In Parliament – Session 2022 - 2023

HS2

High Speed Rail (Crewe – Manchester)

Supplementary Environmental Statement 2 and Additional Provision 2 Environmental Statement

Volume 5: Appendix WR-006-00011

Water resources and flood risk

Hydraulic modelling report – River Bollin

S123

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Water resources and flood risk

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Department for Transport

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1 Introduction

1.1 Background

1.1.1 This report is an appendix to the water resources and flood risk assessment which forms part of Volume 5 of the Supplementary Environmental Statement 2 (SES2) and Additional Provision 2 Environmental Statement (AP2 ES).

1.1.2 This appendix provides details of changes to the water resources and flood risk assessment since the production of the High Speed Two (HS2) High Speed Rail (Crewe – Manchester) Environmental Statement (ES) published in 2022[1] (the main ES), and the Supplementary Environmental Statement 1 (SES1) and Additional Provision 1 Environmental Statement (AP1 ES) also published in 2022[2].

1.1.3 This appendix presents the results of the hydraulic modelling carried out for the River Bollin, a tributary of the River Mersey. The River Bollin runs through the Hulseheath to Manchester Airport (MA06) community area.

1.1.4 This appendix should be read in conjunction with the SES2 and AP2 ES:

- Volume 2, Community Area reports;
- Volume 3, Route-wide effects; and
- Volume 5, Appendices.

1.1.5 The hydraulic modelling has been used to inform the flood risk assessment for the Hulseheath to Manchester Airport area (MA06), see SES2 and AP2 ES Volume 5, Appendix: WR-005-0MA06. The Tributaries of Birkin Brook hydraulic modelling report (SES2 and AP2 ES Volume 5, Appendix: WR-006-00010) is also relevant to the Hulseheath to Manchester Airport area (MA06).

1.1.6 For the Hulseheath to Manchester Airport (MA06) area, the SES2 and AP2 ES Volume 5, Appendix: WR-003-0MA06, Water resources assessment should also be referred to. Additional information is included in Background Information and Data (BID) WR-004-0MA06 SES2 and AP2 ES, Water resources assessment baseline data[3].

[1] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Environmental Statement.* Available online at: https://www.gov.uk/government/collections/hs2-phase2b-crewe-manchester-environmental-statement.

[2] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Supplementary Environmental Statement 1 and Additional Provision 1 Environmental Statement*. Available online at: https://www.gov.uk/government/collections/hs2-phase-2b-crewe-manchester-supplementary-environmental-statement-1-and-additional-provision-1-environmental-statement.

[3] High Speed Two Ltd (2023), High Speed Rail (Crewe – Manchester), *Background Information and Data accompanying Supplementary Environmental Statement 2 and Additional Provision 2 Environmental*

1.1.7 The AP2 amendment of relevance to this report is Additional land permanently required to reconfigure M56 Junction 6 (AP2-006-014).

1.1.8 In order to differentiate between the original scheme and the subsequent changes, the following terms are used:

- 'the original scheme' – the Bill scheme submitted to Parliament in 2022, which was assessed in the main ES;
- 'the SES1 scheme' – the original scheme with any changes described in SES1 that are within the existing powers of the Bill;
- 'the AP1 revised scheme' – the original scheme as amended by SES1 changes and AP1 amendments;
- 'the SES2 scheme' – the original scheme with any changes described in SES1 (submitted in July 2022) and the SES2; and
- 'the AP2 revised scheme' – the original scheme as amended by SES1 and SES2 changes (as relevant) and AP2 amendments.

1.2 Aims

1.2.1 The aim of this study was to develop a hydraulic model of a section of the River Bollin to simulate peak flood levels, without and with the AP2 revised scheme. The relevant changes in the reconfiguration of M56 junction 6 (AP2-006-014) are an upstream and downstream extension of the existing M56 River Bollin underbridge due to the widening of the M56. The HS2 route also crosses the River Bollin on a viaduct. This report also aims to document the methods used, the results, assumptions and limitations.

1.2.2 The hydraulic model has informed the preliminary design of the amendment additional land permanently required for the reconfiguration of M56 junction 6 (AP2-006-014), with the specific objectives of ensuring that the design of hydraulic structures (e.g. viaducts, bridges and culverts) takes account of flood risk issues. The methodology is as detailed in the Water resources and flood risk technical note, Updated guidance on flood risk assessment (see SES2 and AP2 ES Volume 5, Appendix: CT-001-00005)[4].

Statement, Water resources assessment baseline data, BID WR-004-0MA06. Available online at: https://www.gov.uk/government/collections/hs2-phase-2b-crewe-manchester-supplementary-environmental-statement-2-and-additional-provision-2-environmental-statement.

[4] High Speed Two Ltd (2023), High Speed Rail (Crewe – Manchester), *Supplementary Environmental Statement 2 and Additional Provision 2 Environmental Statement*, *Environmental Impact Assessment Scope and Methodology Report Part 3: Flood risk Technical note – Water resources and flood risk – flood risk*, Volume 5, Appendix CT-001-00005. Available online at: https://www.gov.uk/government/collections/hs2-phase-2b-crewe-manchester-supplementary-environmental-statement-2-and-additional-provision-2-environmental-statement.

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 M56 River Bollin underbridge extension and at the HS2 route crossing location, associated with the following Annual Exceedance Probabilities (AEP): 5.0% AEP, 1.0% AEP + climate change (CC), and 0.1% AEP; 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 AP2 amendment.

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 M56 River Bollin underbridge extension and the HS2 route crossing location on peak flood levels and the sensitivity of nearby receptors to flooding.

1.4.2 The River Bollin is a main river at the proposed M56 River Bollin underbridge extension and the upstream HS2 route crossing location. The Environment Agency confirmed that a hydraulic model is not available for this reach of the River Bollin.

1.4.3 A combination of direct rainfall and an inflow boundary have been applied in a 2D hydraulic model. Direct rainfall has been applied in the vicinity of the M56 River Bollin underbridge extension and the HS2 route crossing. Input rainfall hyetographs have been derived using the Revitalised Flood Hydrograph 2 (ReFH2) software. Due to the large size of the catchment of 144.8km^2 (refer to Figure 3), an inflow boundary has been applied on the River Bollin. The inflow boundary is located at the upstream end of the 2D model domain, notably 2km upstream of the HS2 route crossing and 1.5km upstream of the M56 River Bollin underbridge extension.

1.5 Scope

1.5.1 The scope of the study was to undertake detailed hydraulic modelling to enable assessment of the impact of the M56 River Bollin underbridge extension and the HS2 route crossing on the local environment. The model aimed to be detailed enough to allow assessment of different options for the crossing locations, to allow the management of flood risk and correct sizing of crossing structures.

1.5.2 This report focuses on a 4.5km reach of the River Bollin, extending upstream and downstream of the proposed M56 River Bollin underbridge extension and the HS2 route crossing. 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)[5];
- risk of flooding from surface water (RoFSW)[6] map; and
- flood defence asset information.

2.1.2 Additional information from the lead local flood authority and publicly available sources included:

- Trafford Metropolitan Borough Council Preliminary Flood Risk Assessment (PFRA) (2017)[7];
- Manchester City Council (MCC) PFRA[8];
- Manchester City, Salford City and Trafford Councils Hybrid Strategic Flood Risk Assessment (SFRA) (2008)[9];
- MCC Local Flood Risk Management Strategy[10]; and
- Trafford Metropolitan Borough Council Local Flood Risk Management Strategy (2017)[11.]

2.2 Description of the study area

Study area

2.2.1 Figure 1 shows the modelled 4.0km long reach of the River Bollin in the study area, along with the Environment Agency surface water flood mapping[3]. The upstream boundary is located to the south of Mill Lane approximately 2.5km upstream of the existing M56 River

[5] Environment Agency (2023), *Flood map for planning.* Available online at: https://flood-map-for-planning.service.gov.uk.
[6] Environment Agency (2023), *Long-term flood risk information.* Available online at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map.
[7] JBA Consulting (2011), *Trafford Council Preliminary Flood Risk Assessment.* Available online at: https://webarchive.nationalarchives.gov.uk/20140328094439/http://www.environment-agency.gov.uk/research/planning/135532.aspx.
[8] JBA Consulting (2011), *Manchester City Council Preliminary Flood Risk Assessment.* Available online at: https://www.manchester.gov.uk/egov_downloads/MCC_PFRA.pdf.
[9] JBA Consulting (2010), *Manchester City, Salford City and Trafford Councils Level 2 Hybrid Strategic Flood Risk Assessment.* Available online at: https://www.trafford.gov.uk/planning/strategic-planning/docs/manchester-salford-and-trafford-councils-level-2-hybrid-sfra-level-1-sfra-march-2011.pdf.
[10] Manchester City Council (2014), *Manchester City Council Local Flood Risk Management Strategy.* Available online at: https://secure.manchester.gov.uk/downloads/download/5603/lfrms_documents.
[11] Trafford Council (2014), *Trafford Local Flood Risk Management Strategy.* Available online at: https://www.trafford.gov.uk/planning/strategic-planning/docs/lfrms-trafford-final-2014.pdf.

Bollin underbridge. The downstream boundary is located approximately 1.5km downstream of the existing M56 River Bollin underbridge, just off Rossmill Lane.

2.2.2 The primary hydraulic control on the River Bollin is the existing M56 River Bollin underbridge.

Hydrological description

2.2.3 The River Bollin originates to the west of the outfall of the Bottoms and the Teggsnose Reservoirs, immediately to the east of Langley, Macclesfield. Figure 2 shows the 144.8km^2 catchment of the River Bollin.

2.2.4 There are no gauging stations present immediately in the vicinity of the model domain. However, there are two gauging stations on the River Bollin. The first is located approximately 10km upstream of the study area (River Bollin at Wilmslow (Environment Agency gauging station number 69012) with a 72.5km^2 catchment area). The second is located approximately 10km downstream from the reconfiguration of M56 junction 6 (AP-006-014) (River Bollin at Dunham Massey (Environment Agency gauging station number 69006) with a 257.6km^2 catchment area).

2.2.5 Standard annual average rainfall catchment descriptor from the FEH Web Service, at the model downstream catchment boundary is 929mm.

Figure 1: Study area and Environment Agency flood zones at River Bollin

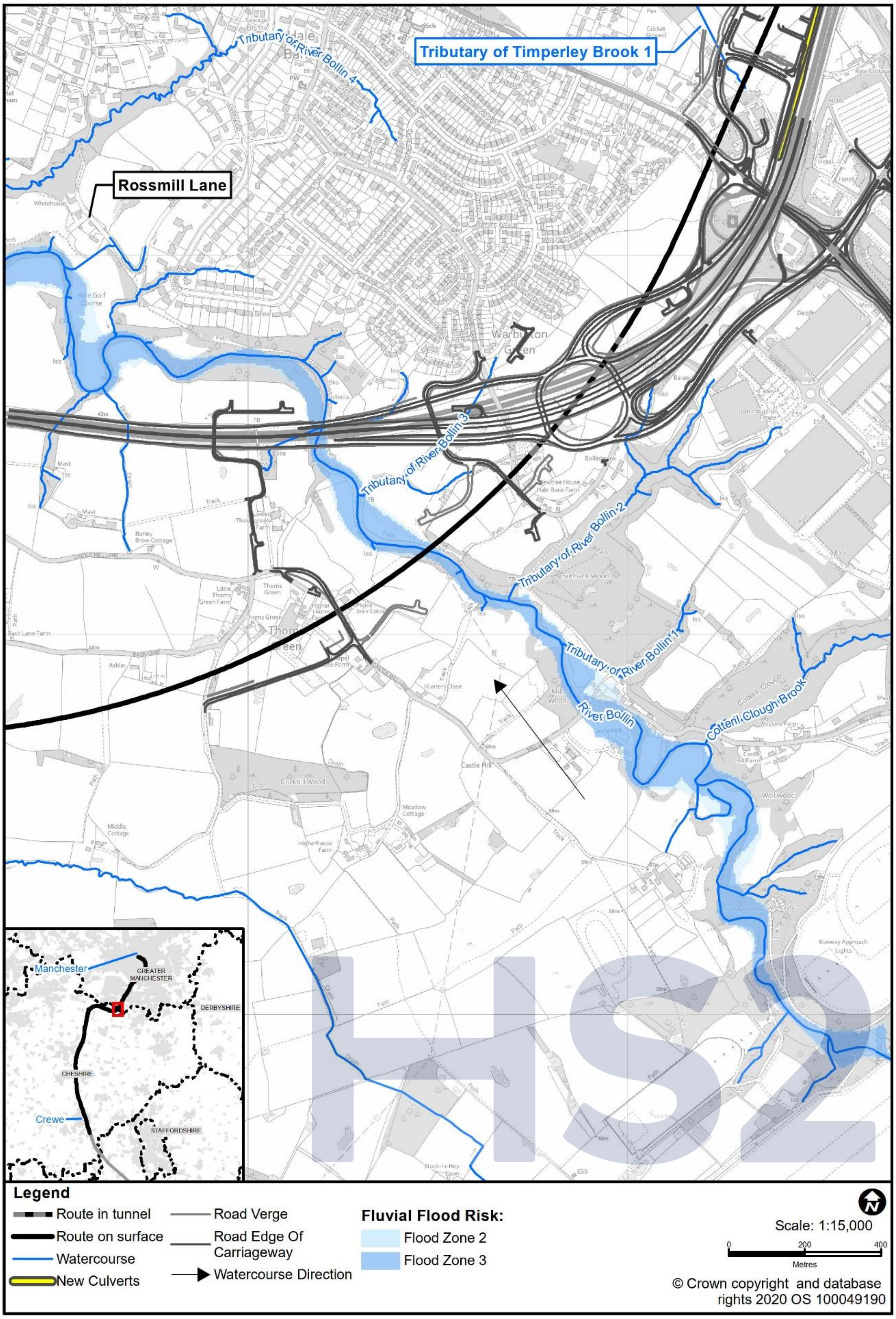
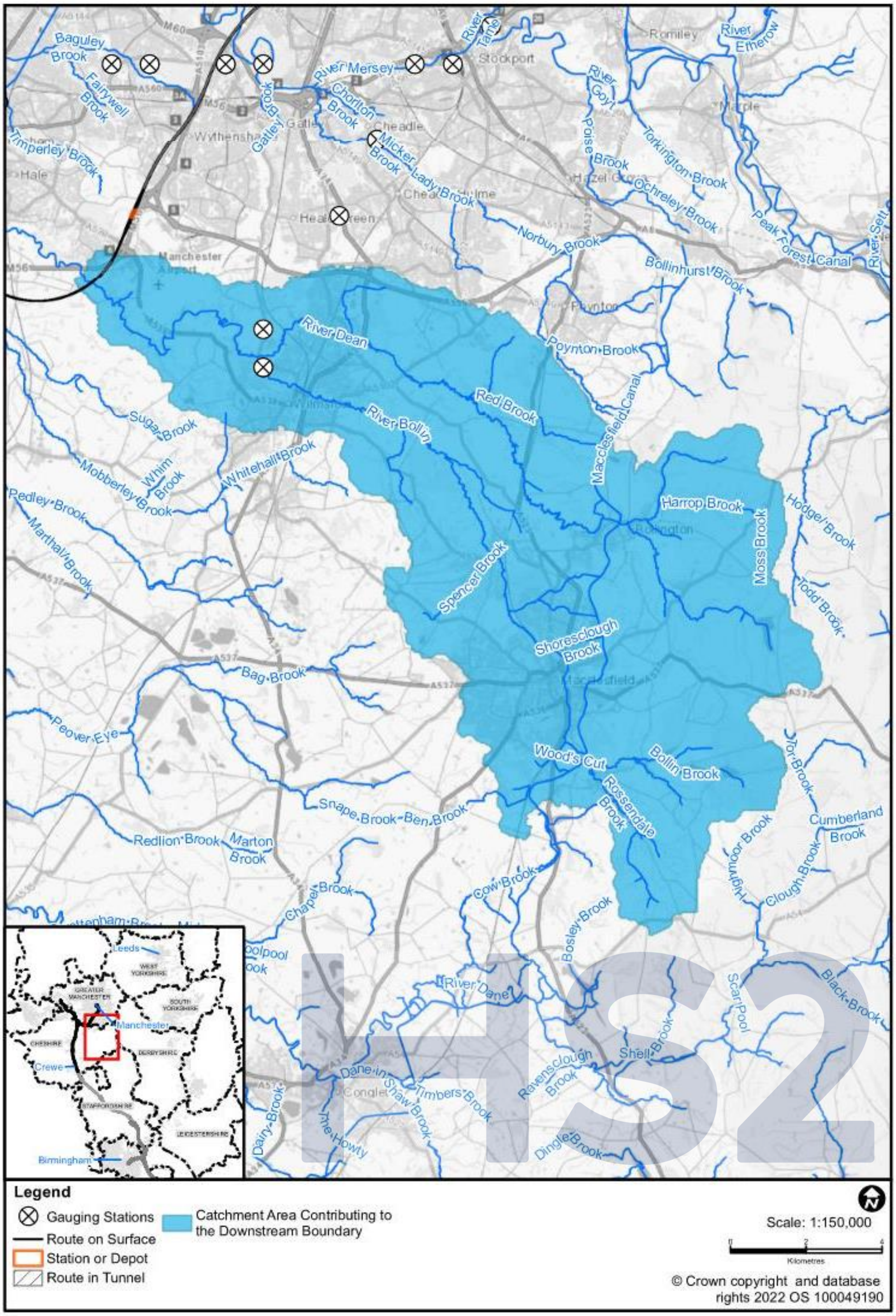


Figure 2: River Bollin catchment area



AP2 revised scheme

2.2.6 The HS2 route crosses the River Bollin 412m to the south-east of the reconfiguration of M56 junction 6 (AP2-006-014) (which includes the M56 River Bollin underbridge extension). In the reconfiguration of M56 junction 6 (AP2-006-014) the M56 will be realigned up to 30m to the south for a length of 2.5km and junction 6 will be reconfigured with the introduction of a new six-arm gyratory located 600m to the south-west of the existing junction 6. Other works will include the introduction of a direct link to the Manchester Airport High Speed station, a direct link to the A538 Wilmslow Road, and the construction of overbridges to accommodate the reconfigured junction.

2.2.7 The location of the reconfigured junction will require the extension of the existing M56 River Bollin underbridge. The bridge will be extended on both sides of the carriageway to accommodate the M56 junction 6 northbound exit slip road and the M56 junction 6 westbound access slip road.

2.2.8 The reconfiguration of M56 junction 6 (AP2-006-014) will require the realignment of existing watercourses and introduction of new culverts on tributaries of the River Bollin 2, 3, 4 and 5, Drains of M56 1 and 2 and Tributary of Timperley Brook 1.

2.2.9 Further details on the AP2 revised scheme can be found in SES2 and AP2 ES Volume 2, MA06 Map Book: Map Series CT-06 – Proposed Scheme, maps CT-06-354-L1, CT-06-355, CT-06-355-L1, CT-06-356, CT-06-356-L1, CT-06-356-R1 and CT-06-357a.

Features of note

2.2.10 The existing M56 River Bollin underbridge has an opening with a width of 11m (taken from the as-built design layout with drawing reference number. M56D/80/08/18). The soffit level of the structure was found to be many metres above the maximum water level predicted from the model for the most extreme flood event. Therefore, it was not necessary to include the soffit of the culvert in the model (modelled as walls separated by 11m distance).

2.2.11 Several tributaries are present within the modelled study area. These are Cotterill Clough Brook, Tributary of River Bollin 1, Tributary of River Bollin 2 and Tributary of River Bollin 3 located upstream of the M56 River Bollin underbridge extension.

2.2.12 Tributary of River Bollin 4 and Tributary of River Bollin 5 are located immediately downstream of the M56 River Bollin underbridge extension. Based on available Environment Agency watercourse data, tributaries of River Bollin 4 and 5 are culverted watercourses at the point of confluence with the River Bollin.

2.3 Existing understanding of flood risk

Flood mechanisms

2.3.1 The Environment Agency flood zones (shown in Figure 1) follow the alignment of the River Bollin, except for an area located approximately 30m downstream of the M56 River Bollin underbridge extension. The Environment Agency's risk of flooding from surface water (RoFSW) dataset shows smaller flood extent than the flood zones along this river reach.

2.3.2 The Environment Agency's flood zones do not include the tributaries of the River Bollin within the study area. The tributaries of the River Bollin are located in deep steep sided valleys, as evidenced by the small flood extents shown in the RoFSW dataset.

2.3.3 Environment Agency's online 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 flooding from the River Bollin has been identified from the local SFRA or PFRA and there are no relevant Section 19 flood investigation reports[12].

Availability of existing hydraulic models

2.3.5 Available information, which includes information from the Environment Agency, does not indicate the existence of river flooding hydraulic models for the River Bollin in this area.

2.4 Site visit

2.4.1 At this stage no site survey or site visit was required to inform the proposed hydraulic analysis. When the hydraulic model is updated at the detailed design stage, in accordance with HS2 Ltd requirements, a site visit will be undertaken by a hydraulic modeller for the preparation of a topographic survey specification.

[12] 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 lead local flood authority 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 the River Bollin study area as no 1D channel survey data was available.

3.1.2 The existing M56 River Bollin underbridge was modelled using wall line features in Infoworks Integrated Catchment Model (ICM) to create a narrowing of the natural river through the entire length of the structure. This approach enables the representation in the model of a reduced flow area through the structure. A width of 11m was modelled as the minimum width value between the toes of the structure abutments (taken from the as built structure drawing). The 2D model domain has been extended sufficiently upstream and downstream to ensure that any effects caused by the model boundary do not affect water levels in the area of the reconfiguration of M56 junction 6 (AP2-006-014) or the HS2 route viaduct.

3.1.3 High resolution 0.5m and 1m Light Detection And Ranging (LiDAR) data has been used to define the channel and to take account of the watercourse capacity and conveyance in the 2D model domain. This potentially results in reduced modelled channel capacity and underestimated peak flows at the crossing. However, it also results in higher modelled peak water levels, as well as overestimation of out-of-bank flooding. Therefore, this is a conservative approach which is considered sufficient for this design stage of the crossing and for the impact assessment to receptors.

3.2 Software

3.2.1 Infoworks Integrated Catchment Model (ICM) (version 9.5.5.19020) has been used. The use of ICM is in line with standard practice to use the latest available build at the time modelling commenced, while 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 during design development to inform detailed design. This will include survey data to define the channel cross section and all key existing structures.

3.4 Input data

3.4.1 The elevation data for the study area were produced using the Environment Agency 0.5m and 1m grid LiDAR Digital Terrain Model.

4 Technical method and implementation

4.1 Hydrological assessment

4.1.1 The ReFH2 has been used to estimate the inflow hydrograph at the existing M56 River Bollin underbridge, based on the catchment descriptors obtained from the Flood Estimation Handbook (FEH) Web Service[13]. These estimates have then been conservatively applied to the upstream end of the model which is located approximately 2.5km upstream of the AP2 revised scheme.

4.1.2 The ReFH2 methodology has been checked by comparing the ReFH2 peak flows against the statistical method estimates, using as a donor site the downstream Dunham Massey gauging station.

4.1.3 Table 1 shows the peak flows obtained from the ReFH2 and the FEH Statistical Method at the M56 River Bollin underbridge.

Table 1: Peak flows at the River Bollin M56 River Bollin underbridge (baseline model)

AEP	Return period	ReFH2 peak flow (m^3/s)	FEH Statistical Method (m^3/s)
5.0%	20y	43.3	54.2
1.0%	100y	69.3	69.1
1.0% + CC (53%)	100y + CC (53%)	106	105.7
0.1%	1000y	110	89.2

4.1.4 The results indicate that the statistic method estimates are smaller than the ReFH2 for the 1 in 100 year + CC and the 1 in 1000 year events, although larger in the 1 in 20 year event. It is therefore confirmed that the use of the ReFH2 flow is a conservative approach for this stage in the design. As this assessment is precautionary, further hydrological assessment will be undertaken during design development to refine the understanding of the flood impacts.

4.2 Hydraulic model build - baseline model

4.2.1 Figure 3 shows the existing and proposed model schematic.

1D representation

4.2.2 A 1D element has been modelled for the M56 River Bollin underbridge.

[13] UK Centre for Ecology and Hydrology (2022), *Flood estimation handbook web service*. Available online at: https://fehweb.ceh.ac.uk/.

2D representation

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

Inflow boundaries

4.2.4 In the baseline and AP2 revised scheme models, the inflow boundary is approximately 2.5km upstream of the existing M56 River Bollin underbridge and 2km upstream of the HS2 viaduct.

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. This indicates that flood waters cannot backup and impact on the zone of influence. The downstream boundary location is 1.5km downstream of the existing M56 River Bollin underbridge.

Key structures

4.2.6 The existing M56 River Bollin underbridge has been modelled based on the sizes set out in the as-built design drawings of this structure provided by National Highways.

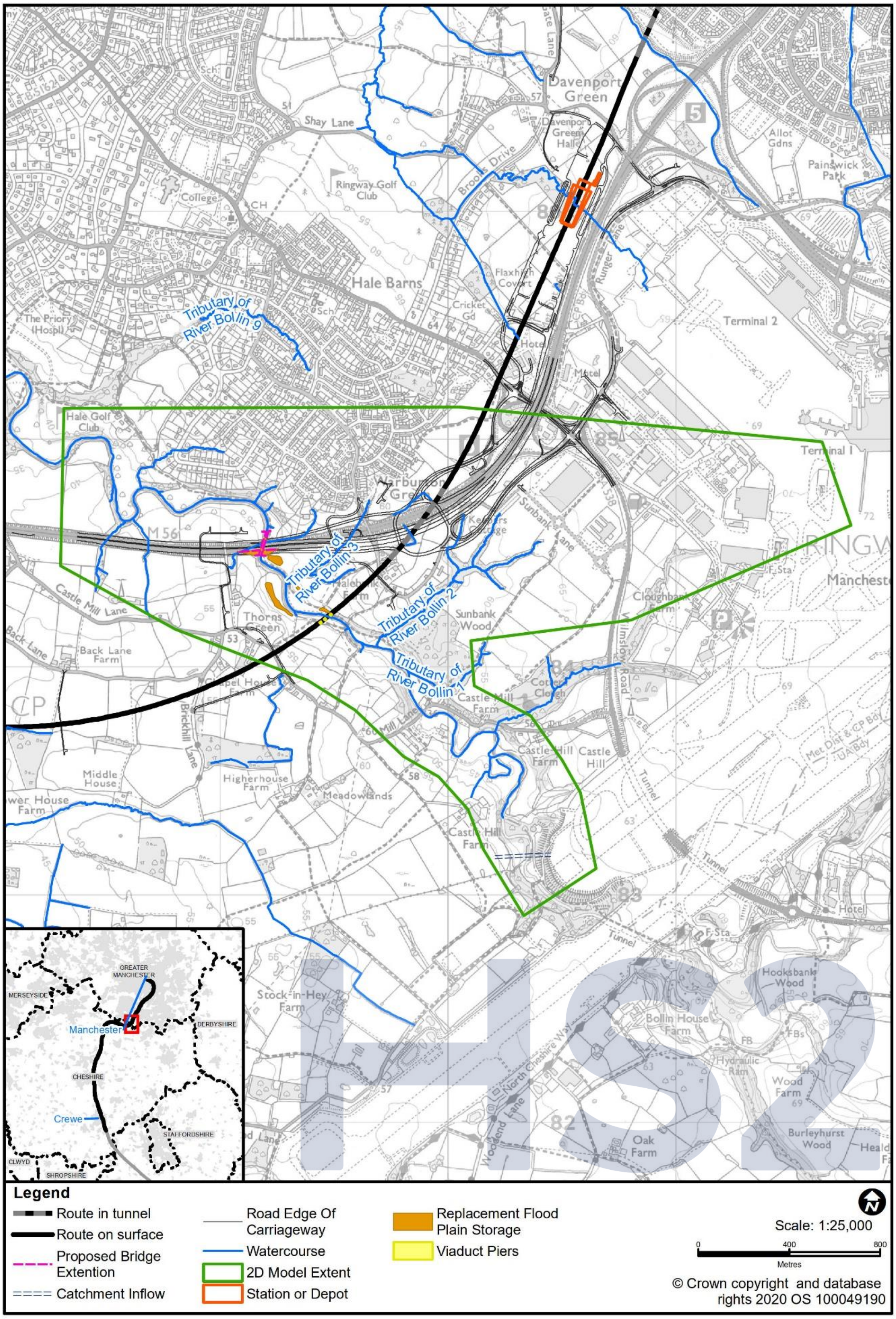
4.2.7 The Mill Lane bridge is located in the vicinity of the upstream end of the model. Due to its location, the Mill Lane bridge has been modelled as unrestricted flow. This bridge is composed of a large arched crossing across the entire river span. Due to its location at the upstream end of the model, there will be no significant influence on the modelled peak water levels at the HS2 scheme and M56 River Bollin underbridge.

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[14].

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

Figure 3: Model schematic



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4.3 Hydraulic model build – AP2 revised scheme

4.3.1 The AP2 revised scheme model has been edited from the baseline to include the following design elements.

Bridges

4.3.2 The reconfiguration of the M56 junction 6 (AP2-006-014) includes widening of the M56 River Bollin underbridge over the River Bollin. The bridge will be extended on both sides to allow for additional access lanes to the reconfigured junction.

Topographic changes

4.3.3 The proposed M56 River Bollin underbridge extension (AP2-006-014) has not only been modelled as wall extensions but by also raising the ground levels on both sides of the M56, based on the details shown in SES2 and AP2 ES Volume 2, MA06 Map Book: Map Series CT-06 – Proposed Scheme, map CT-06-356.

Viaduct

4.3.4 The soffit of the River Bollin east viaduct is at least 9m above the 0.1% AEP flood level. Therefore, only the piers have been modelled, as a physical (vertical) obstruction (via porous polygon feature and set as fully impermeable i.e. zero porosity) based on the most conservative footprint of their foundations and assuming piers of infinite height.

Channel realignments and diversions

4.3.5 The realignments and diversions of the tributaries of the River Bollin have not been modelled in 2D as these have been sized separately using manual hydraulic calculations. The design peak flows for the realignments and diversions have been obtained from a number of 2D flow lines in the baseline model. These 2D flow lines calculate the flows at a number of locations along each tributary.

Replacement floodplain storage areas

4.3.6 Replacement floodplain storage areas have not been modelled.

Production of flood extents

4.3.7 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 AP2 revised 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 less than $50m^2$. The differences were mapped to indicate the potential impacts of the reconfiguration of the M56 junction 6 (AP2-006-014).

Modelling assumptions

4.3.8 LiDAR described in Section 3.1 above is assumed to be correct.

4.3.9 A 2D modelling approach based on LiDAR data (no river cross-section data) is assumed to be sufficient at this design stage for estimating conservatively the peak flood levels and flood extents associated with the 5.0% AEP, 1.0% AEP + CC and 0.1% AEP events.

4.3.10 Flow estimates of the tributaries have been obtained from the 2D model results as opposed to catchment hydrological estimates. As tributary catchments and flows are relatively small, the minimum culvert size should be sufficient, independent of the hydrological estimate used.

4.4 Climate change

4.4.1 In July 2021, the Environment Agency published revised guidance and CC allowances for peak river flows to reflect the UK Climate Projections 2018 (UKCP18)[15]. In May 2022, updated peak rainfall intensity allowances were published by the Environment Agency using UKCP local projections of extreme rainfall[15]. Further details are provided in the SES2 and AP2 ES Technical note – Water resources and flood risk – flood risk[4]. The main changes to the guidance of relevance to SES2 and AP2 ES are:

- peak river flow and rainfall intensity allowances are given for 'management catchments' instead of river basin districts. The smaller geographical units better reflect variability of the catchment response to CC impact;
- the Higher central peak river flow allowance should be used for catchments which contain 'essential infrastructure', elsewhere the Central allowance should be used; and
- the Upper end peak rainfall intensity allowance should be used for all developments with a lifespan beyond 2100.

4.4.2 The River Bollin is located within the Upper Mersey Management catchment. The CC allowance for peak flow is estimated for this area as 53% as Higher Central allowance and 85% as Upper End allowance[15].

4.4.3 The CC allowance for direct rainfall is estimated for this area as 30% for the central allowance and 45% for the upper-end allowance[15].

[15] Environment Agency (2022), *Flood risk assessments: climate change allowances.* Available online at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

4.4.4 For the purpose of this study the 30% rainfall and 53% peak flow allowances have been used to take account of CC. A CC sensitivity test has been undertaken using the 45% increase in peak rainfall intensity and 85% increase in peak river flow allowance.

5 Model results

5.1.1 The modelled flood extents with and without the AP2 revised scheme for the 5.0% AEP and the 1.0% AEP + CC event are presented in the SES2 and AP2 ES Volume 5, Water Resources Map Book: Map Series WR-05 - Modelled Baseline and Post Development Flood Extent 1 in 100 (1%CC) including Climate Change Annual Probability of River Flooding, and Map Series WR-06 - Modelled Baseline and Post Development Flood Extent 1 in 20 (5%) Annual Probability of River Flooding, maps WR-05-321 and WR-06-321 respectively.

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

5.1.3 The modelled impact of the AP2 revised scheme, without mitigation, on peak flood levels indicates the potential for:

- an increase in peak flood level up to 500mm and 1000m at two localised spots in woodland and agricultural land; and
- an increase in peak flood level up to 100mm in average at other locations in woodland and agricultural land.

5.1.4 Model results indicate that the current proposed design achieves the freeboard requirements for both the top of rail level and AP2 revised scheme watercourse crossing soffits (AP2-006-014). This has been confirmed by checking the design peak water level of (34.142m above Ordnance datum (AOD)) at the M56 River Bollin underbridge against the M56 River Bollin underbridge soffit (36.832m AOD) and the AP2 revised scheme viaduct soffit of 43m AOD.

6 Model proving

6.1 Run performance

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

6.2 Calibration and verification

6.2.1 There is no 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 by the Environment Agency RoFSW for the 1% AEP and 0.1% AEP events.

6.4 Sensitivity analysis

6.4.1 Analysis was undertaken to assess the sensitivity of the 1.0% AEP + CC AP2 revised scheme model outputs to the following scenarios:

- a CC sensitivity test has been undertaken by using the 45% peak rainfall intensity and 85% peak river flow allowance;
- 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 No sensitivity tests have been undertaken for the downstream unrestricted flow boundary at this stage, as the model is only 2D and has been extended sufficiently downstream to ensure that there is no effect at the route of the AP2 revised scheme crossings. These tests will be undertaken once the models are fully converted to 1D-2D at the detailed design stage.

6.4.3 Sensitivity tests indicate that the AP2 revised scheme hydraulic design is sensitive to changes in CC flows. The model sensitivity indicates that an increase from 30% rainfall and 53% peak flow allowance to the 45% rainfall and 85% peak flow allowance would result in an increase in peak water level of 280mm upstream of the M56 River Bollin underbridge and 237mm increase at the location of the River Bollin east viaduct. Less significant are the changes in roughness (around half) when compared to increases in flows due to changes in CC predictions.

6.5 Blockage analysis

6.5.1 Due to the size of the M56 River Bollin underbridge, no blockage analysis was considered necessary.

6.6 Run parameters

6.6.1 There is no deviation from the 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 consequently, 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. Channel conveyance will therefore not be fully represented in the model. This is likely to have resulted in a conservative estimate of peak flood levels.

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

7.1.4 Replacement flood storage areas have not been modelled however sufficient land area has been allocated for the provision of level for level compensation storage. Detailed modelling will be required to demonstrate that these are able to mitigate the effects.

8 Conclusions and recommendations

8.1.1 The model has been run for the 5.0% AEP, 1.0% AEP, 1.0% AEP + CC, and 0.1% AEP.

8.1.2 The CC allowance for the 30% peak rainfall intensity and 53% peak river flow increases have been used. A CC sensitivity test has been undertaken by using the 45% peak rainfall intensity and 85% peak river flow allowance.

8.1.3 The modelled flood extents with and without the AP2 revised scheme for the 5.0% AEP and the 1.0% AEP + CC events are presented in the Volume 5, Water Resources Map Book: Map Series WR-05 and WR-06, maps WR-05-321 and WR-06-321 respectively.

8.1.4 The modelling impact indicates no increase in flood risk for the 5.0% AEP.

8.1.5 The modelled impact of the AP2 revised scheme, without mitigation, on peak flood levels for the 1.0% AEP + CC indicates the potential for:

- an increase in peak flood level up to 500mm and 1000mm at two localised spots in woodland and agricultural land; and
- increases in peak flood level up to 100mm in average at other locations in woodland and agricultural land.

8.1.6 Model results indicate that the current proposed design achieves the freeboard requirements for both the top of rail level and AP2 revised scheme watercourse crossing soffits (AP2-006-014).

8.1.7 Sensitivity tests indicate that the AP2 revised scheme hydraulic design is sensitive to changes in flows and less sensitive to changes in the roughness coefficient.

8.1.8 At the detailed design stage, the hydraulic modelling of the watercourse will 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 AP2 revised scheme with a view to reducing impacts in peak flood levels as far as is reasonably practicable.

8.1.9 Detailed modelling of the proposed replacement floodplain storage (AP2-006-014) should also be undertaken to verify the magnitude of residual impacts (if any) of the final scheme design, for consenting purposes. Sufficient space has been allocated for level-to-level replacement flood storage areas, which could potentially provide double the volume of the estimated loss of floodplain volume.

Annex A: Flood level impact maps

The water level difference has been mapped for 5.0% AEP and 1.0% AEP + CC events as described in Section 5, see Figure A1 and Figure A2.

Figure A1: River Bollin impact map for 5.0% AEP (1 in 20 year) with AP2 revised scheme

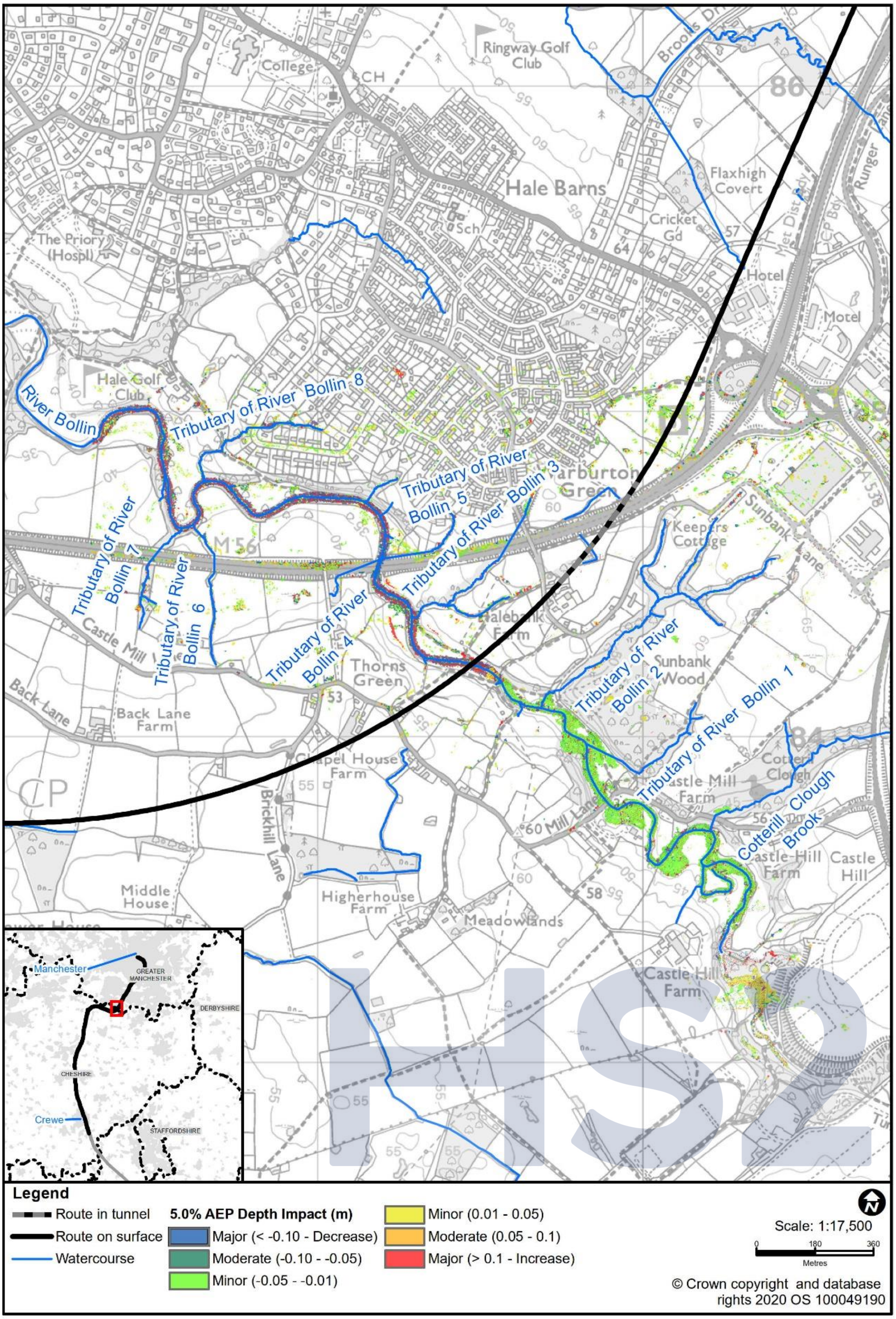
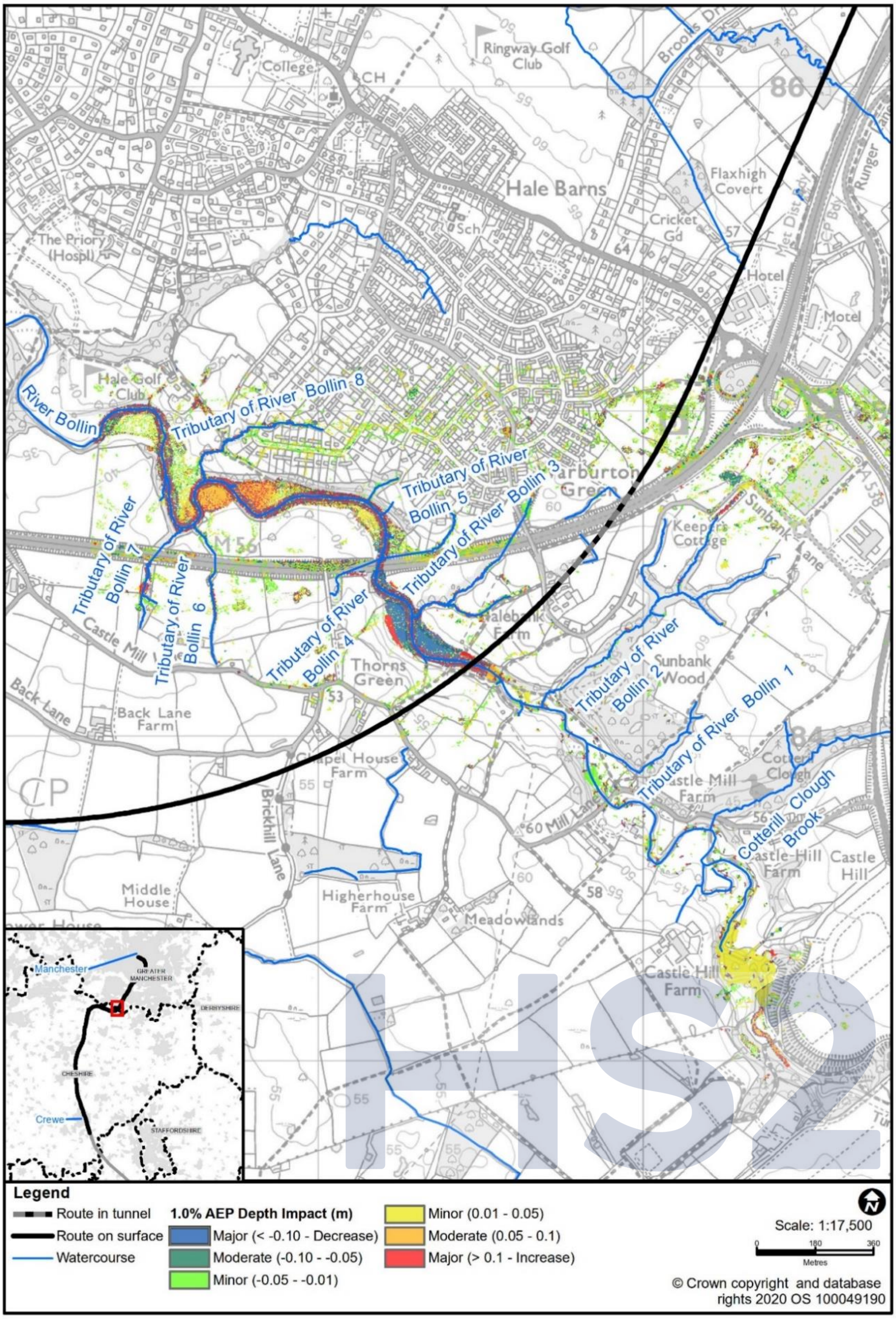


Figure A2: River Bollin impact map for 1.0% AEP + CC event (1 in 100 year plus CC) with AP2 revised scheme



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