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HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix WR-006-00005

Water resources and flood risk

MA05: Risley to Bamfurlong

Hydraulic modelling report - Carr Brook

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Department for Transport

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High Speed Two (HS2) Limited,
Two Snowhill
Snow Hill Queensway
Birmingham B4 6GA

Telephone: 08081 434 434

General email enquiries: HS2enquiries@hs2.org.uk

Website: www.hs2.org.uk

A report prepared for High Speed Two (HS2) Limited:

ARUP+ ERM | FOSTER + PARTNERS | JACOBS
RAMBOLL | TYPSA | COSTAIN

MWJV
Mott MacDonald | WSP

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Contents

Tables

Figures

1 Introduction

1.1 Background

1.1.1 This appendix presents the results of the hydraulic modelling carried out for Carr Brook in the Glaze Brook catchment. Carr Brook runs through the Risley to Bamfurlong community area (MA05).

1.1.2 The hydraulic modelling has been used to inform the Flood risk assessment (Volume 5: Appendix WR-005-0MA05) for this community area.

1.1.3 The following hydraulic modelling reports are also relevant to this area:

- Hydraulic modelling report – Tributaries of Holcroft Lane Brook (Volume 5: Appendix WR-006-00003);
- Hydraulic modelling report – Small Brook (Volume 5: Appendix WR-006-00004); and
- Hydraulic modelling report – Hey Brook (Volume 5: Appendix WR-006-00006).

1.1.4 The water resources and flood risk assessments include both route-wide and community area specific appendices. The route-wide appendices comprise:

- a Water Framework Directive (WFD) compliance assessment (Volume 5: Appendix WR-001-00000); and
- a Draft water resources and flood risk operation and maintenance plan (Volume 5: Appendix WR-007-00000).

1.1.5 For the Risley to Bamfurlong area the Water resources assessment, Volume 5: Appendix WR-003-0MA05 should also be referred to.

1.1.6 Additional information is included in Background Information and Data (BID):

- Water resources assessment baseline data that is reported in (BID WR-004-0MA05)[1]; and
- Water Framework Directive compliance assessment baseline data (BID WR-002-00001)[2].

1.2 Aims

1.2.1 The aim of this study was to develop a hydraulic model of Carr Brook at the proposed Carr Brook aqueduct crossing to simulate peak flood levels, with and without the Proposed

[1] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Background Information and Data, Water resources assessment baseline data*, BID WR-004-0MA05. Available online at: http://www.gov.uk/government/collections/hs2-phase-2b-crewe-manchester-environmental-statement.

[2] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Background Information and Data, Water Framework Directive compliance assessment data,* BID WR-002-00001. Available online at: http://www.gov.uk/government/collections/hs2-phase-2b-crewe-manchester-environmental-statement.

Scheme. This report also aims to document the methods used, the results, assumptions and limitations.

1.2.2 The outputs from the study have been used to inform the flood risk assessment for the Risley to Bamfurlong area, that is reported in Volume 5, Flood risk assessment, Appendix: WR-005-0MA05. The hydraulic model has also informed the preliminary design of the Proposed Scheme, with the specific objective of ensuring that the design of hydraulic structures (for example: viaducts, bridges and culverts) takes account of flood risk issues, as detailed in the Environmental Impact Assessment Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-00001).

1.3 Objectives

1.3.1 The objectives of this study were to:

- develop an understanding of existing hydraulic conditions at the proposed watercourse crossings, including channel and floodplain characteristics, hydraulic structures and flow paths, through desk study and, where possible, by conducting a site visit;
- estimate peak flows, and hydrographs, at the Proposed Scheme crossing locations, associated with the following Annual Exceedance Probabilities (AEP): 5.0%, 1.0%, 1.0% + climate change (CC), and 0.1%; and
- develop a hydraulic model, using the information available at this stage, to estimate the flood levels associated with these peak flows along the study reach, both before and after construction of the Proposed Scheme.

1.4 Justification of approach

1.4.1 A risk-based approach has been adopted, whereby the level of modelling detail supporting the flood risk assessment at a specific site reflects the magnitude of the likely impacts of the Proposed Scheme on peak flood levels and the sensitivity of nearby receptors to flooding.

1.4.2 Carr Brook is an ordinary watercourse at the location of the Proposed Scheme crossing and becomes main river immediately downstream, with associated Environment Agency flood zone information available. A number of vulnerable receptors are predicted to be at risk of surface water flooding. Due to the small size of the catchment, a direct rainfall 2D hydraulic modelling approach has been adopted, with input hyetographs derived using Revitalised Flood Hydrograph 2 (ReFH2) software.

1.5 Scope

1.5.1 The scope of the study was to undertake hydraulic modelling to enable assessment of the impact of the Proposed Scheme on the local environment. The model aimed to be detailed enough to allow assessment of different options for the crossing location, to allow the management of flood risk and correct sizing of the crossing opening.

1.5.2 This report focuses on a 2.2km reach of Carr Brook extending upstream and downstream of the crossing of the Proposed Scheme. The Proposed Scheme crossing comprises an aqueduct, to carry Carr Brook over the Proposed Scheme which is in cutting at this location. A description of the location and type of scheme is provided in Section 2.

1.5.3 The scope of the report includes:

- discussion of all relevant datasets, in terms of their quality and gaps;
- details of the hydrological analysis undertaken, the approach used and the calculation steps;
- details of how the hydrological analysis has been integrated with the hydraulic modelling;
- identification and justification of the hydraulic modelling methodology selected; and
- a description of the hydraulic modelling parameters, assumptions, limitations and uncertainty.

2 Qualitative description of flood response

2.1 Sources of information

2.1.1 The following sources of information were obtained from the Environment Agency:

- flood map for planning (rivers and sea)[3];
- risk of flooding from surface water (RoFSW)[4] map; and
- flood defence asset information.

2.1.2 Additional information from the Lead Local Flood Authority (LLFA) and publicly available sources included:

- Wigan Metropolitan Borough Council (WMBC) Preliminary Flood Risk Assessment (PFRA) (2011)[5];
- WMBC Strategic Flood Risk Assessment (SFRA) (2011)[6]; and
- WMBC Local Flood Risk Management Strategy (LFRMS) (2014)[7].

2.2 Description of the study area

Study area

2.2.1 Carr Brook is a tributary of Glaze Brook, with the confluence located 4.8km downstream from the Proposed Scheme crossing.

2.2.2 Figure 1 shows the 2.6km long reach of Carr Brook in the study area. The upstream model boundary is located at B5207 Church Lane. The downstream boundary is located upstream of the A579 Atherleigh Way, approximately 1.2km downstream of the Proposed Scheme crossing. The 2D model domain has been extended sufficiently upstream and downstream to ensure the catchment of Carr Brook is captured, and to ensure that any effects caused by the model boundary do not affect water levels in the area of the Proposed Scheme.

[3] Environment Agency (2021), *Flood map for planning.* Available online at: https://flood-map-for-planning.service.gov.uk.

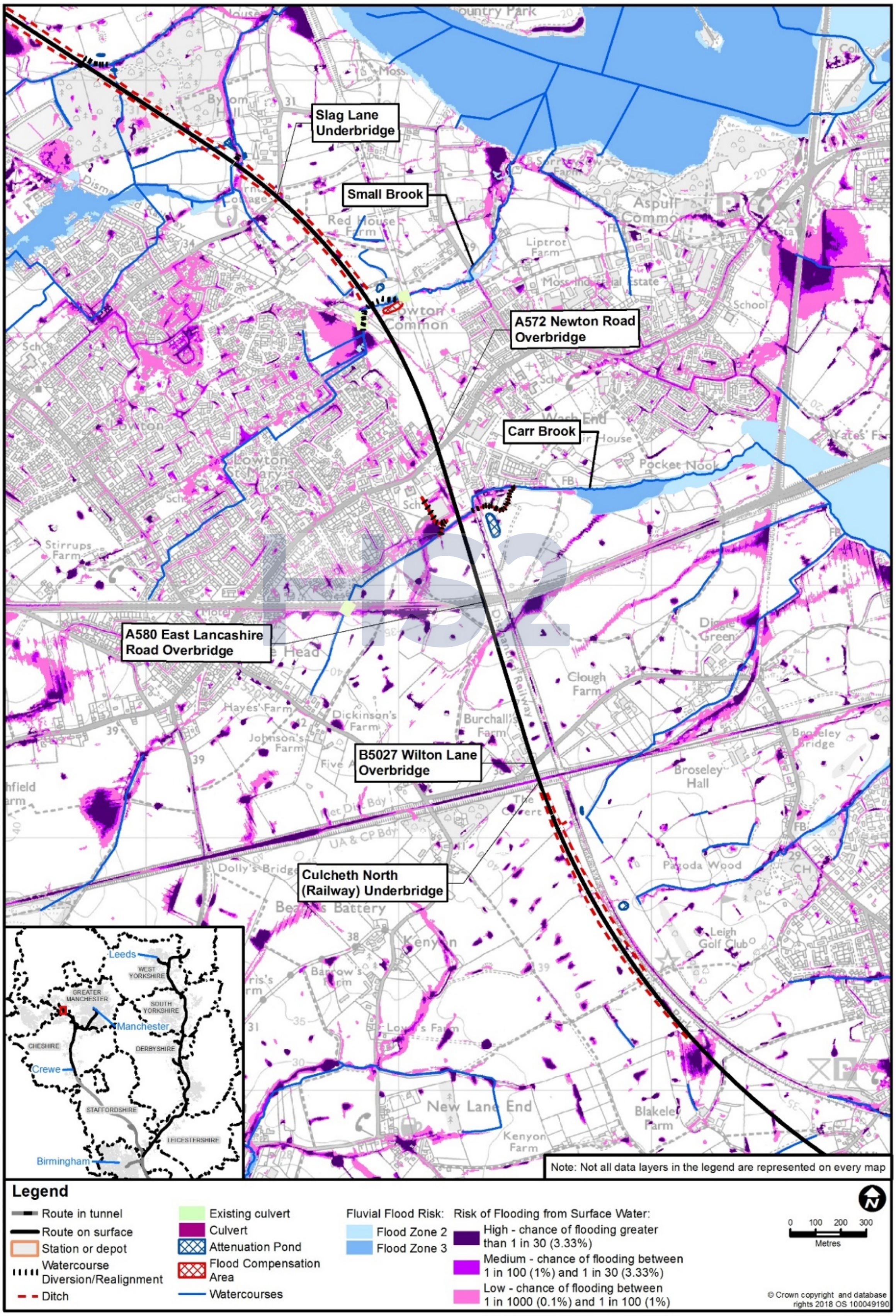
[4] Environment Agency (2021), *Long-term flood risk information.* Available online at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map.

[5] JBA Consulting (2011), *Wigan Preliminary Flood Risk Assessment*. Available online at: https://www.wigan.gov.uk/Docs/PDF/Resident/Crime-Emergencies/Flood-Risk-Assessment.pdf.

[6] JBA Consulting (2011), *Wigan Strategic Flood Risk*. Available online at: https://www.wigan.gov.uk/Docs/PDF/Council/Strategies-Plans-and-Policies/Planning/Environment/FloodRiskAssessmentReport1411kb.pdf.

[7] Wigan Metropolitan Borough Council (2014), *Wigan Local Flood Risk Management Strategy*. Available online at: https://www.wigan.gov.uk/Docs/PDF/Resident/Crime-Emergencies/Flood-Risk-Management-Strategy.pdf.

Figure 1: Study area and Environment Agency flood zones and RoFSW (0.1% AEP) at Carr Brook



2.2.3 The primary flow control on Carr Brook is a culverted section that runs along the rear of properties on Brancaster Drive, just downstream of the Proposed Scheme crossing.

Hydrological description

2.2.4 Carr Brook originates from immediately downstream of B2507 Kenyon Lane, south of Lowton St Mary, as shown in Figure 2. The Carr Brook catchment is partially urban in the north while the southern part of the catchment is rural. Its total extent based on the FEH (Flood Estimation Handbook) catchment delineation is 1.65km^2. However, within the FEH catchment[8], 0.89km^2 is the Small Brook catchment. The Carr Brook catchment area based on Light Detection and Ranging (LiDAR) data is 0.66km^2. This is a more appropriate size when considering surface water flow paths and LiDAR data.

2.2.5 There are no gauging stations present within the Carr Brook catchment[8].

2.2.6 Standard annual average rainfall for the catchment at the model downstream boundary is 910mm[8].

Proposed Scheme

2.2.7 The route of the Proposed Scheme crosses Carr Brook in cutting, requiring an aqueduct to carry the brook flows, approximately 350m to the north of the A580 East Lancashire Road. Further details of the Proposed Scheme can be found in the Volume 2, Map Books: maps CT-06-330.

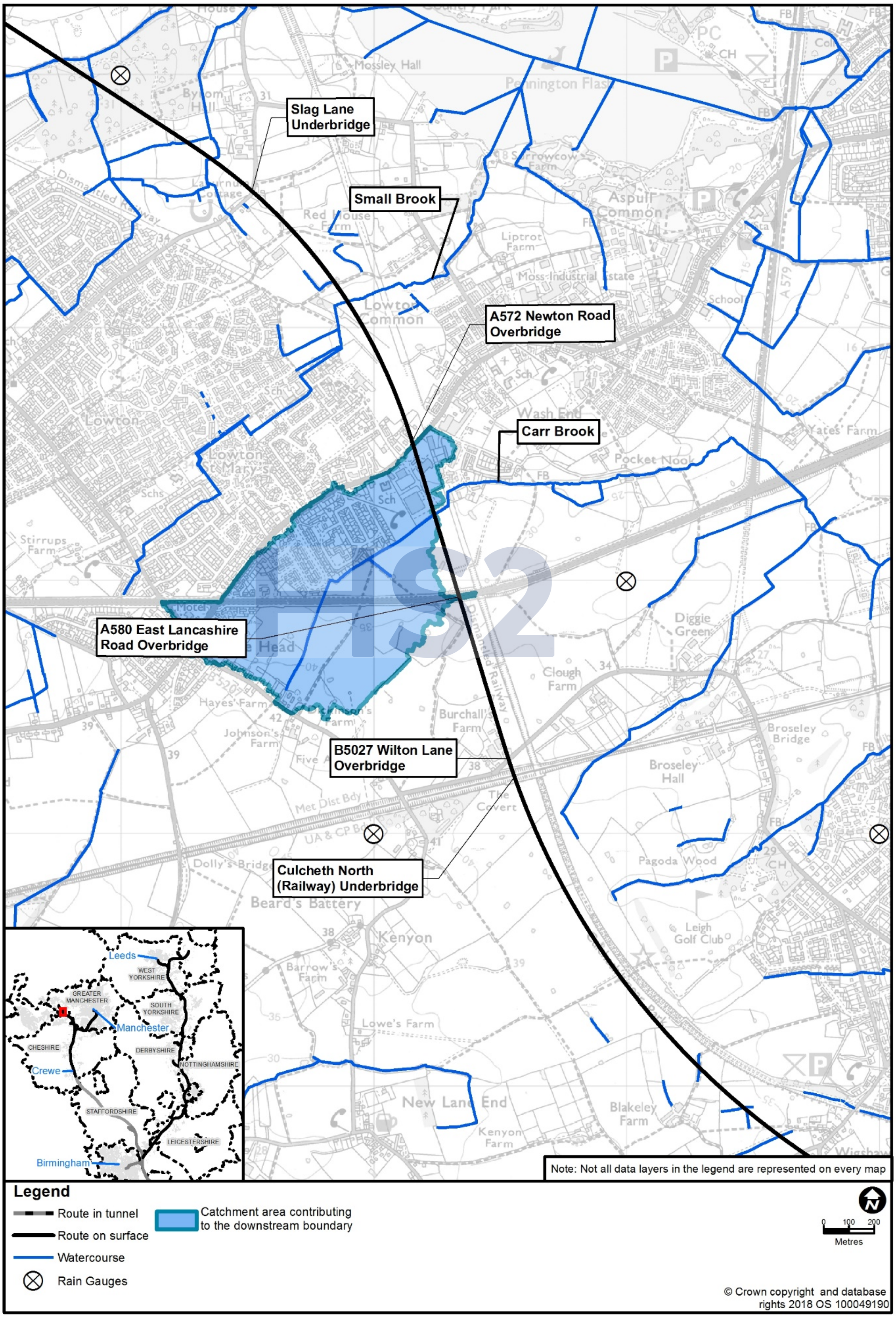
Features of note

2.2.8 Upstream of the Proposed Scheme crossing, Carr Brook runs in a straight line that suggests the watercourse has been realigned in the past.

2.2.9 Immediately downstream of the Proposed Scheme crossing, Carr Brook is culverted along the rear of properties on Brancaster Drive. Approximately 500m downstream of the Proposed Scheme Carr Brook is culverted beneath Pocket Nook Lane at Lower Pocket Nook Farm.

[8] Centre for Ecology and Hydrology (2021), *Flood estimation handbook web service.* Available online at: http://fehweb.ceh.ac.uk.

Figure 2: Carr Brook river catchment area



2.3 Existing understanding of flood risk

Flood mechanisms

2.3.1 The Environment Agency flood zone information available for the main river part of Carr Brook indicates the area downstream of the Proposed Scheme crossing is at risk of flooding in the 0.1% AEP event, as shown in Figure 1. The flood zones also indicate localised 1.0% AEP event flooding approximately 500m downstream of the Proposed Scheme crossing. This is potentially caused by a road culvert on Carr Brook under Pocket Nook Lane at Lower Pocket Nook Farm that is acting as a flow restriction.

2.3.2 The RoFSW indicates significant flooding of a number of more vulnerable residential properties just upstream and downstream of the Proposed Scheme crossing.

2.3.3 Available information does not indicate the presence of any flood defence assets within the model extent.

Analysis of historical flooding

2.3.4 No information on historical flood incidents has been identified from the SFRA[6], PFRA[5], or Section 19 flood investigation reports[9].

Availability of existing hydraulic models

2.3.5 Available information, that includes modelling data from the Environment Agency, does not indicate the existence of a hydraulic model for Carr Brook.

2.4 Site visit

2.4.1 At this stage no site survey or site visit was undertaken to inform the proposed hydraulic analysis. When the hydraulic model is updated during design development, in accordance with the HS2 Ltd requirements, a site visit will be undertaken by a hydraulic modeller to ensure a site-specific topographic survey specification can be developed.

[9] Section 19 of the Flood and Water Management Act 2010 sets out the requirement for that on becoming aware of a flood in its area, a LLFA must investigate and report on which risk management authorities have relevant flood risk management functions and whether each authority has exercised those functions in response to the flood.

3 Model approach and justification

3.1 Model conceptualisation

3.1.1 A 2D hydraulic modelling approach was chosen for Carr Brook due to the presence of nearby more vulnerable properties at risk. In addition, 1D survey data was not available to inform the model build or the sizing of the existing culvert at the rear of properties on Brancaster Drive.

3.1.2 Existing culverts were modelled with assumed dimensions at locations where there was a possibility that a culvert would have an effect on the sizing of the Proposed Scheme crossing or if the impact from the Proposed Scheme crossing would be affected by the presence of the culvert. This approach was based on engineering judgment and was subsequently tested by inspecting the model results. Sensitivity tests were undertaken for the assumed culvert dimensions at those locations where the size of the Proposed Scheme crossing could be affected or if the outcome of the impact assessment could be affected.

3.1.3 Culvert dimensions were assumed based on engineering judgment from the Digital Terrain Model (DTM) and aerial photography.

3.1.4 The baseline and Proposed Scheme models include the existing A580 East Lancashire Road culvert as a 1D structure.

3.1.5 The 2D model domain has been extended sufficiently upstream and downstream to ensure the catchment of Carr Brook is captured, and to ensure that any effects caused by the model boundary do not affect water levels in the area of the Proposed Scheme.

3.1.6 High resolution 0.2m to 1m LiDAR data has been used to define the channel and to take account of the watercourse capacity and conveyance in the 2D model domain. In the absence of 1D survey data for the channel and the existing culvert to the rear of Brancaster Drive, this approach is considered to be sufficiently conservative for this stage of the design as the modelled channel has lower capacity than the actual channel. This leads to an underestimate of peak flows at the crossing but higher modelled peak water levels, as well as an overestimation of out of bank flows. The latter leading to a more conservative assessment of replacement flood storage requirements.

3.2 Software

3.2.1 Infoworks Integrated Catchment model (ICM) (version 4.0.3.8010) has been used. This software is in line with standard practice to use the latest available build at the time modelling commenced, while Infoworks ICM is industry standard software.

3.3 Topographic survey

3.3.1 No additional topographic survey was commissioned for this study but will be required at a future stage.

3.4 Input data

3.4.1 The elevation data for the study area were produced using 0.2m LiDAR DTM flown specifically for HS2 Ltd. Where required, additional 1m grid LiDAR DTM data provided by the Environment Agency were used in areas further away from the proposed crossings, to provide full coverage of the 2D model domain.

4 Technical method and implementation

4.1 Hydrological assessment

4.1.1 No flow records are available for Carr Brook. Given the small catchment size (0.66km^2) at the Proposed Scheme crossing, a surface water modelling approach has been adopted. Direct net rainfall is applied to a 2D domain (the 2D domain covers an area larger than the catchment) and surface runoff is routed towards the downstream model boundary. A fixed runoff-coefficient of 0.4 (40% on applied rainfall) has been applied to represent infiltration losses as a reasonable estimate given the nature of the soils in the catchment.

4.1.2 The critical ReFH2 summer storm duration of 6.5hr for the catchment upstream of the proposed crossing has been used for estimating the rainfall hyetographs. A summer profile has been adopted throughout the Proposed Scheme at this early stage in scheme development, as it results in conservative water level estimates in urbanised areas.

4.1.3 A hydrological verification has been undertaken by estimating catchment hydrology ReFH2 peak flow estimates at the proposed crossing locations. This was to check that the surface water modelled peak flows are similar, or greater, than the ReFH2 flow estimates. ReFH2 flow calculations are based on relevant catchment descriptors, that were obtained from the FEH Web Service database.

4.1.4 Table 1 shows the peak flows derived from the surface water modelling with Infoworks ICM at the proposed crossing and their comparison with the ReFH2 peak flow estimates.

Table 1: Peak flows at the Carr Brook crossing

AEP	Return period	Peak flow (m^3/s)	
		Modelled	ReFH2
5.0%	20 year	0.44	0.90
1.0%	100 year	0.75	1.36
1.0 + CC (40%)	100 year + CC (40%)	1.62	1.90
0.1%	1,000 year	2.36	2.42

4.1.5 It is concluded that the adopted surface modelling approach is less conservative than the estimates from the ReFH2 and therefore the ReFH2 estimates have been used for sizing the aqueduct As this assessment is precautionary, further hydrological assessment will be undertaken during design development to improve the accuracy of the peak flow estimate for Carr Brook.

4.2 Hydraulic model build – baseline model

4.2.1 Figure 3 shows the existing and proposed model schematic.

1D representation

4.2.2 The existing culvert under the A580 East Lancashire Road has been modelled in 1D as a 0.9m circular culvert, based on inspection of LiDAR data and aerial imagery. The dimensions will need to be confirmed during design development. The existing culvert at the rear of properties on Brancaster Drive has not been modelled in the baseline or Proposed Scheme model as no 1D survey was available. Instead, 0.2m to 1m LiDAR data has been used to define the channel and to take account of the watercourse capacity and conveyance in the 2D model domain. As detailed in Section 3.1, this gives a sufficiently conservative estimate of peak flood levels and flood extents to assess the potential impact of the Proposed Scheme and the volume of replacement flood storage provided on a precautionary basis.

2D representation

4.2.3 The element size of the model was varying where maximum triangle area was set to $20m^2$ and minimum element area was set to $15m^2$. Element size and alignment for the 2D model mesh were optimised to ensure appropriate representation of the flow pathways whilst maintaining reasonable run times.

Inflow boundaries

4.2.4 There are no inflow boundaries in the model as direct rainfall has been applied over the 2D domain.

Downstream boundary

4.2.5 Unrestricted flow out of the 2D domain has been set based on inspection of the LiDAR and mapping along the 2D domain boundary, that indicates that flood waters cannot backup and impact on the zone of influence.

Key structures

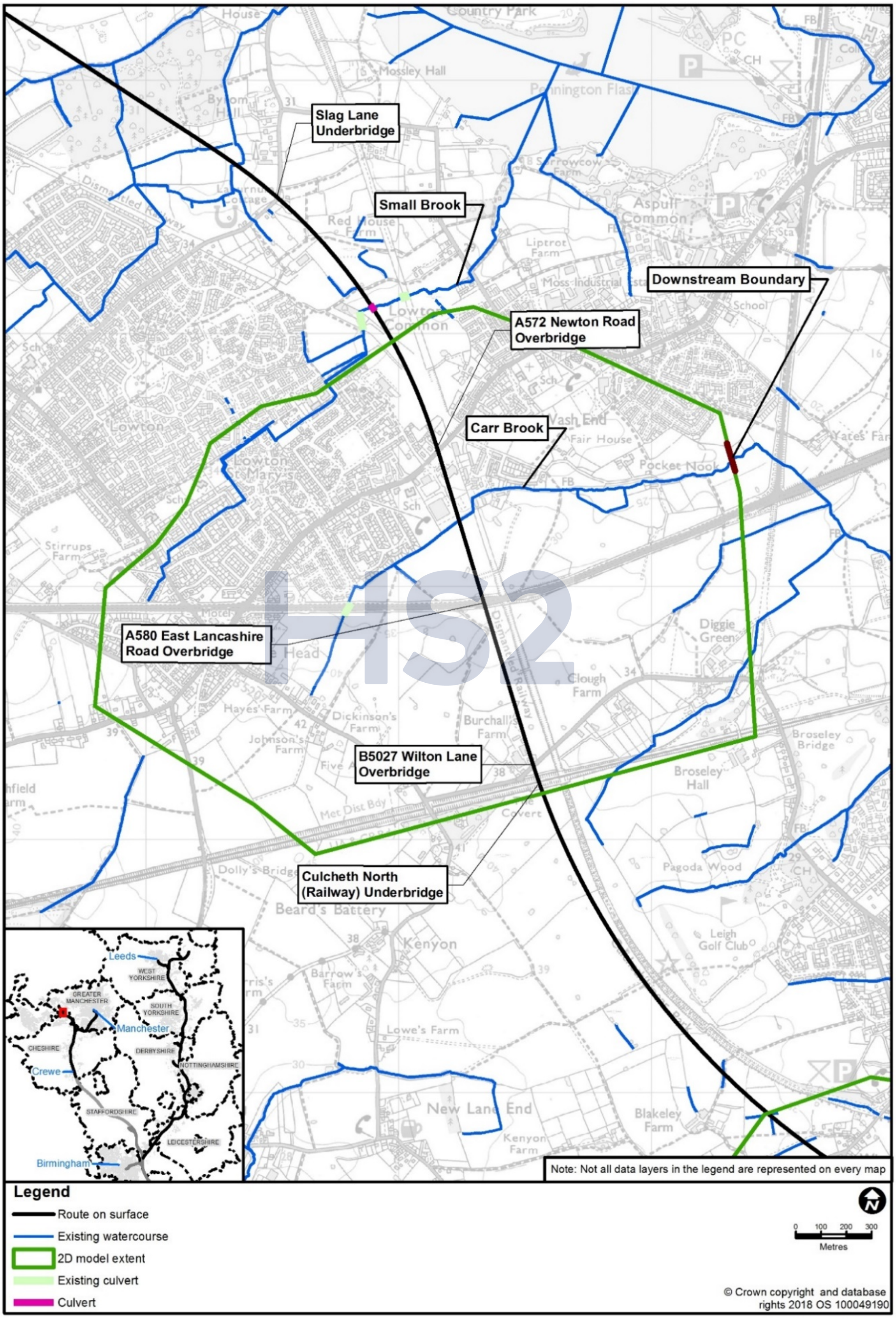
4.2.6 The review of the model impact on peak flood depths in Figures 4 and 5 indicates that there are no key structures where the size of the Proposed Scheme crossing could be affected or where the outcome of the impact assessment could be affected. This is the case because the only location where there is a major increase in peak flood depth is caused by the Proposed Scheme cutting.

4.2.7 Modelled structures and their dimensions are shown in Table 2. The culvert sizes are not based on visual inspections or survey. However, they are considered reasonable when compared to the size of the channel cross sections (assumed from LiDAR and aerial photography).

Table 2: Modelled structures within the modelled extent

Structure reference	Structure description	Modelling representation and justification
Culvert under the A580 East Lancashire Road	0.9m diameter	Culvert modelled as a circular pipe dimension assumed from LiDAR and aerial photography

Figure 3: Model schematic



Roughness

4.2.8 Roughness is represented by Manning's n, selected based on Ordnance Survey (OS) Mastermap data and aerial photography in line with the recommended values stated within Chow, 1959[10].

4.3 Hydraulic model build – Proposed Scheme

4.3.1 The Proposed Scheme model has been edited from the baseline to include the following design elements.

Culverts

4.3.2 Culverts in the baseline model have been kept in the Proposed Scheme model.

Aqueduct

4.3.3 The proposed aqueduct has been modelled as a rectangular 2.9m wide and 1.5m high channel.

Topographic changes

4.3.4 The Proposed Scheme cutting has been modelled as a void with an impermeable wall preventing flood waters from entering the cutting of the Proposed Scheme, further details are shown in the Volume 2, Map Books: maps CT-06-322b.

Channel realignments and diversions

4.3.5 Upstream of the Proposed Scheme crossing, cut-off ditches have been included in the 2D domain to direct overland runoff towards the inlet of the aqueduct. There is a watercourse realignment immediately downstream of the Proposed Scheme crossing. This realignment comprises a naturalised channel running to the south of the Brancaster Drive residential estate. The culverted section of Carr Brook running at the rear of properties on Brancaster Drive will remain in place and receive baseflows. Flood flows will be diverted down the new channel realignment, reducing the risk of flooding at the Brancaster Drive residential estate properties.

4.3.6 Flood extents have been derived using the direct output option available in Infoworks ICM, producing maximum flood depth and stage. The outputs have undergone a Proposed Scheme minus baseline calculation. The resulting layer was converted to polygons and cleaned to remove all bow ties (where two polygons overlap) and any dry islands that are

[10] Chow, V.T. (1959), *Open-channel hydraulics,* McGraw-Hill, New York.

less than $50m^2$. The differences were mapped to indicate the potential impacts of the Proposed Scheme.

Modelling assumptions made

4.3.7 LiDAR described in Section 3.1 is assumed to be correct.

4.3.8 A 2D modelling approach is assumed to be sufficient for estimating the 5.0%, 1.0% and 0.1% AEP events.

4.3.9 Existing hydraulic structures are assumed to be drowned out in large flood events (5.0%, 1.0% and 0.1% AEP events) and therefore will not impact on the hydraulics of the return periods assessed.

4.3.10 The dimensions of the existing A580 East Lancashire Road culvert are assumed from LiDAR data and aerial imagery.

4.4 Climate change

4.4.1 The climate change allowance for Carr Brook is a 40% increase in input peak rainfall intensity as the catchment is less than $5km^2$ in size[11].

4.4.2 The H++ allowance for Carr Brook is a 60% increase in input peak rainfall intensity, and this has been used for the purpose of sensitivity analysis.

[11] Environment Agency (2021), *Flood risk assessments: climate change allowances*. Available online at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

5 Model results

5.1.1 The model has been run for the 5.0%, 1.0%, 1.0%+CC and 0.1% AEPs. The 1.0% AEP + CC simulation is based on a 40% increase in peak rainfall intensity.

5.1.2 The water level difference has been mapped for 5.0% AEP and 1.0% AEP + CC. These flood maps are included in Annex A.

5.1.3 The modelled flood extents with and without the Proposed Scheme for the 1.0% AEP + CC events and the 5.0% AEP are presented in the Volume 5, Water resources and flood risk Map Book: maps WR-05-317 and WR-06-317 respectively.

5.1.4 The modelled impact of the Proposed Scheme, without mitigation, on peak flood levels indicates the potential for a decrease in peak flood levels of up to 170mm in the vicinity of the Proposed Scheme crossing. This reduction in peak flood levels is due to the realigned channel to the rear of the properties at Brancaster Drive which provides increased flood conveyance capacity.

5.1.5 This crossing is on an aqueduct above the Proposed Scheme therefore, a freeboard allowance is not applicable.

6 Model proving

6.1 Run performance

6.1.1 The time step used was 30 seconds. The total mass error is within +/-1.0% for all model runs undertaken.

6.2 Calibration and verification

6.2.1 There is no river (flow or level) gauge situated within an appropriate distance of this location to provide calibration or verification data.

6.3 Validation

6.3.1 Flood extents generated for this study are similar to those shown on the Environment Agency RoFSW for the 1.0% and the 0.1% AEP events.

6.4 Sensitivity analysis

6.4.1 Analysis was undertaken to assess the sensitivity of the 1.0% AEP + CC Proposed Scheme model outputs to the following scenarios:

- use of H++ climate change scenario of 60%;
- increase in roughness (channel, structures and floodplain) (Manning's n) by 20%; and
- decrease in roughness (channel, structures and floodplain) (Manning's n) by 20%.

6.4.2 Sensitivity tests have not been undertaken for the downstream boundary normal depth slope at this stage, as the model is only 2D and has been extended sufficiently downstream to ensure that there is no effect at the Proposed Scheme crossing. These tests will be undertaken once the models are fully converted to 1D-2D during design development.

6.4.3 Sensitivity tests indicate that the Proposed Scheme hydraulic design is not unduly sensitive to changes in key input parameters. In all cases, changes in peak water levels are less than 100mm.

6.5 Blockage analysis

6.5.1 Blockage of 50% at the proposed crossing was simulated by reducing the width of the crossing by half. The blockage scenario results were compared to the 0.1% AEP results for the Proposed Scheme model. This comparison indicated that there was no increase in peak water levels upstream or at the crossing of Carr Brook.

6.5.2 This crossing is on an aqueduct above the Proposed Scheme, therefore a freeboard of a minimum of 1m to the Proposed Scheme rail track in a 0.1% AEP event is not applicable.

6.6 Run parameters

6.6.1 There is no deviation from default run parameters recommended in Infoworks ICM for all model runs.

7 Limitations

7.1.1 Land access for new topographic survey was not possible and so the model was built using available LiDAR information supplemented by Mastermap and OS map data.

7.1.2 All channels have been represented in 2D as the 200mm LiDAR data captures the channel depression. Channel conveyance will therefore not be fully represented in the model. This is likely to have resulted in a conservatively high estimate of peak flood levels.

7.1.3 The model does not include the existing culvert at the rear of properties on Brancaster Drive as there is no data on this culvert.

7.1.4 Calibration was not possible due to a lack of available historical data.

8 Conclusions and recommendations

8.1.1 The model results indicate that there is no increase in peak flood levels from construction of the Proposed Scheme, without mitigation, in the immediate vicinity of the Proposed Scheme. The model results show a decrease of approximately 170mm at the Proposed Scheme crossing and a reduction in flood risk to properties along Brancaster Drive.

8.1.2 Blockage and sensitivity analyses indicate that the results are not unduly sensitive to changes in key input variables.

8.1.3 During design development, the hydraulic modelling of the watercourse should be revisited. Topographic survey data of the channel and structures should be collected and used to extend the model to cover the full modelled extent reported in this document. The updated model should be used to develop the detailed hydraulic design of the Proposed Scheme with a view to reducing impacts in peak flood levels as far as is reasonably practicable. The model should also be used to verify the magnitude of residual impacts (if any) of the final scheme design, for consenting purposes.

Annex A: Flood level impact maps

The water level difference has been mapped for 5.0% AEP and 1.0% AEP +CC events see Figure A 1 and Figure A 2.

Figure A 1: Carr Brook impact map for 5.0% AEP (1 in 20 year)

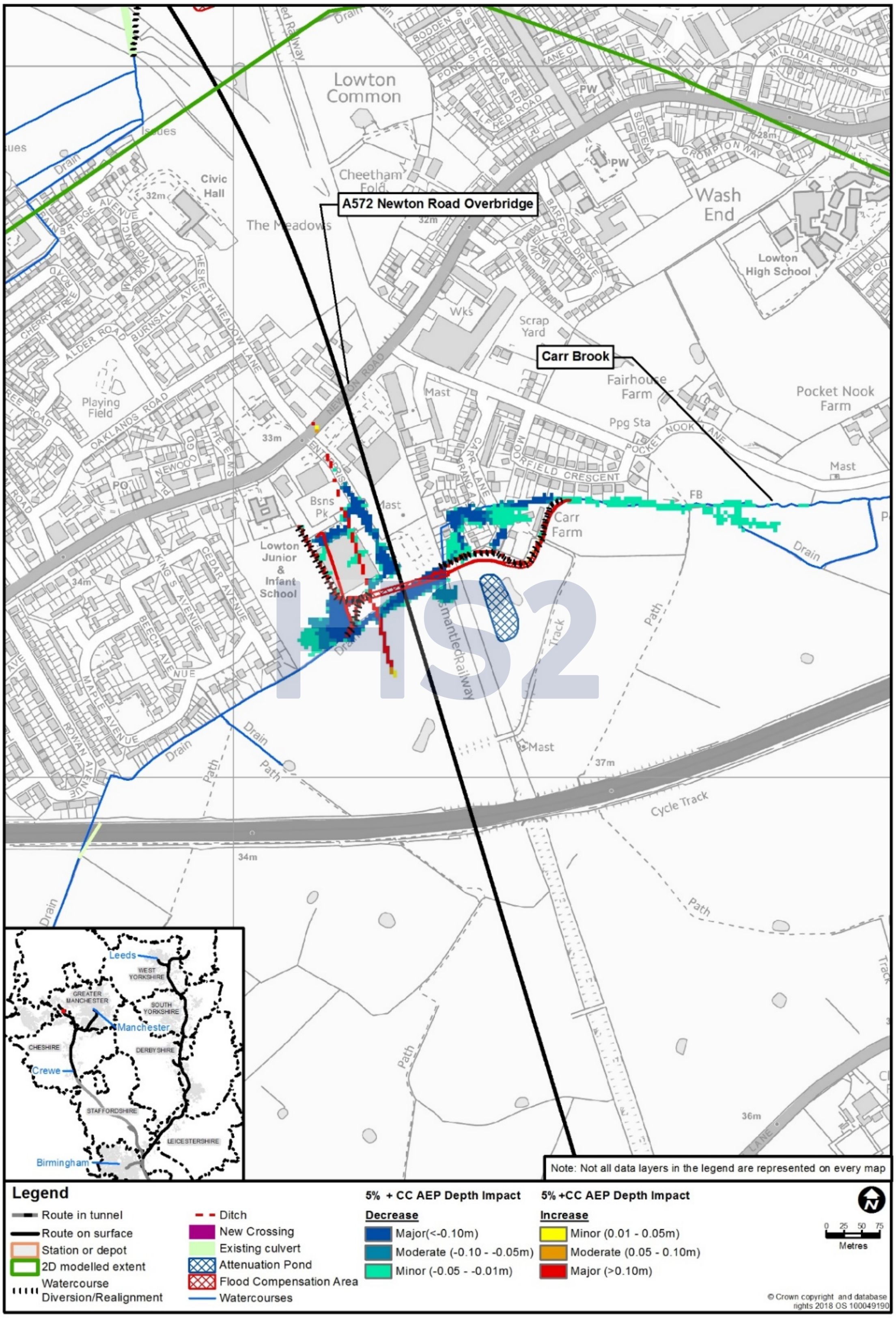
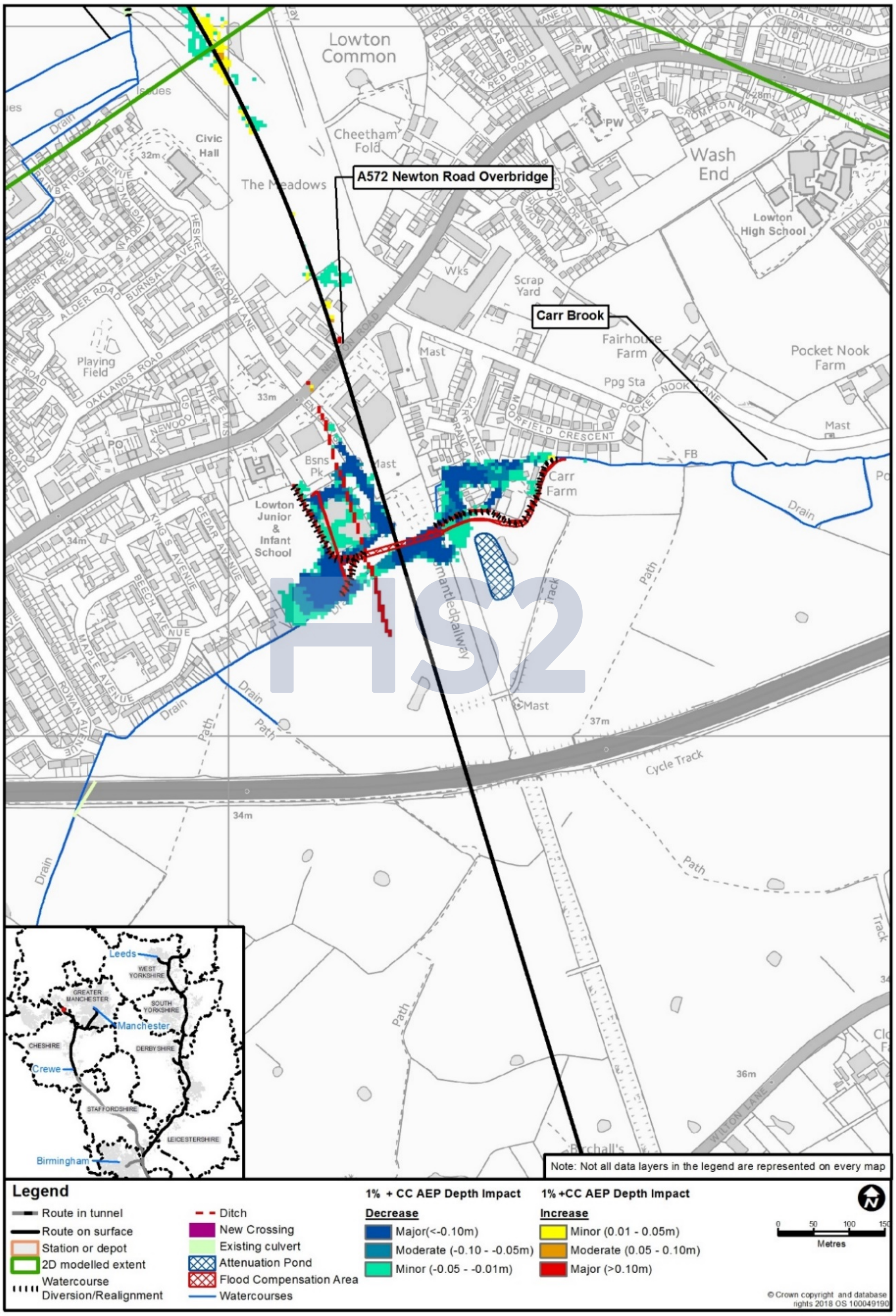


Figure A 2: Carr Brook impact map for 1.0% AEP + CC (1 in 100 year plus climate change)



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High Speed Two (HS2) Limited
Two Snowhill
Snow Hill Queensway
Birmingham B4 6GA
Freephone: 08081 434 434
Minicom: 08081 456 472
Email: HS2enquiries@hs2.org.uk