to ensure stable hydraulics	This route has a clear high point, high enough for gravity to feed the water down the gravity main	This route has a clear high point, high enough for gravity to feed the water down the gravity main	This route has a clear high point, high enough for gravity to feed the water down the gravity main	This route has a clear high point, high enough for gravity to feed the water down the gravity main	This route has a clear high point, high enough for gravity to feed the water down the gravity main	This route has a clear high point, high enough for gravity to feed the water down the gravity main	
1611m of pipeline route is within road, therefore, it was given the score of 3 for this sub-criteria	8200m of pipeline route is within road, therefore, it was given the score of 1 for this sub-criteria	9550m of pipeline route is within road, therefore, it was given the score of 1 for this sub-criteria	0m of pipeline route is within road, therefore, it was given the score of 5 for this sub-criteria	0m of pipeline route is within road, therefore, it was given the score of 5 for this sub-criteria	0m of pipeline route is within road, therefore, it was given the score of 5 for this sub-criteria	0m of pipeline route is within road, therefore, it was given the score of 5 for this sub-criteria	0m of pipeline route is within road, therefore, it was given the score of 5 for this sub-criteria	0m of pipeline route is within road, therefore, it was given the score of 5 for this sub-criteria	
This route crosses ribbon development once	This route crosses ribbon development once	This route crosses ribbon development once	This route crosses ribbon development once	This route crosses ribbon development twice	This route crosses ribbon development once	This route crosses ribbon development once	This route crosses ribbon development once	This route crosses ribbon development once	
1139m of pipeline route within 50m of residential properties, therefore the route is given the score of 4 in this sub-criteria	8175m of pipeline route within 50m of residential properties, therefore the route is given the score of 1 in this sub-criteria	6898m of pipeline route within 50m of residential properties, therefore the route is given the score of 2 in this sub-criteria	1120m of pipeline route within 50m of residential properties, therefore the route is given the score of 4 in this sub-criteria	627m of pipeline route within 50m of residential properties, therefore the route is given the score of 5 in this sub-criteria	1059m of pipeline route within 50m of residential properties, therefore the route is given the score of 4 in this sub-criteria	1120m of pipeline route within 50m of residential properties, therefore the route is given the score of 4 in this sub-criteria	1470m of pipeline route within 50m of residential properties, therefore the route is given the score of 4 in this sub-criteria	1120m of pipeline route within 50m of residential properties, therefore the route is given the score of 4 in this sub-criteria	
A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.6 was given to this route, equivalent to 5 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.7 was given to this route, equivalent to 4 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.8 was given to this route, equivalent to 3 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.7 was given to this route, equivalent to 4 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.8 was given to this route, equivalent to 3 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.7 was given to this route, equivalent to 4 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.7 was given to this route, equivalent to 4 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.7 was given to this route, equivalent to 4 here	A separate constructability assessment were conducted to look at all the crossings for this route and a score of 1.8 was given to this route, equivalent to 3 here	
This BPT is in a remote location, with only single track roads	This BPT has close proximity to A/B road	This BPT has close proximity to A/B road	This BPT has moderate distance to A/B road	This BPT has moderate distance to A/B road	This BPT has moderate distance to A/B road	This BPT has moderate distance to A/B road	This BPT has moderate distance to A/B road	This BPT has moderate distance to A/B road	
The locations of the BPTs have similar geological layers, therefore, all the routes were give a similar score of 4 for this sub-criteria.									
All routes have zero lengths within high grade agricultural land, therefore, all the routes were give a similar score of 5 for this sub-criteria.									
337m of pipeline route is impcating high value land, therefore, a score of 5 is given for this sub-criteria	0m of pipeline route is impcating high value land, therefore, a score of 5 is given for this sub-criteria	0m of pipeline route is impcating high value land, therefore, a score of 5 is given for this sub-criteria	0m of pipeline route is impcating high value land, therefore, a score of 5 is given for this sub-criteria	0m of pipeline route is impcating high value land, therefore, a score of 5 is given for this sub-criteria	65m of pipeline route is impcating high value land, therefore, a score of 4 is given for this sub-criteria	0m of pipeline route is impcating high value land, therefore, a score of 5 is given for this sub-criteria	0m of pipeline route is impcating high value land, therefore, a score of 5 is given for this sub-criteria	0m of pipeline route is impcating high value land, therefore, a score of 5 is given for this sub-criteria	
A long stretch of residential properties directly affected i.e. gardens, or trenchless beneath	In more than 5 occasions residential properties are directly affected i.e. gardens, or trenchless beneath	In more than 5 occasions residential properties are directly affected i.e. gardens, or trenchless beneath	Only one occasion, residential properties are directly affected i.e. gardens, or trenchless beneath	Only one occasion, residential properties are directly affected i.e. gardens, or trenchless beneath	Only one occasion, residential properties are directly affected i.e. gardens, or trenchless beneath	Only one occasion, residential properties are directly affected i.e. gardens, or trenchless beneath	Only one occasion, residential properties are directly affected i.e. gardens, or trenchless beneath	Only one occasion, residential properties are directly affected i.e. gardens, or trenchless beneath	
69,388 tCO2e is the embodied carbon value for this route, therefore, it is given the score of 5 for this sub-criteria	81,634 tCO2e is the embodied carbon value for this route, therefore, it is given the score of 3 for this sub-criteria	113,212 tCO2e is the embodied carbon value for this route, therefore, it is given the score of 1 for this sub-criteria	79,693 tCO2e is the embodied carbon value for this route, therefore, it is given the score of 4 for this sub-criteria	94,022 tCO2e is the embodied carbon value for this route, therefore, it is given the score of 2 for this sub-criteria	112,861 tCO2e is the embodied carbon value for this route, therefore, it is given the score of 1 for this sub-criteria	80,414 tCO2e is the embodied carbon value for this route, therefore, it is given the score of 3 for this sub-criteria	89,763 tCO2e is the embodied carbon value for this route, therefore, it is given the score of 3 for this sub-criteria	78,519 tCO2e is the embodied carbon value for this route, therefore, it is given the score of 3 for this sub-criteria	
72,540 tCO2e is the operational carbon value for this route, therefore, it is given the score of 1 for this sub-criteria	35,340 tCO2e is the operational carbon value for this route, therefore, it is given the score of 5 for this sub-criteria	39,060 tCO2e is the operational carbon value for this route, therefore, it is given the score of 5 for this sub-criteria	61,380 tCO2e is the operational carbon value for this route, therefore, it is given the score of 2 for this sub-criteria	61,380 tCO2e is the operational carbon value for this route, therefore, it is given the score of 2 for this sub-criteria	61,380 tCO2e is the operational carbon value for this route, therefore, it is given the score of 2 for this sub-criteria	61,380 tCO2e is the operational carbon value for this route, therefore, it is given the score of 2 for this sub-criteria	66,961 tCO2e is the operational carbon value for this route, therefore, it is given the score of 2 for this sub-criteria	61,380 tCO2e is the operational carbon value for this route, therefore, it is given the score of 2 for this sub-criteria	

J. MODA Weightings

STEP 8: Est. Consensus Weights

☑ Show Sub Criteria

Minworth SRO

To appraise multiple pipeline route options to transfer flows from Minworth WwTW to the River Avon for use by STT SRO

ID#	Evaluation Criteria	Consensus Weights	HB	VL	JG	BS	SM	CC	Mean	Sdev	Max	Min
1	Constructability	100	850	600	550	530	620	860	668.3	148.2	860.0	530.0
1.1	Length with steep slopes (incl. side slopes > 1 in 10)	77	80	80	10	80	100	80	71.7	31.3	100.0	10.0
1.2	Length within flood zone	80	100	90	60	30	70	100	75.0	27.4	100.0	30.0
1.3	Length within landfill	89	100	60	100	80	60	100	83.3	19.7	100.0	60.0
1.5	Length within high groundwater table	100	100	90	100	90	80	100	93.3	8.2	100.0	80.0
1.6	Likely complexity of trenchless crossings	96	100	100	80	60	100	100	90.0	16.7	100.0	60.0
1.7	Other geotechnical risks	88	70	100	80	80	80	80	81.7	9.8	100.0	70.0
1.8	Length within water supply source protection zone	75	100	30	60	80	50	100	70.0	28.3	100.0	30.0
1.9	Length with narrow working width - where less than 40m available	75	100	50	60	30	80	100	70.0	28.3	100.0	30.0
2	Planning risk	60	500	320	340	470	360	400	398.3	72.8	500.0	320.0
2.1	No. of points where available options constrained i.e. pipe corridor width less than 200m	67	100	50	60	100	100	100	85.0	23.5	100.0	50.0
2.2	Flexibility of BPT site location	72	100	90	80	80	100	100	91.7	9.8	100.0	80.0
2.3	No. of HS2 crossings	100	200	80	100	200	80	100	126.7	57.5	200.0	80.0
2.4	Route crosses land where permission likely to be difficult e.g. common land, trenchless beneath houses	75	100	100	100	90	80	100	95.0	8.4	100.0	80.0
3	Operational considerations	26	210	200	120	130	170	210	173.3	40.3	210.0	120.0
3.1	Maintenance requirements - likely number of air valves and washouts	100	80	100	60	100	80	80	83.3	15.1	100.0	60.0
3.3	Hydraulics favourable	88	80	100	60	30	90	80	73.3	25.0	100.0	30.0
4	Customer disruption during construction	44	280	300	310	220	380	280	295.0	52.1	380.0	220.0
4.1	Length working within road (including lengths in verge)	100	70	100	100	80	100	70	86.7	15.1	100.0	70.0
4.2	Ribbon development impact - pipe routed across ribbon development	88	70	80	80	60	100	70	76.7	13.7	100.0	60.0
4.3	Length of route within 50m of residential properties	81	70	70	80	50	80	70	70.0	11.0	80.0	50.0
4.4	Traffic disruption during construction	71	70	50	50	30	100	70	61.7	24.0	100.0	30.0
5	Break Pressure Tank siting	23	160	180	140	110	160	160	151.7	24.0	180.0	110.0
5.1	Site access	82	80	80	60	30	80	80	68.3	20.4	80.0	30.0
5.2	Geotechnical risks	100	80	100	80	80	80	80	83.3	8.2	100.0	80.0
6	Land Costs	35	240	170	240	230	270	240	231.7	33.1	270.0	170.0
6.1	Length within high grade agricultural land	74	80	50	60	50	70	80	65.0	13.8	80.0	50.0
6.2	High value land impacted - sports fields, golf courses, equine	89	80	50	80	80	100	80	78.3	16.0	100.0	50.0
6.3	Residential properties directly affected i.e. gardens, or trenchless beneath	100	80	70	100	100	100	80	88.3	13.3	100.0	70.0
8	Carbon	29	200	160	200	200	200	200	193.3	16.3	200.0	160.0
8.1	Embodied carbon	100	100	80	100	100	100	100	96.7	8.2	100.0	80.0
8.2	Operational carbon	100	100	80	100	100	100	100	96.7	8.2	100.0	80.0

Percent Weights

Minworth SRO

To appraise multiple pipeline route options to transfer flows from Minworth WwTW to the River Avon for use by STT SRO

ID#	Evaluation Criteria	Consensus	HB	VL	JG	BS	SM	CC
1	Constructability	32%	35%	31%	29%	28%	29%	37%
1.1	Length with steep slopes (incl. side slopes > 1 in 10)	4%	4%	4%	1%	4%	5%	4%
1.2	Length within flood zone	4%	5%	5%	3%	2%	3%	5%
1.3	Length within landfill	4%	5%	3%	5%	4%	3%	5%
1.5	Length within high groundwater table	5%	5%	5%	5%	5%	4%	5%
1.6	Likely complexity of trenchless crossings	4%	5%	5%	4%	3%	5%	5%
1.7	Other geotechnical risks	4%	3%	5%	4%	4%	4%	4%
1.8	Length within water supply source protection zone	3%	5%	2%	3%	4%	2%	5%
1.9	Length with narrow working width - where less than 40m available	3%	5%	3%	3%	2%	4%	5%
2	Planning risk	19%	20%	17%	18%	25%	17%	17%
2.1	No. of points where available options constrained i.e. pipe corridor width less than 200m	4%	4%	3%	3%	5%	5%	4%
2.2	Flexibility of BPT site location	4%	4%	5%	4%	4%	5%	4%
2.3	No. of HS2 crossings	6%	8%	4%	5%	11%	4%	4%
2.4	Route crosses land where permission likely to be difficult e.g. common land, trenchless beneath houses	4%	4%	5%	5%	5%	4%	4%
3	Operational considerations	8%	9%	10%	6%	7%	8%	9%
3.1	Maintenance requirements - likely number of air valves and washouts	4%	4%	5%	3%	5%	4%	4%
3.3	Hydraulics favourable	4%	4%	5%	3%	2%	4%	4%
4	Customer disruption during construction	14%	11%	16%	16%	12%	18%	12%
4.1	Length working within road (including lengths in verge)	4%	3%	5%	5%	4%	5%	3%
4.2	Ribbon development impact - pipe routed across ribbon development	4%	3%	4%	4%	3%	5%	3%
4.3	Length of route within 50m of residential properties	3%	3%	4%	4%	3%	4%	3%
4.4	Traffic disruption during construction	3%	3%	3%	3%	2%	5%	3%
5	Break Pressure Tank siting	7%	7%	9%	7%	6%	7%	7%
5.1	Site access	3%	3%	4%	3%	2%	4%	3%
5.2	Geotechnical risks	4%	3%	5%	4%	4%	4%	3%
6	Land Costs	11%	10%	9%	13%	12%	13%	10%
6.1	Length within high grade agricultural land	3%	3%	3%	3%	3%	3%	3%
6.2	High value land impacted - sports fields, golf courses, equine	4%	3%	3%	4%	4%	5%	3%
6.3	Residential properties directly affected i.e. gardens, or trenchless beneath	4%	3%	4%	5%	5%	5%	3%
8	Carbon	9%	8%	8%	11%	11%	9%	9%
8.1	Embodied carbon	5%	4%	4%	5%	5%	5%	4%
8.2	Operational carbon	5%	4%	4%	5%	5%	5%	4%

K. Geotechnical Analysis

Route Geology Analysis

The following tables discuss the ground conditions at potential trenchless crossing location points, at Railways, Major roads, Motorways, Canals and Rivers which are expected to be encountered along the six route options.

1. WRMP19

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
Minworth Effluent Channel – 1.1km	1.0km to 1.15km	River Terrace Deposits – Sand and Gravel	Sidmouth Mudstone	≈3m at top of Sidmouth Mudstone
River Tame - 1.3km	1.25km to 1.35km	Alluvium		
M42 M6 Toll / A446 Litchfield Road and Railway 1.6km to 1.7km	1.5km to 1.8km			
Future HS2 Crossing – 2.1km	2.05km to 2.35km			
River Tame – 2.3km				
River Tame – 3.1km	3.05km to 3.15km			
4 Track Railway – 4.15km	4.1km to 4.4km			
River Cole – 4.2km				
River Blyth 4.3km				
Blythe Road – 4.7km	4.6km to 4.8km	None recorded		
Maxstoke Park Golf course	Not indicated as a trenchless crossing at present			
M6 Motorway – 10.7km			Tile Hill Mudstone	Probably at depth in bedrock
Break-Pressure Tanks – 13.2km				
A45 – 14.4km				
Duggins Lane and Railway – 20.0km	19.80km to 20.1km			
Coventry Road A429 and Railway – 24.80km & 25.0km	24.75km to 25.10km			
A46 Warwick By-pass – 26.6km to 26.7m (including slip roads)	26.5km to 26.8km		Kenilworth Sandstone	
B4115 – 27.5km	27.35km to 27.45km	Alluvium		≈3m in superficial deposits
Outfall River Avon – 27.5km				

2. G1 North Warwick

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
M42 / M6 Toll Motorway – 1km to 1.2km	1.0km to 1.2km	Glaciofluvial Deposits – Sand and Gravel	Sidmouth Mudstone	≈3m at top of bedrock
A446 Litchfield Road – 1.5km	1.4km to 1.6km	River Terrace Deposits – Sand and Gravels		
Minworth Effluent Channel – 1.95km	1.9km to 2.0km	Alluvium		
River Tame – 2.1km	2.1km to 2.2km			
Railway – 2.35km	23.km to 2.4km			
Railway – 2.8km	2.75km to 2.85km	River Terrace Deposits – Sands and Gravel		

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
A446 Litchfield Road & Future HS2 (x2 lines) Crossing – 3km to 3.1km	2.9km to 3.2km			
River Cole – 4.6km	4.55km to 4.65km	Alluvium		
A446 / M42 – 7.0km to 7.2km	6.9km to 7.25km			
M6 Junction 4 – 7.6km to 7.9km	**7.5km to 7.9km**	Glaciofluvial Deposits – Sand and Gravel		
A446 junction to M42 – 8.8km to 8.9km	**8.7km to8.9km**		**Branscombe Mudstone**	
A452 / A45 junction – 11.5km to 11.7km (Stonebridge)	11.3km to 11.6km	Non recorded		
River Blyth – 12.8km	Not indicated as TL crossing	Alluvium	Sidmouth Mudstone	
A452 / B4102 Junction – 13.2km	Not indicated as TL crossing	River Terrace Deposits – Sand and Gravel	Branscombe Mudstone	
Under A452 – 15.5km	15.2km to 15.3km			
Future HS2 Crossing – 14.1km	Not indicated as TL crossing	Glaciofluvial Deposits – Sand and Gravel	Sidmouth Mudstone	
Railway – 15.55km	**15.5km to 15.6km**			
Break-Pressure Tanks – 22.5km			**Mercia Mudstone**	
Warwick By-pass A46 – 31.55km	31.5km to 31.6km	None Recorded		
B4115 / Warwick By-pass Junction – 32.3km	32.25km to 32.35km	River Terrace Deposits – Sand and Gravel	**Helsby Sandstone**	≈3m in superficial deposits
Outfall on River Avon – 32.4km		Alluvium		

3. G1 South Warwick

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
M42 / M6 Toll Motorway – 1km to 1.2km	1.0km to 1.2km	Glaciofluvial Deposits – Sand and Gravel	Sidmouth Mudstone	≈3m at top of Sidmouth Mudstone
A446 Litchfield Road – 1.5km	1.4k to 1.55km	River Terrace Deposits – Sand and Gravel		
Minworth Effluent Channel – 1.95km	1.9km to 2.0km	Alluvium		
River Tame – 2.1km	2.1km to 2.2km			
Railway – 2.35km	2.8km to 2.9km			
Railway – 2.8km	2.75km to 2.85km	River Terrace Deposits – Sand and Gravel		
A 446 Litchfield Road & Future HS2 Crossings (x2) – 3km to 3.1km	2.90km to 3.2km			
A446/B4117 roundabout junction - 4.4km	**Not indicated as a trenchless crossing at present**	Alluvium	Branscombe Mudstone	Probably at depth in bedrock
River Cole – 4.6km	4.55km to 4.65km			
A446 / M42 – 7.0km to 7.2km	6.9km to 7.3km	Glaciofluvial Deposits – Sand and Gravel		
M6 Junction 4 – 7.6km to 7.9km	7.6km to 7.9km			

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
A446 junction to M42 – 8.8km to 8.9km	8.75km to 8.95km			
Hollywell Brook – 10.9km	Not indicated as a TL Crossing	Alluvium		
A452 / A45 junction – 11.5km to 11.7km (Stonebridge)	11.4km to 11.7km	None recorded		
River Blyth – 12.8km	**Not indicated as a trenchless crossing at present**	Alluvium		
A452 / B4102 Junction – 13.2km	13.15km to 13.3km	River Terrace Deposits – Sand and Gravel	Sidmouth Mudstone	
Under A452 – 13.9km	**Not indicated as a trenchless crossing at present**		Branscombe Mudstone	
Future HS2 Crossing – 14.1km	Not indicated as a TL Crossing	Glaciofluvial Deposits – Sand and Gravel	Sidmouth Mudstone	
Under A452 – 15.3km	15.2km to 15.4km			
Railway – 15.6km	15.5km to 15.7km	River Terrace Deposits – Sand and Gravel		
Break-Pressure Tanks – 22.9km		Glaciofluvial Deposits – Sand and Gravel	Mercia Mudstone	
Canal - 32.6km	32.50km to 32.65km	None recorded		
Railway 32.8km	32.7km to 32.9km	Alluvium and River Terrace Deposits – Sand and Gravel		
A46 Warwick By-pass – 33.5km	33.4km to 33.6km	None recorded	**Helsby Sandstone**	≈3m in superficial deposits
Outfall on River Avon – 36.4km		Alluvium and River Terrace Deposits – Sand and Gravel		

4. G2 WRMP19

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
Minworth Effluent Channel – 1.1km	1km to 1.4km	River Terrace Deposits – Sand and Gravel	Sidmouth Mudstone	≈3m at top of Sidmouth Mudstone
M6 Toll – 1.2km		Alluvium		
A446 Litchfield Road – 1.4km				
Railway 1.64km	1.6km to 2.10km			
Future HS2 Crossing – 2km				
Minworth Effluent Channel & Edison Road– 2.7 to 2.9km	2.65km to 2.95km			
River Tame - 3.7km	3.4km to 3.6km			
Railway - 3.9km	3.8km to 4.1km			
River Cole – 4.0km				
River Blyth - 4.1km				
Blythe Road – 4.7km	4.6km to 4.8km			

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
M6 – 10.5km		None recorded	Tile Hill Mudstone	Probably at depth in Bedrock
A45 dual Carriageway 13.8km	13.75km to 13.9km			
Break-Pressure Tanks – 16.1km				
Coventry Road A429 and Railway – 25.4km to 25.6km	25.35km to 25.70km			
A46 Warwick By-pass - 27.2km to 27.3km (including slip roads)	27.1km to 27.35km	Alluvium and River Terrace Deposits – Sand and Gravel	Kenilworth Sandstone	≈3m in superficial deposits
B4115 – 28.0km	28.0km to 28.1km			
Outfall on River Avon – 28.0km				

5. G2 North Warwick

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
Minworth Effluent Channel – 1.1km	1.0km to 1.4km	Alluvium	Sidmouth Mudstone	≈3m at top of bedrock
M42/M6 Toll - 1.2km		Glaciofluvial Deposits – Sand and Gravel		
A446 Litchfield Road 1.35km		River Terrace Deposits – Sand and Gravel		
Railway – 1.7km & Future HS2 Crossing – 1.9km	1.6km to 2.1km	Alluvium		
Minworth Effluent Channel – 2.7km	Not indicated as a trenchless crossing at present			
River Tame – 3.4km	3.3km to 3.6km			
Railway 4 track – 3.9km	3.8km to 4.2km			
River Cole - 4.0km				
River Blyth – 4.1km				
M6 – 10.4km	10.35km to 10.45km	None recorded		
A45 Dual Carriageway– 13.85km	13.8km to 13.9km			
Break-Pressure Tanks – 16.1km		Glaciolacustrine Deposits – Clay and Silt	Tile Hill Mudstone	
Railway and Future HS2 Crossing - 20.4km	20.40km to 20.6km	Alluvium	Sidmouth Mudstone	
A46 Warwick By-pass – 30.1km	30.0km to 30.2km	None recorded	Helsby Sandstone	≈3m in superficial deposits
A46 Warwick By-pass Junction B4115 – 31.9km	30.85km to 30.95km	River Terrace Deposits – Sands and Gravels		
Outfall on River Avon – 32km		Alluvium		

6. G2 South Warwick

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
Minworth Effluent Channel – 1.1km	1km to 1.45km	River Terrace Deposits – Sand and Gravel	Sidmouth Mudstone	≈3m at top of Sidmouth Mudstone
M42/M6 Toll - 1.2km		Alluvium		
A446 Litchfield Road 1.35km				
Railway – 1.7km and Future HS2	1.6km to 2.1km			
Minworth Effluent Channel – 1.7km	Not indicated as a trenchless crossing at present			
River Tame – 3.4km	3.35km to 3.60km			
Railway & River Cole & River Blyth – 3.9km to 4.1km	3.85km to 4.15km			
M6 – 10.4km	10.3km to 10.5km	None recorded		
A45 Dual carriageway – 13.8km	13.7km to 13.8km			
Break-Pressure Tanks – 16.2km		Glaciolacustrine Deposits – Clay and Silt	Tile Hill Mudstone	Probably at depth in bedrock
Railway and Future HS2 Crossing - 20.5km	20.4km to 20.6km	None recorded		
A452 – 22.5km	22.45km to 22.55km		Mercia Mudstone	
Birmingham Road A4177 - 32.8km	Not indicated as a trenchless crossing at present			
Canal – 33.0km	33.0km to 33.1km			
Railway 33.3km	33.2km to33.4			
Warwick By-pass 36.2km & 36.5km	33.1km to 33.3km & 33.4km to 33.6km	Alluvium		≈3m in superficial deposits
Stratford Road –37.0km	36.95km to 37.05km			
Outfall on River Avon – 37.3km				

7. G2 WRMP19 Redesign A

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
M42/M6 Toll - 1.1km	1km to 1.2km	Alluvium – Clay, silt, sand & gravel	Sidmouth Mudstone	≈3m in superficial deposits
A446 Litchfield Road – 1.35km	1.3km to 1.4km			
Railway - 1.6km	1.55km to 1.65km			
Future HS2 Crossing – 1.7km	1.65m to 1.85km			

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
River Tame - 3.3km	3.25km to 3.35km			
Dual Railway 3.7km to 3.8km	3.7km to 3.8km			
River Cole – 3.9km	3.85km to 4.05km			
River Blyth – 4.0km				
Coleshill Road – 4.5km	4.45km to 4.55km	River Terrace Deposits – Sand and Gravel		
M6 Motorway – 10.2m	10.15km to 10.25km	None Recorded		
		Glacial Till (Thrussington Member (Gravelly Clay)		Probably at depth in bedrock
A45 – 13.7km	13.67km to 13.75km			
Duggins Lane and Railway – 19.6km	19.55km to 19.65km			
Coventry Road A429 and Railway – 25.3km & 25.6km	25.25km to 25.65km	None Recorded		
A46 Warwick By-pass – 27.1m (including slip roads)	27km to 27.1km			
B4115 – 27.9km	27.85km to 27.95km	Alluvium – Clay, Silt, Sand & Gravel.	Mercia Mudstone	
Outfall River Avon – 28.2km				≈3m in superficial deposits

8. G2 WRMP19 Redesign B

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
M42 M6 Toll / A446 Litchfield Road - 1.0km to 1.2km	1.0km to 1.15km	River Terrace Deposits – Sand and Gravel	Sidmouth Mudstone	≈3m in superficial deposits
A446 Litchfield Road - 1.85km	1.8km to 1.9km			
Future HS2 Crossing – 2.1km	2.05km to 2.25km			
River Tame and Railway - 4.2km	4.1km to 4.3km	Alternating Glaciofluvial Deposits – Sands & Gravels and Glaciolacustrine Deposits – Clay & Silts, with Alluvium at river crossing		
Railway - 6.4km	6.3km to 6.5km	River Glaciofluvial Deposits – Sands & Gravels		
Railway - 6.9km	6.8km to 7.0km			

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
River Bourne - 7.05km	7.1km to 7.2km	Alluvium – Clay, Silt, Sand & Gravel.		
Coleshill Road - 7.75km	7.7km to 7.8km	Alternating Glaciofluvial Deposits – Sands & Gravels and Glaciolacustrine Deposits – Clay & Silts		
M6 Motorway – 13.6km	*13.5km to 13.7km*	None Recorded		
Break-Pressure Tanks – 15.9km				
A45 – 16.9km	16.8km to 17.0km	Glacial Till (Thrussington Member (Gravelly Clay)		Probably at depth in bedrock
Duggins Lane and Railway – 22.7km				
Coventry Road A429 and Railway – 18.3km & 18.7km	18.3km to 18.7km	None Recorded		
A46 Warwick By-pass – 30.9m (including slip roads)	30.0km to 31.0km			
B4115 – 31.3km	31.2m to 31.3km	Alluvium – Clay, Silt, Sand & Gravel.	Mercia Mudstone	≈3m in superficial deposits
Outfall River Avon – 31.4km				

9. G2 WRMP19 Redesign C

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
M42/M6 Toll - 1.1km	1.1km to 1.3km	Alluvium – Clay, silt, sand & gravel	Sidmouth Mudstone	≈3m in superficial deposits
A446 Litchfield Road – 1.35km	1.3km to 1.4km			
Railway - 1.6km	1.65km to 1.7km			
Future HS2 Crossing – 1.80km	1.75km to 1.85km			
Effluent channel – 2.3km	2.25km to 2.35km			
River Tame - 3.4km	3.35km to 3.45km			
Dual Railway 3.9km to 4.0km	3.85km to 4.05km			
River Cole – 4.1km	4.05km to 4.25km			
River Blyth – 4.2km				
Coleshill Road – 4.7km	4.65km to 4.75km	River Terrace Deposits – Sand and Gravel		
M6 Motorway – 10.4m	10.35km to 10.45km	None Recorded		Probably at depth in bedrock

Infrastructure Crossings (approx. locations)	Trenchless Crossing Lengths (approx.)	Geology		Groundwater
		Superficial Deposits	Bedrock	
A45 – 13.8km	13.75km to 13.85km	Glacial Till (Thrussington Member (Gravelly Clay)		
Duggins Lane and Railway – 19.7km	19.65km to 19.75km			
Coventry Road A429 and Railway – 25.4km & 25.7km	25.35km to 25.75km	None Recorded		
A46 Warwick By-pass – 27.2m (including slip roads)	27.15km to 27.2km			
B4115 – 28.0km	27.95km to 28.05km	Alluvium – Clay, Silt, Sand & Gravel.	Mercia Mudstone	
Outfall River Avon – 28.2km				≈3m in superficial deposits

Geology - Superficial Deposits

1. Made Ground and Landfills

These are mainly located in and around the Minworth WwTW, comprising infilled ground, landfill and artificial land (i.e., re-worked natural). This can range from loose to dense sandy clayey compact Gravels and soft to stiff gravelly Clays. Potential constituents include ash, PFA, concrete, brick and asbestos with a depth to ≈5m deep. The material and groundwater are both potentially contaminated. Trench instability is anticipated due to variable soil types and high groundwater, therefore may require trench support for the pipeline and dewatering to enable construction.

The landfills are concentrated in and around the Minworth WwTW, immediately east of site along all routes for approximately 4km, but isolated landfills are also noted south as far as Meriden. The latter includes Coleshill Gas Works landfill and the Coles Hill Water Works which may potentially contain highly contaminated soils, groundwater and gas.

2. Alluvium

This will be mainly a combination of soft silty sandy compressible Clay, loose silty Sand and loose sandy Gravel; in addition, Peat layers maybe present in any stratum. The Alluvium is potentially ≈7m deep. Trench instability due to variable soil types and high groundwater may require trench support for the pipeline and dewatering to enable construction.

3. River Terrace Deposits

These deposits are mostly variable loose to medium dense sandy Gravels, potentially ≈3m deep. Lenses of Silt, Clay or Peat may also be present. Trench instability due to variable soil types and high groundwater may require trench support for the pipeline and dewatering to enable construction. Trenchless crossing installation / drilling using HDD is not generally a suitable method of crossing installation in granular materials.

4. Glacial Till

Stiff to very stiff sandy silty Clays with varying degrees of weathering, with possible groundwater but assumed to be limited inflows and usually concentrated in sandier horizons.

5. Glaciofluvial Deposits

Comprising loose to medium dense sandy Gravel with layers of Silt and Clay present. Trench instability due to variable soil types and high groundwater may require trench support for the pipeline and dewatering to enable construction. Trenchless crossing installation / drilling using HDD is not generally a suitable method of crossing installation in a granular material.

Bedrock Geology

1. Mercia Mudstone

Sedimentary mudstone and sandstones with the upper weathered layers likely to be stiff to very stiff Clay.

2. Sidmouth, Warwickshire Group, Helsby Formation, Branscombe Formations

Sedimentary mudstones and sandstones, the upper parts of which are likely to be weathered. They are typically comprised of stiff to very stiff Clay or dense to very dense gravelly Sand depending on the underlying bedrock, i.e., a mudstone or a sandstone.

Hydrogeology

The bedrock is designated as a Low Productivity aquifer. The lower part of the routes (Kenilworth) are designated a moderately to occasionally high Productive Aquifers. Limited borehole data exists on the BGS database, but indications are that the groundwater in the bedrock may be >8m.bgl. Therefore, there should not be a problem for near surface pipeline trench installation, but groundwater would affect any trenchless crossing installation and methods.

Mining

Based on maps on the Groundsure database, these indicate the initial sections of all routes are not in any mining designated area. However, from approximately the M6 motorway to south of Kenilworth the routes are located in a Coal Mining Report Area and Surface Coal Resource Area. The Coal Mining Report Area ceases just south of Kenilworth, but the routes are still indicated to be in a Surface Coal Resource Area through to the proposed outfalls. The database does not indicate any mine surface entries in the vicinity of the routes, and the Groundsure database is compiled from information provided by the Coal Authority.

L. Geotechnical Risk Register

Geotechnical Risk Register

In accordance with BS EN 1997-1:2004 the project is classified as Geotechnical Category 2 as it includes conventional types of structures and foundations with no exceptional risks, difficult soil or loading conditions.

A qualitative approach has been used to develop the Geotechnical Risk Register (GRR) for the proposed routes. Using this system, the degree of risk is the expected impact of damage, loss or harm for a given hazard under particular circumstances and is the product of the likelihood and consequence of that hazard materializing. The scales of likelihood and consequences are shown in Tables 1 and 2, and the degrees of risk are summarized in Table 3.

Table 1 - Scale of likelihood

Likelihood	Scale
Improbable	1
Remote	2
Occasional	3
Probable	4
Frequent	5

Table 2 - Scales of consequence

Consequences	Scale
Insignificant	1
Marginal	2
Serious	3
Critical	4
Catastrophic	5

Table 3 - Degrees of risk

Degree of Risk	Risk Level	Recommended Response
1 to 5	Low risk	Broadly acceptable if all reasonably practicable control measures are in place
6 to 8	Medium risk	Tolerable only if further mitigation is not reasonably practical and there is need to continue activity with identified controls
9 to 15	High risk	Apply further mitigation measures and/or alter method of work to reduce risk further
16 to 25	Very high risk	Unacceptable. Re - examine activities to provide lower risk

Hazard	Consequences	Initial Risk index			Practicable mitigation	Mitigated Risk Index		
		L	I	R		L	I	R
Geotechnical Risks								
Unforeseen ground and groundwater conditions	Programme delays, inadequate design, and unexpected settlement of the proposed structures and incorrect trenchless crossing methods.	3	4	12	A desk study, followed by a ground investigation, is required to confirm the ground conditions along the preferred route option, especially in regard to the trenchless crossings.	2	4	8
Differential settlement during construction dewatering	Poor serviceability state, damage to adjacent infrastructures, programme delays and additional costs.	3	4	12	A desk study, followed by a ground investigation, is required to confirm the ground conditions along the preferred route option. Settlement should be taken into consideration during the detailed design and during construction, especially under major infrastructure owned and operated by others (roads, railways, canals).	2	4	8
Unexpected high ground-water levels.	Programme delays and insufficient design leading to additional costs.	3	5	15	A ground investigation which includes installation of monitoring standpipes/piezometers and subsequent groundwater level monitoring is required to inform the detailed design and any dewatering that may be needed during construction.	2	5	10
Unknown and variability of landfill materials, and presence of compressible ground.	Unexpected settlement of loaded structures and pipelines leading to eventual failure. Health risks to site operatives, contamination, and programme delays.	3	4	12	Ground investigation is required to confirm the volume of the landfill, its composition (potentially including asbestos) and chemical properties.	2	4	8
Encountering obstructions during ground intrusive works (including the ground investigation)	Delay to programme and additional costs.	3	3	9	A desk study, followed by a ground investigation, is required to confirm the ground conditions along the preferred route option. Historical data to be made available for the Minworth WwTW and other utility owned assets, including historical locations.	2	3	8
Damage to buried services.	Potential for injury to site operatives and general public, programme delays, and additional costs incurred. Damage to utility services serving the area, with delays and additional costs to others.	4	4	16	Any available information shall be reviewed before any ground intrusive works commence and all exploratory holes shall be positioned to avoid known buried services. Also required for the construction of the pipeline routes and trenchless crossings.	2	4	8

Hazard	Consequences	Initial Risk index			Practicable mitigation	Mitigated Risk Index		
		L	I	R		L	I	R
Geotechnical Risks								
Aggressive ground conditions to buried concrete.	Damage to infrastructure, serviceability issues and additional costs.	3	4	12	A ground investigation is required to collect samples for BRE Special Digest 1 (2005) testing and to determine the concrete AC-DC classification for the proposed structures, pipeline and trenchless crossings.	4	2	8
Unexploded Ordnance (UXO)	Risk of injury or death to site operatives and members of the public, programme delays and additional costs.	2	5	10	UXO Detailed Desk Study to be commissioned upon decision to cover the Route Option. This will inform any mitigation measures required.	2	5	10

Hazard	Consequences	Initial Risk index			Practicable mitigation	Mitigated Risk Index		
		L	I	R		L	I	R
Geo-Environmental Risks								
Unforeseen Contamination including asbestos, gas and chemicals, associated with the historical construction of the Minworth WwTW and landfills.	Harm to health of site operatives. Project delay to undertake clean-up if contamination is at levels above acceptable limits.	3	3	9	A ground investigation and assessment of near surface soils shall be undertaken to establish the nature and extent of any contamination present and potential associated risks. Regular inspections of arisings, and chemical testing to appropriately classify materials. Appropriate protection measures (e.g., PPE) to be utilized during below ground works.	2	3	6
Leaching of contaminants into the groundwater and surface runoff from stockpiles into adjacent watercourses	Contamination of controlled water receptors (groundwater and surface waters)	3	3	9	Ground investigation to be undertaken to establish shallow groundwater regime. If significantly contaminated soils are identified from the ground investigation, a programme of groundwater monitoring shall be considered prior to construction works enabling a qualitative risk assessment. Possible groundwater sampling and analysis if ground works are anticipated to interact with shallow groundwater.	2	3	6
Excavated materials requiring disposal as hazardous waste	Increased disposal costs	3	3	9	Undertake a ground investigation to assess contaminant levels in soils. Develop a Materials Management Plan (MMP) in accordance with CL:AIRE DoW CoP to avoid where possible, material disposal. Preliminary waste classification to be undertaken on samples obtained during the ground investigation to enable preliminary classification of materials. A further assessment shall be undertaken if material is required to be disposed off-site.	2	3	6

M. Carbon Calculator Record Sheets

Carbon calculator sheets key:

Route name	STW carbon tool reference
WRMP19	Option 1
G1 North Warwick	Option 2
G1 South Warwick	Option 3
G2 WRMP19	Option 4
G2 North Warwick	Option 5
G2 South Warwick	Option 6
G2 WRMP19 RE_A	Option 7
G2 WRMP19 RE_B	Option 8
G2 WRMP19 RE_C	Option 9

Severn Trent Water - Embodied Carbon Calculator - Summary of Results by Gateway

Project Setup & Navigation

Use this page to compare options against each other from a greenhouse gas perspective.
This tab represents baseline emissions, prior to any low carbon initiatives.

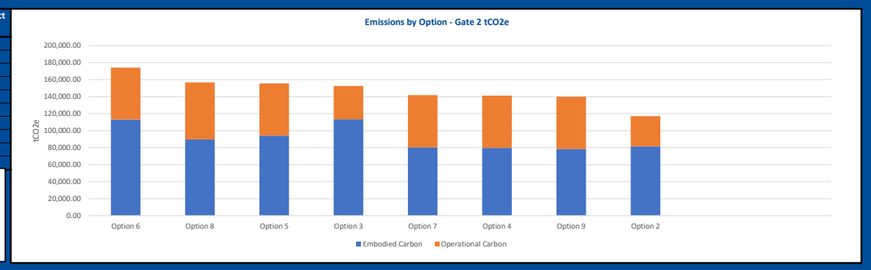
Project Design Lifetime	**50.0 Years**
Chosen Gateway	**Gate 2**

choose annual / lifetime

Option	Embodied Carbon (tCO2e)	Operational Carbon - Lifetime (tCO2e)	Total Carbon Impact (tCO2e)
Option 6	112,861.94	61,380.36	**174,242.30**
Option 8	89,763.45	66,960.39	**156,723.84**
Option 5	94,022.29	61,380.36	**155,402.64**
Option 3	113,212.75	39,060.23	**152,272.97**
Option 7	80,414.06	61,380.36	**141,794.41**
Option 4	79,693.12	61,380.36	**141,073.48**
Option 9	78,519.83	61,380.36	**139,900.19**
Option 2	81,634.10	35,340.21	**116,974.30**

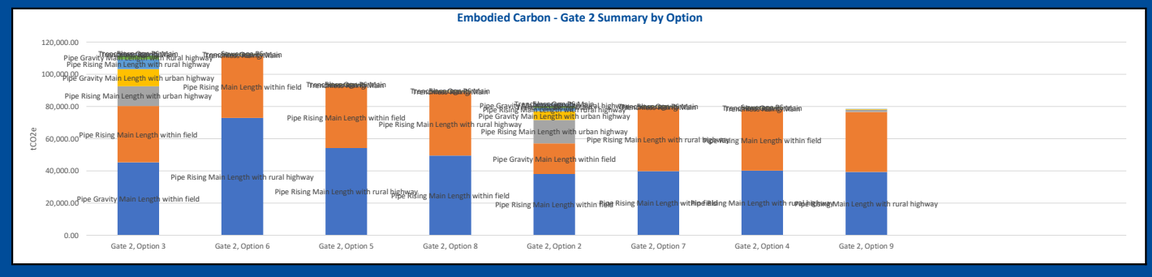
As shown in the Low Carbon Guidance tab, the emissions derived from the carbon curves in this tool are likely to represent the most conservative estimation(s) of emissions, due to their calculation methodology.

Through procurement choices, there may be opportunities to further limit the greenhouse gas impact of this project. ***Click here to view guidance on construction material options.*** **[LINK TO BE INSERTED THAT COVERS WHOLE BOX]**



Embodied Carbon - Breakdown by Option

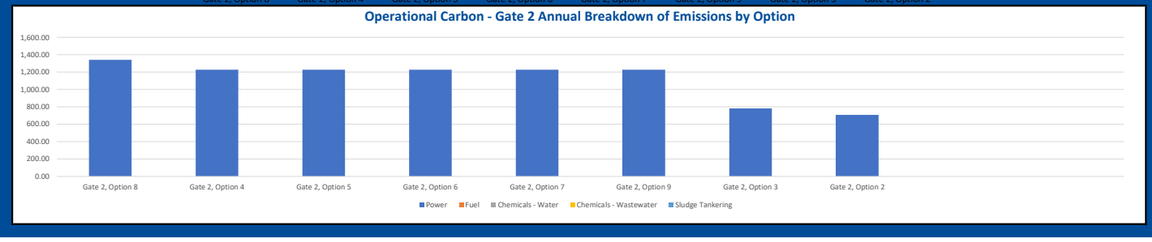
Option 3		Option 6		Option 5		Option 8		Option 2		Option 7		Option 4		Option 9					
Asset	**Embodied Carbon (tCO2e)**	**Asset**	**Embodied Carbon (tCO2e)**	**Asset**	**Embodied Carbon (tCO2e)**	**Asset**	**Embodied Carbon (tCO2e)**	**Asset**	**Embodied Carbon (tCO2e)**	**Asset**	**Embodied Carbon (tCO2e)**	**Asset**	**Embodied Carbon (tCO2e)**	**Asset**	**Embodied Carbon (tCO2e)**	**Asset**	**Embodied Carbon (tCO2e)**	**Asset**	**Embodied Carbon (tCO2e)**
Pipe Gravity Main Length within field	45,393.51	Pipe Rising Main Length with rural highway	72,990.95	Pipe Rising Main Length with rural highway	54,153.89	Pipe Rising Main Length within field	49,511.74	Pipe Rising Main Length within field	38,072.15	Pipe Rising Main Length within field	39,953.05	Pipe Rising Main Length with rural highway	40,237.33	Pipe Rising Main Length with rural highway	39,445.64				
Pipe Rising Main Length within field	34,899.00	Pipe Rising Main Length within field	38,276.78	Pipe Rising Main Length within field	38,276.78	Pipe Rising Main Length with rural highway	39,445.64	Pipe Gravity Main Length within field	19,159.41	Pipe Rising Main Length with rural highway	39,445.64	Pipe Rising Main Length within field	37,965.63	Pipe Rising Main Length within field	37,200.38				
Pipe Rising Main Length with urban highway	12,263.71	Trenchless Rising Main	1,218.73	Trenchless Rising Main	1,218.73	Trenchless Rising Main	406.90	Pipe Rising Main Length with urban highway	14,436.13	Trenchless Rising Main	627.09	Trenchless Rising Main	922.41	Trenchless Rising Main	1,485.54				
Pipe Gravity Main Length with urban highway	10,619.26	Trenchless Gravity Main	262.53	Trenchless Gravity Main	259.93	Trenchless Gravity Main	275.32	Pipe Gravity Main Length with urban highway	5,536.19	Trenchless Gravity Main	275.32	Trenchless Gravity Main	454.80	Trenchless Gravity Main	275.32				
Pipe Rising Main Length with rural highway	6,096.81	Sewerage PS	112.95	Sewerage PS	112.95	Sewerage PS	123.84	Pipe Rising Main Length with rural highway	1,822.04	Sewerage PS	112.95	Sewerage PS	112.95	Sewerage PS	112.95				
Pipe Gravity Main Length with Rural highway	2,517.97							Trenchless Rising Main	1,259.77										
Trenchless Rising Main	1,243.57							Pipe Gravity Main Length with Rural highway	1,191.33										
Trenchless Gravity Main	111.00							Trenchless Gravity Main	96.89										
Sewerage PS	67.91							Sewerage PS	60.18										



Choose annual or lifetime with drop-down

Operational Carbon - Annual Breakdown

	Gate 2									
OpEx Category	**Option 8 Operational Carbon (tCO2e - Annual)**	**Option 4 Operational Carbon (tCO2e - Annual)**	**Option 5 Operational Carbon (tCO2e - Annual)**	**Option 6 Operational Carbon (tCO2e - Annual)**	**Option 7 Operational Carbon (tCO2e - Annual)**	**Option 9 Operational Carbon (tCO2e - Annual)**	**Option 3 Operational Carbon (tCO2e - Annual)**	**Option 2 Operational Carbon (tCO2e - Annual)**	**Operational Carbon (tCO2e - Annual)**	**Operational Carbon (tCO2e - Annual)**
Power	1,339.21	1,227.61	1,227.61	1,227.61	1,227.61	1,227.61	781.20	706.80		
Fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Chemicals - Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Chemicals - Wastewater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Sludge Tankering	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Gate 2, Option 8	Gate 2, Option 4	Gate 2, Option 5	Gate 2, Option 6	Gate 2, Option 7	Gate 2, Option 9	Gate 2, Option 3	Gate 2, Option 2		



N. Environmental Constraints Tech Note

Environmental Constraints Plans Technical Note

Document no: A7W13155-CY-DOC-210015-0A
Revision no: 0A

Severn Trent
A7W13155

Minworth SRO
19 January 2022

Environmental Constraints Plans Technical Note

Client name:	Severn Trent		
Project name:	Minworth SRO		
Client reference:	A7W13155	**Project no:**	B19589
Document no:	A7W13155-CY-DOC-210015-0A	**Project manager:**	Ben Smith
Revision no:	0A	**Prepared by:**	Abigail Li
Date:	19 January 2022	**File name:**	Environmental Constraints Plans Technical Note

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Contents

Appendices

1. Minworth SRO Environmental Constraints Technical Note

1.1 Introduction

Severn Trent (the Client) is one of two partners including Affinity Water required to deliver the Minworth Strategic Resource Option (SRO), which will provide a new raw water source for either the Severn Thames Transfer (STT) SRP, Grand Union Canal Strategic Transfer (GUC) SRO, or potentially a combination of both SROs. These will transport water from areas of water surplus to areas that face a shortfall. It will allow the coordinated use of all major bulk water sources in the regions.

As part of the Minworth SRO Project, Jacobs have been commissioned to achieve four Key Project Objectives:

- **Confirm the technical engineering and environmental scheme feasibility including data collection and assessment;**
- Undertake further options appraisal to define a preferred solution, review overall pipeline routes and treatments options, investigate solution enhancements, mitigations and opportunities;
- Prepare a Conceptual Design Report for Minworth SRO as described in Key Deliverables in section S0220 of the Service Order; and,
- Refine and update data for the regional modelling with updated costs, metrics and benefits ahead of the Water Resources South East (WRSE) January 2022 update.

To assist with determining the environmental scheme feasibility, a series of Environmental Constraints Plans have been produced and are included in the following appendices. The plans identify environmental features and designations of national and some local importance which the options may have a potential impact on or define the route and design choices.

It must be noted that this does not include any assessment of the potential impacts or effects on the environmental features from the proposed SRO options. The environmental constraints plans are to be used by the Engineering Team for guidance and illustration, to help with the development of the SRO routes and designs, with the initial aim to avoid and/or limit the direct impacts to the environmental features in the first instance.

Due to the amount of data available and to allow for clarity when viewing the plans were split into two with information set out in the two tables below. The first plans are predominantly general environmental features (Environmental Constraints Plans) with the second set being historical and archaeological data (Heritage Constraints Plans).

1.2 Available Data

The data presented on the Environmental and Heritage Constraints Plans and the sources of data are provided below in Tables 1.1 and 1.2, respectively.

Table 1.1: List of environmental constraints presented in the Environmental Constraints Plan

Feature	Source of data
Statutory Designated Sites	
Area of Outstanding Natural Beauty (AONB)	Natural England (data.gov.uk)
Biosphere Reserves	Natural England (data.gov.uk)
Local Nature Reserve (LNR)	Natural England (data.gov.uk)
National Nature Reserve (NNR)	Natural England (data.gov.uk)
RAMSAR	Natural England (data.gov.uk)
Special Area of Conservation (SAC)	Natural England (data.gov.uk)
Special Protection Area (SPA)	Natural England (data.gov.uk)
Site of Special Scientific Interest (SSSI)	Natural England (data.gov.uk)
Non-Statutory Designated Sites	

Drinking Water Safeguard Zone	Department for Environment, Food and Rural Affairs (DEFRA) (data.gov.uk)
Source Protection Zone (SPZ)	Environment Agency (data.gov.uk)
Rivers and Watercourses	
Main River	Environment Agency (data.gov.uk)
Other waterbodies	DEFRA and Ordnance Survey (data.gov.uk)
Flood Zones	
Flood Risk Areas	Environment Agency (data.gov.uk)
Priority Habitats	
Priority Habitats	DEFRA (data.gov.uk)
Landfill Sites	
Permitted waste sites	Environment Agency/Permitted Waste Sites Authorised Landfill Site Boundaries (data.gov.uk)
Air and Noise	
Air Quality Management Area (LAQMA)	DEFRA (uk-air.defra.gov.uk)
Noise Important Area (NIA)	DEFRA (data.gov.uk)

Table1.2: List of heritage constraints presented in the Heritage Constraints Plan

Feature	**Source of data**
Statutory Designated Sites	
Scheduled Monuments	Historic England (data.gov.uk)
World Heritage Sites	Historic England (data.gov.uk)
Listed Buildings	Historic England (data.gov.uk)
Non-statutory Designated Sites	
Registered Battlefields	Historic England (data.gov.uk)
Registered Parks and Gardens	Historic England (data.gov.uk)
Landfill Sites	
Historic landfill sites	Environment Agency/Historic Landfill Map Server (data.gov.uk)

1.3 Limitations

The production of the Environmental Constraints Plans does not construe any statutory or non-statutory environmental assessment that has been undertaken and they are only to be used as illustration and guide of key environmental constraints to aid with the selection and definition of appropriate routes; whereabouts the most significant environmental risks and impacts can be avoided or reduced at an early phase.
Due to the scale of the scheme, the spread of the different options and the zone of influence used, it was necessary to break the plans up to allow for more detail to be provided on the boundaries and locations of features in relation to the proposed alignments. Smaller scale plans have been produced to illustrate the entire area.
The following data was not freely accessible via public domains and is required to be requested from Local Authorities (Staffordshire County Council, Warwickshire County Council and West Midlands County Council) and may not be digitised:

- Conservation Areas and Tree Preservation Orders
- English Local Authority Green Belt Dataset
- Local Wildlife Sites (LWS) / Site of Importance for Nature Conservation (SINC) / Site of Nature Conservation Importance (SNCI)

There will be an abundance of Public Right of Ways (PROWs) in close proximity to the route alignments which would need to be reviewed during the environmental assessment. Due to the scale of the scheme and the current vision of the options it was thought that adding PRoW to the plans would potentially create a cluttered illustration and detract from the constraints that are likely to be more critical to the decision and design process.

It should also be noted that the presence / absence of protected species and their habitats has not been included. This data would require specific surveys to be carried out and the data digitised. Assumptions can be made for certain habitats that could support particular protected species that would require specific mitigation and in some circumstances consent from regulators to disturb i.e. rivers/streams can support riparian species such as otter and water vole, or ponds support populations of Great Crested newt, or trees and buildings can be habitat for bats (noting that the habitats for bats are protected along with the individuals). The data.gov.uk data library (illustrated on Magic.gov.uk) does provide locations for previously held protected species licences. However, as per the PRoW illustration it is likely that this would create a cluttered plan.

Although the historic licence locations provide an indication of where particular species have previously been encountered and licences have been granted to complete works that have some level of disturbance, they are relatively limited as they are only a single point in time and do not allow for the likely movement of species or guarantee that they are still present.

The Green Belt designation has not been included on the plans as it covers a significant area of land and would potentially detract from other constraints that are likely to be more critical to the decision and design process. Paragraph 150, of the National Planning Policy Framework (NPPF) 2021 refers to 'engineering operations' as an acceptable form of development within the Green Belt, providing its openness is preserved and the proposals do not conflict with the purposes of including land within it (see para 138. of NPPF for purpose of Green Belt). Any mitigation would need to demonstrate that the openness of the area was not jeopardised.

Appendix A. Environmental Constraints Plan

FIGURE 1.1

SHEET 1 OF 10
SHEET 2 OF 10
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SHEET 8 OF 10
SHEET 9 OF 10
SHEET 10 OF 10

N
W E
S

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study Area
- 20km Study Area
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
- Special Areas of Conservation
- Ancient Woodland
- Permitted Landfill Site
- Flood Zone 3
- Flood Zone 2
- Drinking Water Safeguard Zone
- Source Protection Zone

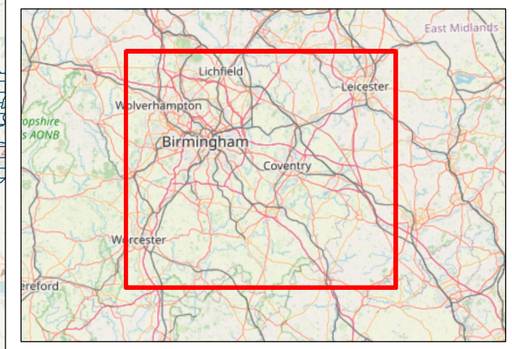

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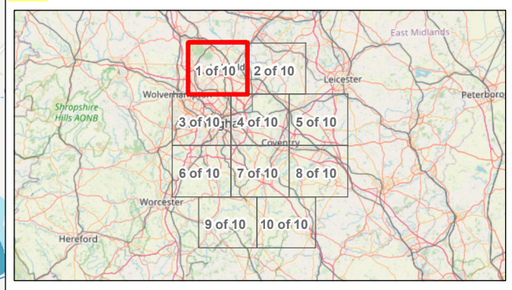
FIGURE 1.2

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
- Special Areas of Conservation
- Ancient Woodland
- Permitted Landfill Site
- Flood Zone 3
- Flood Zone 2
- Drinking Water Safeguard Zone
- Source Protection Zone



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SHEET 1 OF 10

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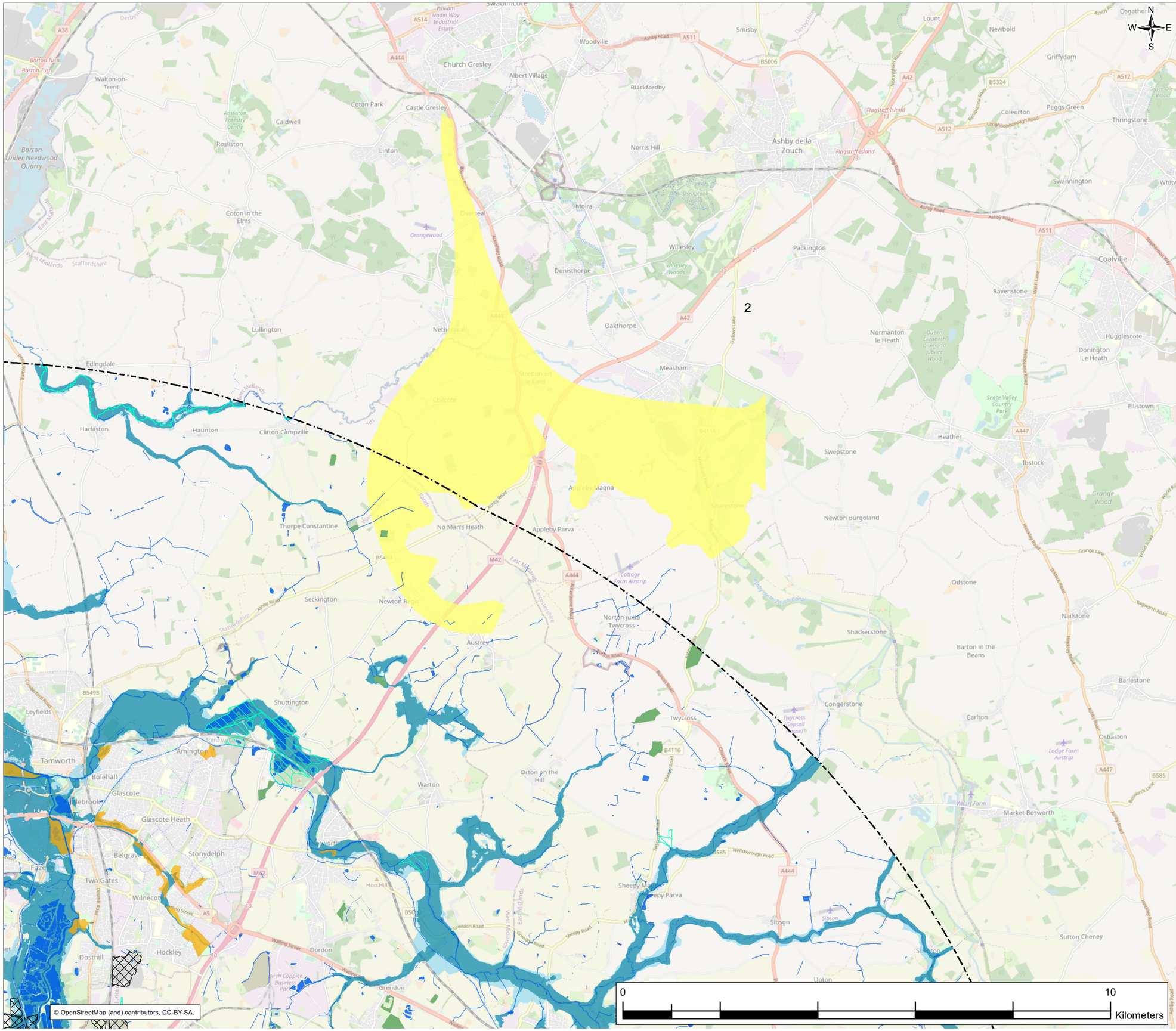
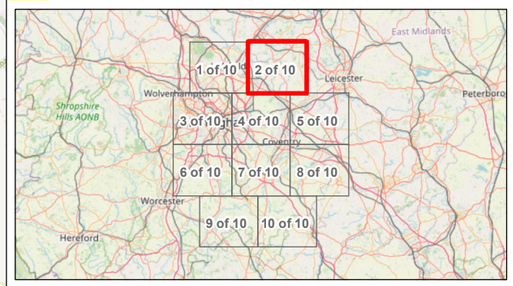
FIGURE 1.3



Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
- Special Areas of Conservation
- Ancient Woodland
- Permitted Landfill Site
- Flood Zone 3
- Flood Zone 2
- Drinking Water Safeguard Zone
- Source Protection Zone



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SHEET 2 OF 10

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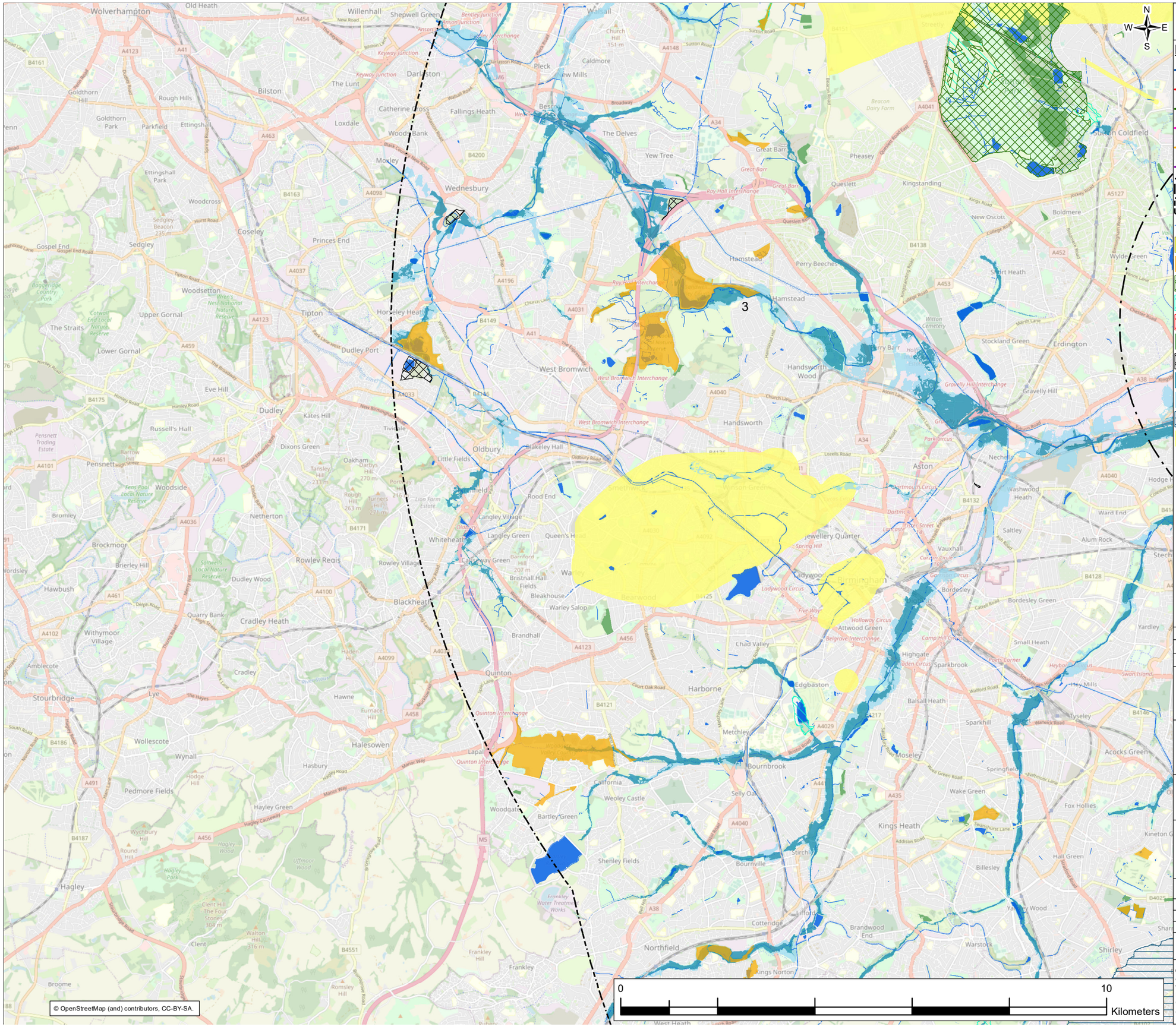
FIGURE 1.4



Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Surface Water
- Areas of Outstanding Natural Beauty
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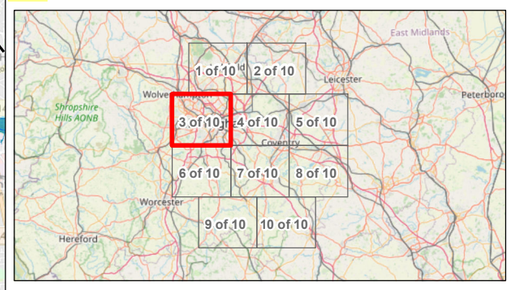

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FIGURE 1.5

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
- Special Areas of Conservation
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- Flood Zone 2
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- Source Protection Zone

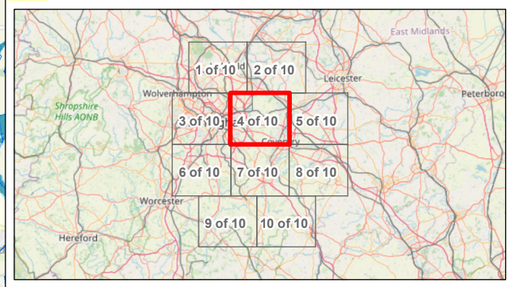

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FIGURE 1.6

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
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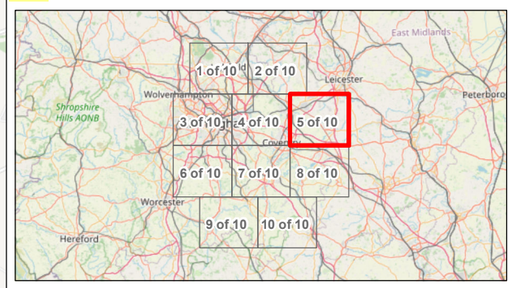

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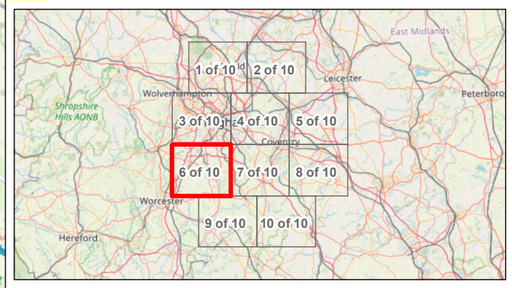
FIGURE 1.7

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
- Special Areas of Conservation
- Ancient Woodland
- Permitted Landfill Site
- Flood Zone 3
- Flood Zone 2
- Drinking Water Safeguard Zone
- Source Protection Zone



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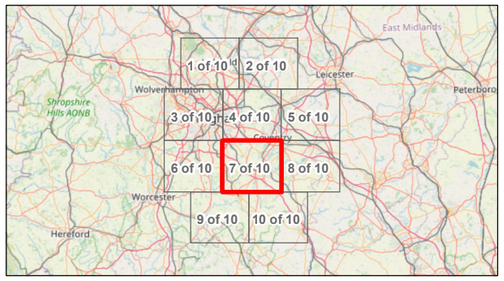
0 10 Kilometers

FIGURE 1.8

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
- Special Areas of Conservation
- Ancient Woodland
- Permitted Landfill Site
- Flood Zone 3
- Flood Zone 2
- Drinking Water Safeguard Zone
- Source Protection Zone



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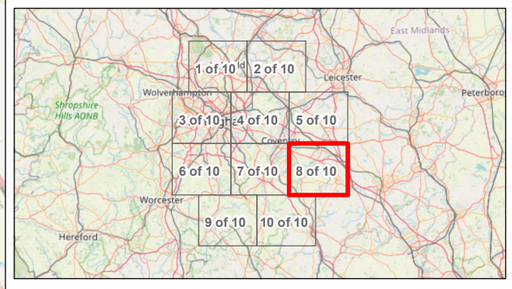
0 — 10 Kilometers

FIGURE 1.9

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
- Special Areas of Conservation
- Ancient Woodland
- Permitted Landfill Site
- Flood Zone 3
- Flood Zone 2
- Drinking Water Safeguard Zone
- Source Protection Zone



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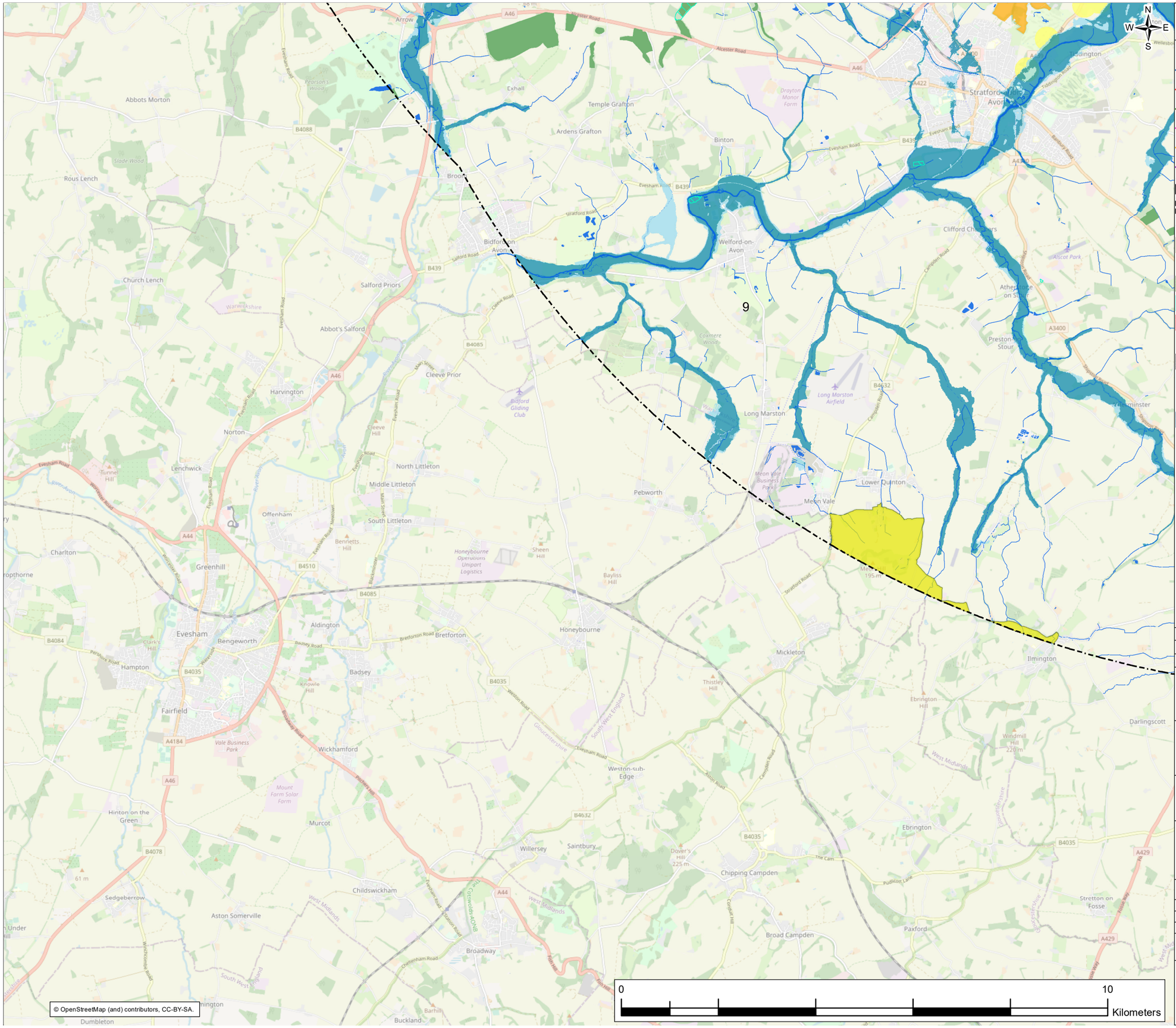
0 — 10 Kilometers

FIGURE 1.10



Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
- Special Areas of Conservation
- Ancient Woodland
- Permitted Landfill Site
- Flood Zone 3
- Flood Zone 2
- Drinking Water Safeguard Zone
- Source Protection Zone

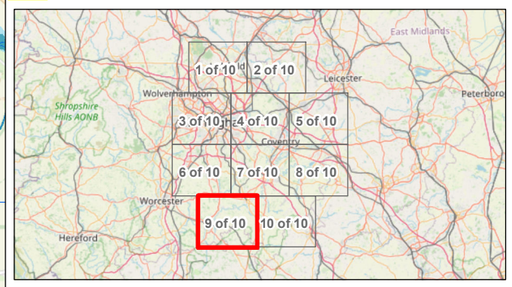


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FIGURE 1.11

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Surface Water
- Areas of Outstanding Natural Beauty
- Local Nature Reserves
- National Nature Reserves
- Sites of Special Scientific Interest
- Special Areas of Conservation
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- Flood Zone 3
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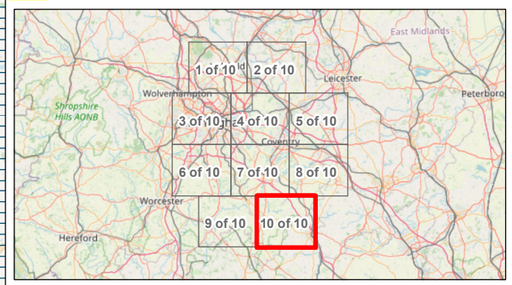

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0 10 Kilometers

Appendix B. Heritage Constraints Plan

FIGURE 2.1

SHEET 1 OF 10
SHEET 2 OF 10
SHEET 3 OF 10
SHEET 4 OF 10
SHEET 5 OF 10
SHEET 6 OF 10
SHEET 7 OF 10
SHEET 8 OF 10
SHEET 9 OF 10
SHEET 10 OF 10

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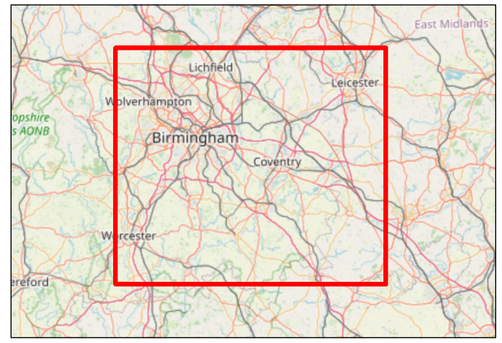
Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site



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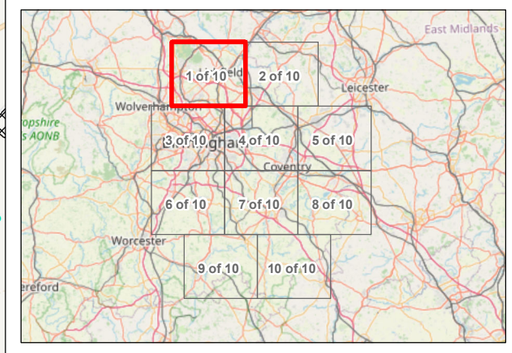
0 10 Kilometers

FIGURE 2.2

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site



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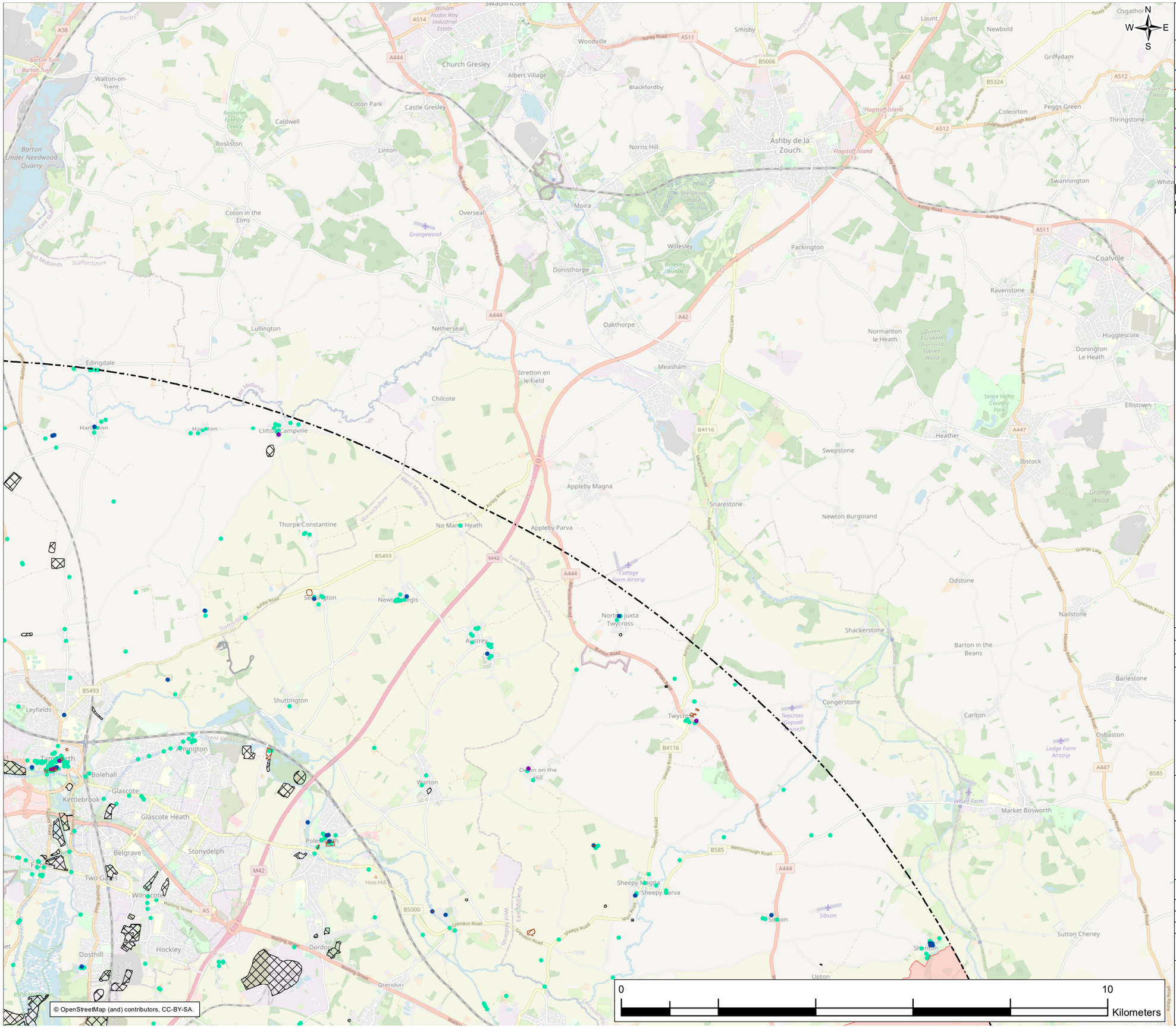
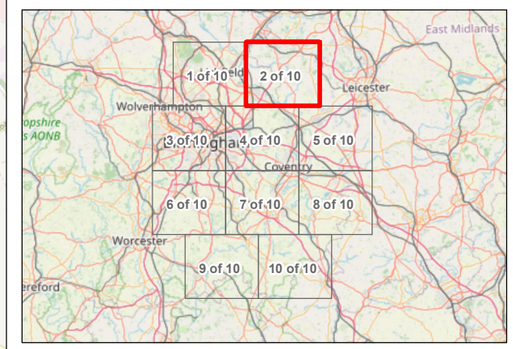
0 — 10 Kilometers

FIGURE 2.3





Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site

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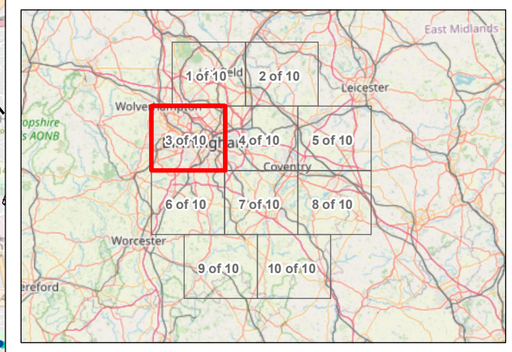
FIGURE 2.4

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site



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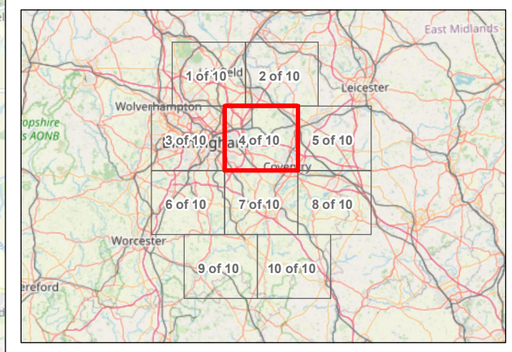
0 10 Kilometers

FIGURE 2.5

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site



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0 10 Kilometers

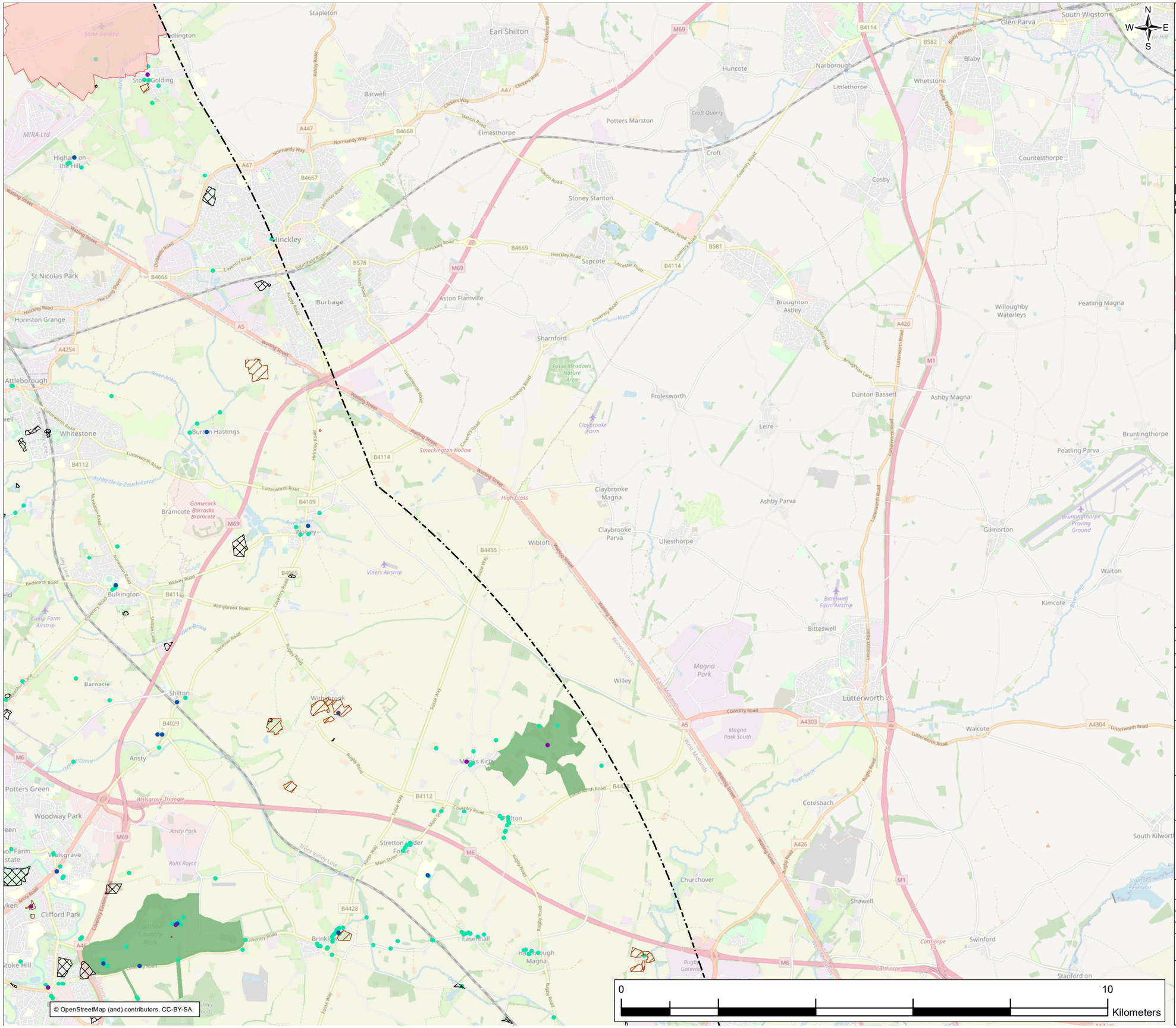

FIGURE 2.6

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site

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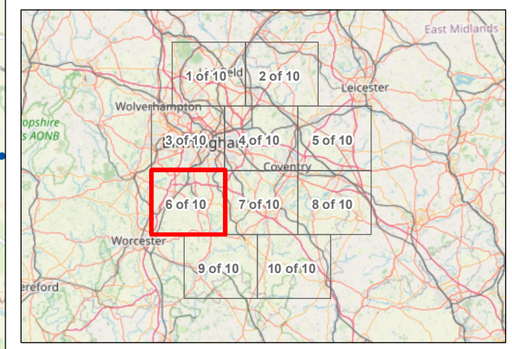
FIGURE 2.7

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site



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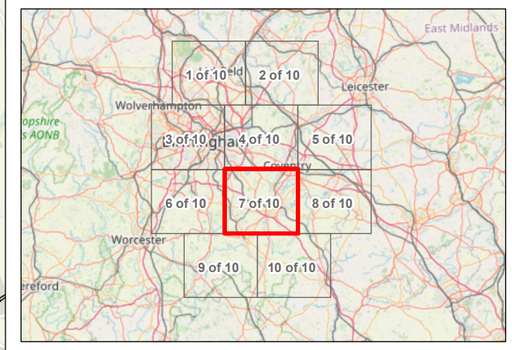
0 10 Kilometers

FIGURE 2.8

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site



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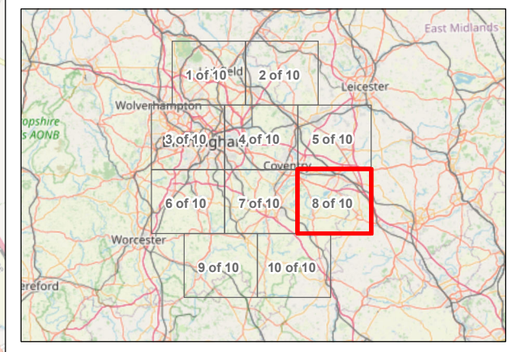
0 10 Kilometers

FIGURE 2.9

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site



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0 10 Kilometers

FIGURE 2.10

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site

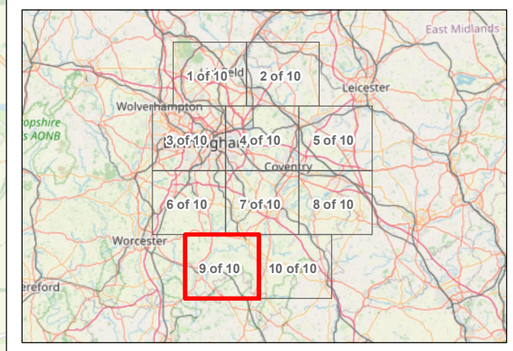

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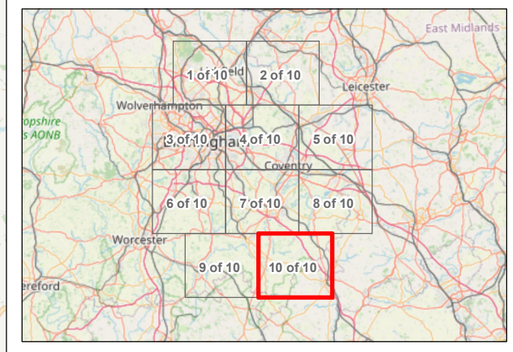
FIGURE 2.11

Legend

- Gate 2 North Warwick
- Gate 2 South Warwick
- Gate 2 WRMP19
- Gate 1 North Warwick
- Gate 1 South Warwick
- Gate 1 WRMP19
- 5km Study
- 20km Study
- Grade I Listed Building
- Grade II* Listed Building
- Grade II Listed Building
- Scheduled Monument
- Battlefield
- Registered Park and Garden
- Historic Landfill Site



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