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-006-00010

Water resources and flood risk

Hydraulic modelling report – Tributaries of Birkin Brook

S122

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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 Tributary of Birkin Brook 1, 2 and 3 in the Birkin Brook catchment. These watercourses are referred to in their collective term hereon as tributaries of Birkin Brook. The tributaries of Birkin Brook run 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 (MA06) community area, see SES2 and AP2 ES Volume 5, Appendix: WR-005-0MA06. The River Bollin hydraulic modelling report (SES2 and AP2 ES Volume 5, Appendix: WR-006-00011) is also relevant to the Hulseheath to Manchester Airport (MA06) area.

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.

[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.

Additional information is included in Background Information and Data (BID) WR-004-0MA06 SES2 and AP2 ES, Water resources assessment baseline data[3].

1.1.7 The AP2 amendment of relevance to this report is the Additional land permanently required for watercourse diversions at Mobberley Road (AP2-006-010).

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 for tributaries of Birkin Brook in the vicinity of the AP2 amendment to simulate peak flood levels, with and without the AP2 revised 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 Hulseheath to Manchester Airport (MA06) area, which is reported in SES2 and AP2 ES Volume 5 of the Environmental Statement. The hydraulic model has also informed the preliminary design of the AP2 amendment for watercourse diversions (AP2-006-010). The specific objective is to ensure that the design of hydraulic structures (for example: viaducts, bridges, culverts etc.) take 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].

[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 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*

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;
- estimate peak flows, and hydrographs, at the AP2 revised scheme crossing locations, associated with the following Annual Exceedance Probabilities (AEP): 5.0% AEP, 1.0% 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 revised 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 AP2 revised scheme on peak flood levels and the sensitivity of nearby receptors to flooding.

1.4.2 Tributary of Birkin Brook 1 is a main river at the Mobberley Road realignment crossing. The receptors located upstream of the watercourse diversions (AP2-006-010) are:

- agricultural land (less vulnerable);
- Mobberley Road (less vulnerable); and
- Mid-Cheshire Railway (essential infrastructure).

1.4.3 A combination of direct rainfall and an inflow boundary has been applied in a 2D hydraulic model. Direct rainfall has been applied within a 2.34km^2 catchment in the area of the AP2 amendment (AP2-006-010). Upstream of the 2D direct rainfall domain, one inflow boundary has been included. This inflow boundary allows for the flows from the 1.93km^2 upstream catchment of Tributary of Birkin Brook 1 (also known as Middle House Brook) (refer to Figure 2-1). At the inflow boundary, near Lower House Farm, input hydrographs have been derived for different return period events, using the Revitalised Flood Hydrograph 2 (ReFH2) software.

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.

1.5 Scope

1.5.1 The scope of the study was to undertake detailed hydraulic modelling to enable assessment of the impact of the AP2 revised scheme 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 2.2km reach of Tributary of Birkin Brook 1 and its tributaries. The modelled reach extends upstream and downstream of the crossing of the realigned Mobberley Road and the temporary Ashley railhead.

1.5.3 The AP2 amendment watercourse diversions (AP2-006-010) comprises a northerly diversion of the Tributary of Birkin Brook 1 during low to normal flow periods. During higher flow periods, part of the existing channel downstream of the northerly diversion is reused as a flood overflow channel. Both the overflow channel and the diverted channel rejoin downstream of the realigned Mobberley Road crossing. A description of the location and the AP2 revised scheme is provided in Section 2.

1.5.4 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:

- Cheshire East Council (CEC) Preliminary Flood Risk Assessment (PFRA)[7];
- CEC Strategic Flood Risk Assessment (SFRA)[8]; and
- CEC Local Flood Risk Management Strategy (LFRMS)[9].

2.2 Description of the study area

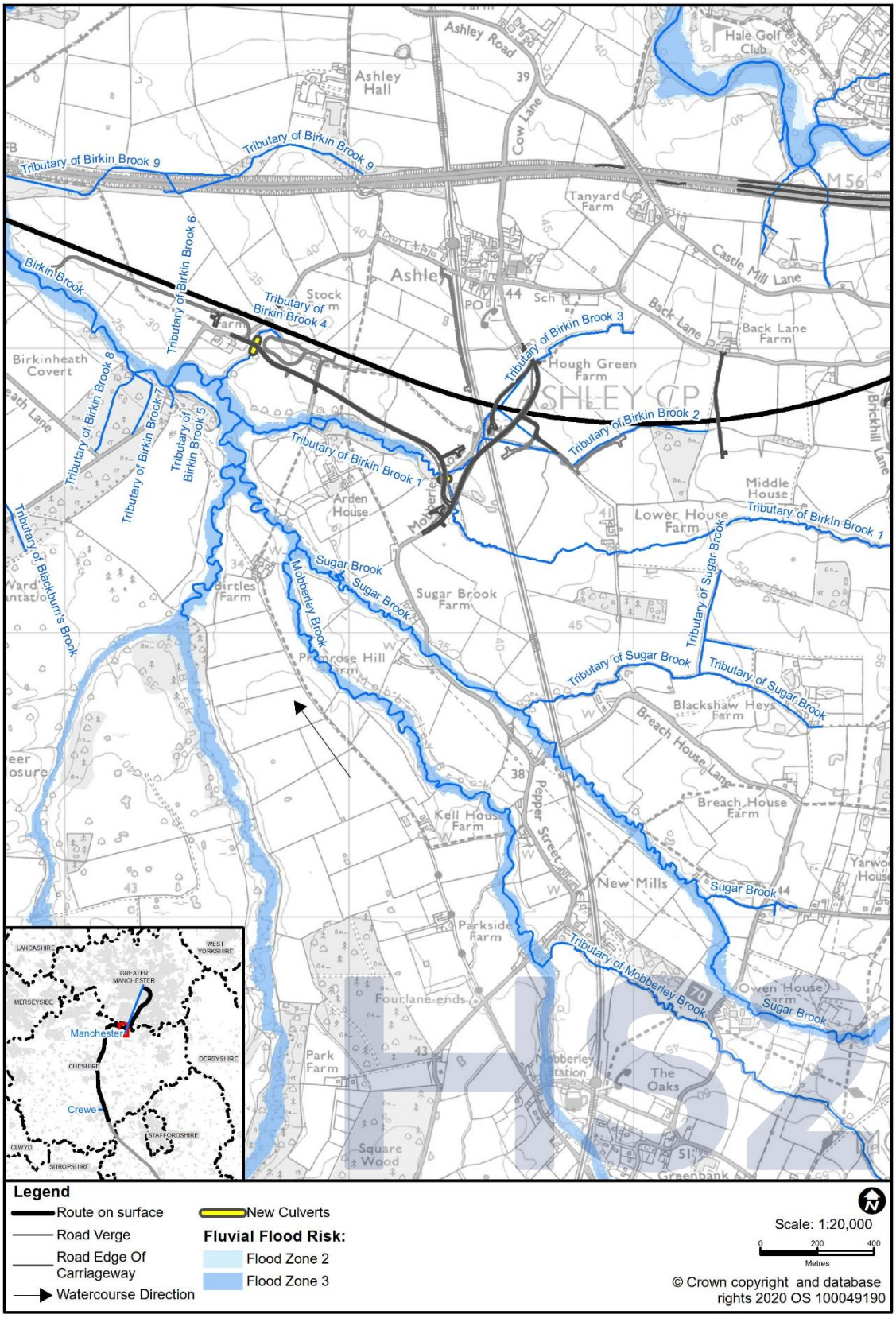
Study area

2.2.1 Figure 4-1 shows the modelled 2.2km long reach of Tributary of Birkin Brook 1 and its tributaries. The model boundaries are located 1.2km upstream and 1.1km downstream from the realigned Mobberley Road crossing.

2.2.2 The primary hydraulic control of Tributary of Birkin Brook 1 is the existing northern and southern culverts beneath the Mid-Cheshire Railway (see Figure 4-1).

[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] Jacobs (2011), *Cheshire East Council Preliminary Flood Risk Assessment.* Available online at: https://moderngov.cheshireeast.gov.uk/ecminutes/mgAi.aspx?ID=13352.
[8] JBA Consulting (2013), *Cheshire East Council Strategic Flood Risk Assessment.* Available online at: https://www.cheshireeast.gov.uk/pdf/planning/spatial-planning/researchand-evidence/strategic-flood-assessment/cheshire-east-council-sfra-final-report-v4.0.pdf.
[9] Cheshire East Council (2017), *Cheshire East Council Local Flood Risk Management Strategy.* Available online at: https://moderngov.cheshireeast.gov.uk/ecminutes/documents/s59547/Local%20Flood%20Risk%20Management%20Strategy%20-%20app%202.pdf.

Figure 2-1: Study area and Environment Agency flood zones and RoFSW (0.1% AEP) at Tributary of Birkin Brook 1



Hydrological description

2.2.3 Tributary of Birkin Brook 1 originates immediately to the south of Manchester airport. The Tributary of Birkin Brook 2 joins the Tributary of Birkin Brook 1 approximately 12m downstream of the existing Mobberley Road crossing. Tributary of Birkin Brook 3 joins Tributary of Birkin Brook 2 immediately downstream of the existing Mid-Cheshire Railway crossing. Figure 2-1 shows the catchment of Tributary of Birkin Brook 1 (in grey) contributing to the flow at the crossing of the Mid-Cheshire Railway and proposed Mobberley Road viaduct. Approximately 740m to the west of the confluence of the Tributary of Birkin Brook 1 and 2, the Tributary of Birkin Brook 1 joins the Birkin Brook.

2.2.4 There are no gauging stations present within the catchment.

2.2.5 Standard annual average rainfall catchment descriptor from the Flood Estimation Handbook (FEH) Web Service at the model downstream catchment boundary, is 826mm.

AP2 revised scheme

2.2.6 The AP2 revised scheme in the study area includes the realignment of Mobberley Road, with an associated viaduct crossing over the existing Mid-Cheshire Railway. A realignment of Ashley Road is also proposed and will join the new Mobberley Road approximately 180m to the west of the Mid-Cheshire Railway.

2.2.7 The temporary Ashley railhead will be in place during the construction of the HS2 route and will be located immediately to the west and adjacent to the existing Mid-Cheshire Railway.

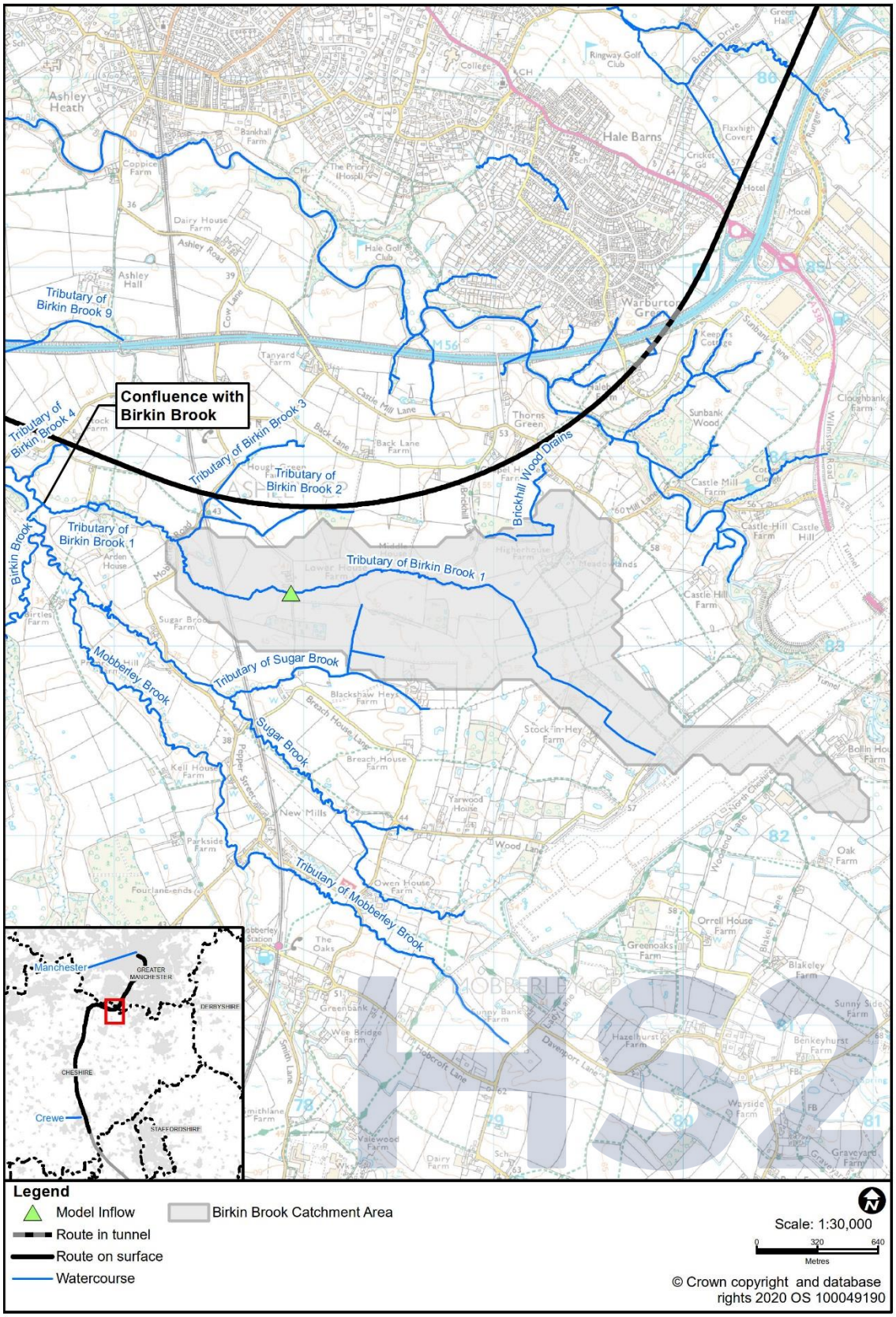
2.2.8 The realigned Mobberley Road, Ashley Road and the Ashley railhead will all cross the existing Tributary of Birkin Brook 1. To reduce the impacts on this surface watercourse from long culverts, Tributary of Birkin Brook 1 has been diverted to the north, where Ashley railhead is at its narrowest. In the main ES, a potential increase in flood risk was reported, due the diversion of flow through an existing small culvert beneath the Mid-Cheshire Railway. Therefore, the watercourse diversions (AP2-006-010) include for an overflow weir, channel and culverts along the route of the existing watercourse.

2.2.9 The model includes the diversion of the Tributary of Birkin Brook 1, the overflow channel and new connections from the tributaries of Birkin Brook 2 and 3. Further details on the AP2 revised scheme can be found in Volume 2, MA06 Map Book: Map Series CT-06 – Proposed Scheme, maps CT-06-354, CT-06-354-R1 and CT-06-355.

Features of note

2.2.10 The existing Mid-Cheshire Railway is the main constraint for Tributary of Birkin Brook 1 and associated surface water runoff in the study area.

Figure 2-2: Birkin Brook catchment area



2.3 Existing understanding of flood risk

Flood mechanisms

2.3.1 Upstream of the Tributary of Birkin Brook 1 crossing of the Ashley Road realignment, the Environment Agency does not define flood zones for the Tributary of Birkin Brook 1. The RoFSW indicates 20m to 30m wide flood extents following the approximate alignment of the Tributary of Birkin Brook 1 and its tributaries, as shown in Figure 2-1.

2.3.2 The RoFSW indicates that the existing Mid-Cheshire Railway embankment acts as a barrier to the surface water east of the railway where significant ponding would occur for the 3.3%, 1% and 0.1% flood event.

2.3.3 No formal Environment Agency flood defence assets are present within the model extent.

Analysis of historical flooding

2.3.4 No information on historical flood incidents has been identified from the local SFRA or PFRA, and there are no relevant Section 19 flood investigation reports[10].

Availability of existing hydraulic models

2.3.5 Available information, which includes information from the Environment Agency, does not indicate the existence of fluvial hydraulic models for the Tributary of Birkin Brook 1 and its tributaries.

2.4 Site visit

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

[10] 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 Tributary of Birkin Brook 1 study area as no 1D channel survey data was available.

3.1.2 Existing culvert dimensions have been assumed based on engineering judgment from channel width and aerial photography of Tributary of Birkin Brook 1 and 2 under the Mid-Cheshire Railway and Mobberley Road. These have been modelled as 1D elements within the 2D model.

3.1.3 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 AP2 amendment (AP2-006-010).

3.1.4 High resolution 0.2m to 1m LiDAR (Light Detection And Ranging) 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 greater modelled peak water levels, as well an 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 0.2m grid LiDAR Digital Terrain Model flown specifically for HS2 Ltd and covers 500m either side of the centre line of the route. Where required, additional 1m grid LiDAR data provided by the Environment Agency was used. This was used in areas further away from the HS2 route, 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 Tributary of Birkin Brook 1 and its tributaries. The hydrological approach has been to have a point inflow for the Tributary of Birkin Brook 1 as this contains the largest catchment (1.93km^2) at the Mid-Cheshire Railway crossing. Direct rainfall has been applied to the other tributaries up to the downstream 2D model limit.

4.1.2 The critical ReFH2 storm duration of 3hrs has been adopted for the direct rainfall model and the point inflow. ReFH2 uses the recently updated FEH[11] rainfall database and parameters.

4.1.3 A hydrological verification has been undertaken by estimating catchment hydrology ReFH2 peak flow estimates at the Mid-Cheshire Railway crossing. This check was to verify that the surface water modelled peak flows are similar to or greater than the ReFH2 peak flow estimates. ReFH2 flow calculations are based on relevant catchment descriptors, which were obtained from the FEH web service database[11].

4.1.4 Table 1 shows the peak flows derived from the surface water modelling with Infoworks ICM at the proposed Tributary of Birkin Brook 1 crossing beneath Mobberley Road and their comparison with the ReFH2 peak flow estimates.

Table 1: Peak flows at the Tributary of Birkin Brook 1 crossing (baseline model)

AEP	Return period	Modelled peak flow (m^3/s)	ReFH2 peak flow (m^3/s)
5.0%	20y	1.5	1.5
1.0%	100y	2.4	2.3
1.0% + CC (53%)	100y + CC (53%)	3.6	3.5
0.1%	1000y	4.1	4.0

4.1.5 It is concluded that the adopted surface modelling approach is more conservative than the estimates from the ReFH2. 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 4-1 and Figure 4-2 shows the existing and proposed model schematic.

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

1D representation

4.2.2 The following existing culverts are located within the 2D domain and have been modelled in 1D:

- the crossing of the Tributary of the Birkin Brook 1 beneath the Mid-Cheshire Railway; and
- the crossing of the Tributary of the Birkin Brook 2 beneath the Mid-Cheshire Railway.

4.2.3 Details of the assumed culvert dimensions represented in the hydraulic model are provided in Table 2 below.

Table 2: Modelled structures within the modelled extent

Structure reference	Structure description	Modelling representation and justification
Tributary of Birkin Brook 2 beneath Mid-Cheshire Railway (North culvert)	600 mm circular culvert	Dimensions assumed from LiDAR and aerial photography.
Tributary of Birkin Brook 1 beneath Mid-Cheshire Railway (South culvert)	1.2m diameter pipe	Dimensions assumed from LiDAR and aerial photography.

2D representation

4.2.4 The element area of the model varied, where the maximum element area is set to 25m^2 and minimum element area is set to 1m^2. Element size and alignment for the 2D model mesh were optimised through the use of a finer mesh zone to ensure appropriate representation of the flow pathways whilst maintaining reasonable run times.

Inflow boundaries

4.2.5 A point inflow boundary has been included in the model to account for the flow contribution of the upstream catchment. This inflow has been placed on the alignment of Tributary of Birkin Brook 1 at the boundary of the 2D domain.

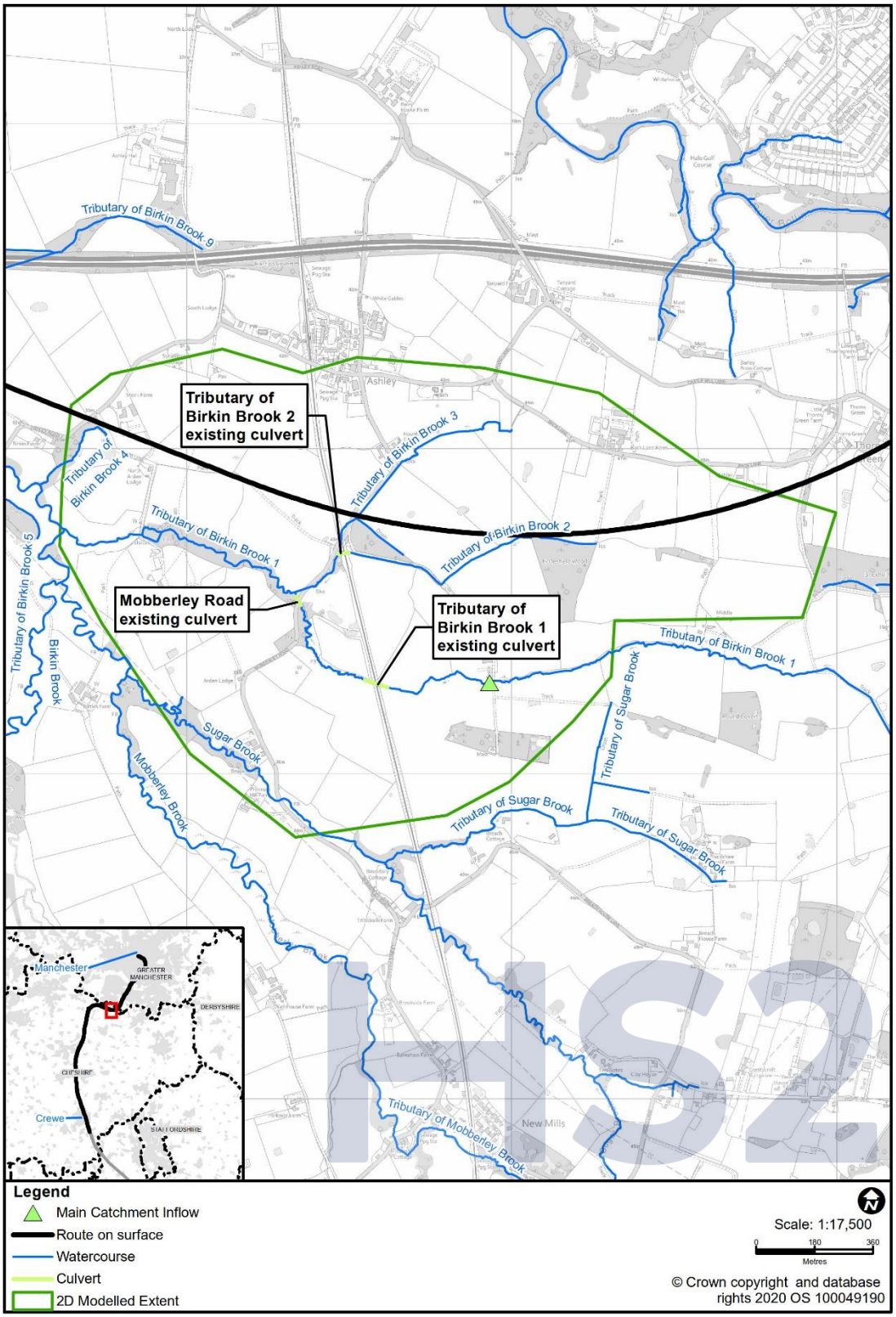
Downstream Boundary

4.2.6 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 area of interest.

Key structures

4.2.7 There are no additional key structures included in the hydraulic model, other than those set out in the 1D representation section above.

Figure 4-1: Baseline 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)[12].

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.

1D channels and culverts

4.3.2 The diversion of Tributary of Birkin Brook 1 to the north will carry normal flows (up to typical winter flow of 0.3m^3/s based on the ReFH methodology). The diversion will start in an open channel travelling north and then west, before passing beneath the Mid-Cheshire Railway and the temporary Ashley railhead via two 1.35m wide by 1.35m high culverts. Following construction, when the Ashley railhead has been removed, the culvert beneath the railhead will also be removed and replaced with open channel. The watercourse passes south in an open channel until crossing beneath the realigned Ashley Road. At the downstream end of this crossing, the diversion will end, re-joining the original course of Tributary of Birkin Brook 1.

4.3.3 During higher flow periods, an overflow channel has been included in the design. This channel starts and ends along the current alignment of Tributary of Birkin Brook 1. At the start of the overflow channel, a 0.3m high weir with a crest level of 37.2m will be built to ensure normal flows are diverted to the diversion to the north. The overflow channel will then run in an open channel along the same alignment of the original Tributary of the Birkin Brook 1, up to the Mid-Cheshire Railway embankment.

4.3.4 During construction, a large temporary infill platform for the Ashley railhead will be located along the western side the Mid-Cheshire Railway in this area. Therefore, up to 3 culverts (1.35m wide by 1.35m high and 197m long) will be provided to convey the overflow channel beneath both the Mid-Cheshire Line and the Ashley railhead. The overflow channel will then run in an open channel, until crossing beneath the realigned Mobberley Road via three 1.35m by 1.35m culverts. After this crossing, the overflow channel will finally run in an open channel until the confluence with the diverted Tributary of Birkin Brook 1.

4.3.5 Once construction is complete, the Ashley railhead will be removed. The three culverts beneath the railhead will then be replaced with an open channel.

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

4.3.6 Tributaries of Birkin Brook 2 and 3 have been modelled in 2D as these carry relatively small flows. There will be minor realignments of these watercourses for the AP2 revised scheme. These have not been modelled at this stage because they do not affect the sizing of the channels and culverts.

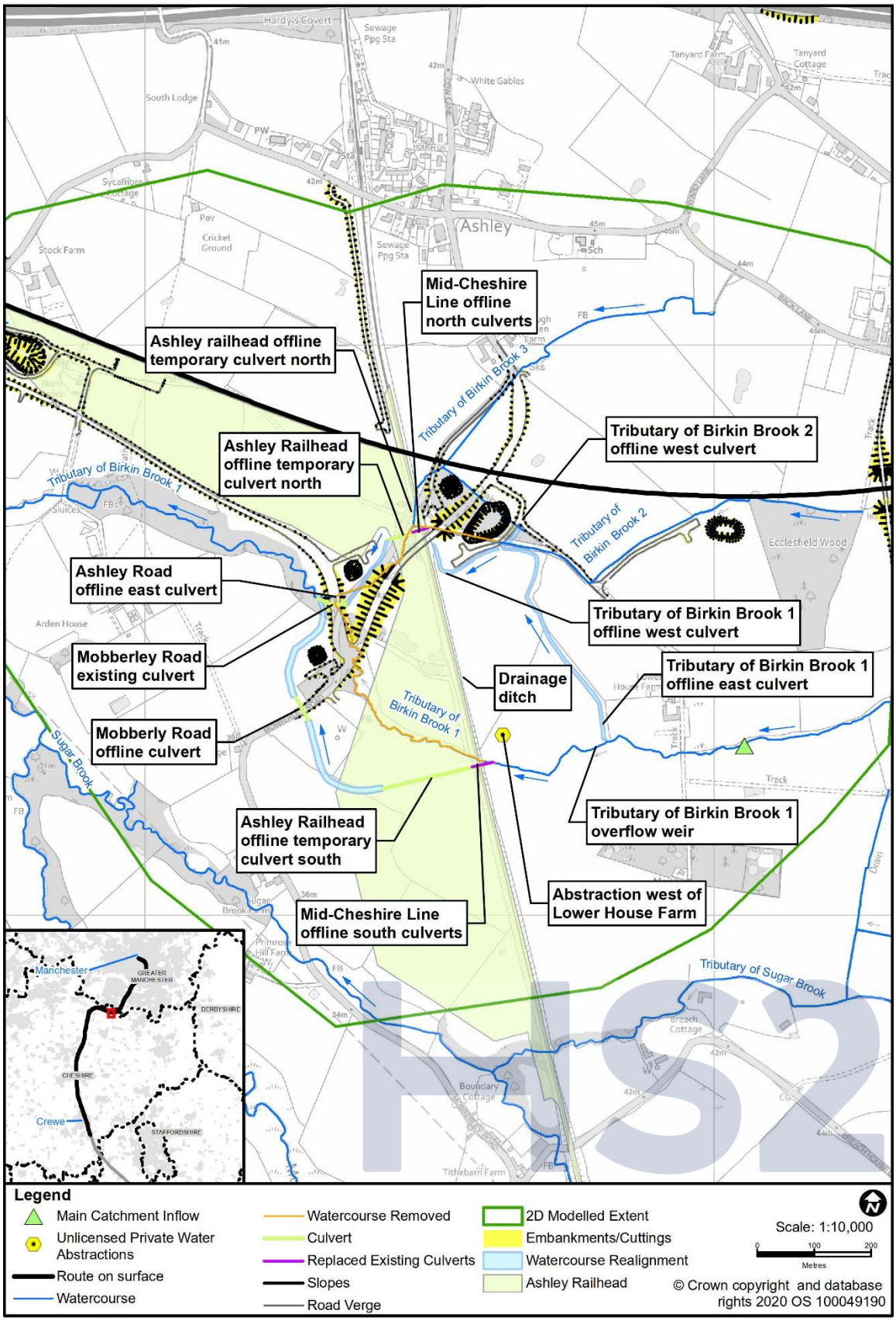
4.3.7 A summary of the proposed culverts, dimensions and lengths is provided in Table 3 below and are shown on Figure 4-2.

Table 3: Summary of AP2 revised scheme culvert dimensions and lengths

Structure reference	Dimensions (mm)	Approximate length (m)
Ashley Road Offline East culvert	1650 x 1350	25
Tributary of Birkin Brook 3 offline culvert	1350 x 1350	55
Mobberley Road offline culvert	3 No. box culvert 1350 x 1350	45
Mid-Cheshire Line offline South culvert (3 for temporary and 6 for permanent condition)	6 No. box culverts 1350 x 1350	26.5
Ashley railhead offline temporary culvert South*	3 No. box culverts 1350 x 1350	165
Mid-Cheshire Line offline North culvert	1350 x 1350	21
Ashley railhead offline temporary culvert North*	1350 x 1350	50

** Scenario modelled with temporary culverts under Ashley railhead.*

Figure 4-2: AP2 revised scheme model schematic



Topographic changes

4.3.8 There are no topographic changes related to the AP2 revised scheme.

Production of flood extents

4.3.9 Flood extents have been derived using the direct output option available in Infoworks ICM, producing maximum flood depth and stage. The outputs have undergone an 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 AP2 revised scheme.

Modelling assumptions made

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

4.3.11 A 2D modelling approach, with the exception of the 1D diversion to the north of Tributary of Birkin Brook 1 and the overflow channel, is assumed to be sufficient for estimating the 5.0% AEP, 1.0% AEP and 0.1% AEP events.

4.3.12 The dimensions of key structures are not based on visual inspection or survey, however, they are considered reasonable when compared to the channel cross sections assumed from LiDAR and aerial photography.

4.4 Climate change

4.4.1 The CC allowance for tributaries of Birkin Brook is a 45% increase in peak rainfall intensity for direct rainfall modelling as the catchment is less than 5km^2 in size. This increase has been applied as an uplift in rainfall intensity to each increment of the net rainfall hyetograph. For the inflow boundary, a 53% increase in the peak river flow hydrographs has been applied.

5 Model results

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

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 AP2 revised scheme for the 5.0% AEP and the 1.0% AEP + CC events 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-05-320/WR-05-321 and WR-06-320/WR-06-321 respectively.

5.1.4 The modelling results indicate no increase in flood risk for the 5.0% AEP.

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

- a reduction in peak flood level of up to 50mm on the Mid-Cheshire Railway, to the north of the diverted Tributary of Birkin Brook 1;
- a reduction in peak flood level of the order of 50mm upstream of the Mid-Cheshire Line offline North culvert, in the area where the diverted channel runs in the vicinity of the Mid-Cheshire Railway embankment; and
- a reduction in flood depth of more than 100mm adjacent to the Mid-Cheshire Railway embankment, on the field further to the south of the Mid-Cheshire Line offline north culvert up to the Mid-Cheshire Line offline south culvert. There is also a reduction in flood depth along the overflow channel up to the confluence with the diverted channel.

5.1.6 The reduction in flood risk to the Mid-Cheshire Railway and adjacent fields, is due to flood flow being diverted into the southern channel. This reduction in flood risk can be adjusted to ensure no increase in flood flows downstream by adjusting the height of the overflow weir to balance the flood flows between the two channels.

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 the baseline model are similar to those shown on the Environment Agency RoFSW for the 1.0% 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:

- use of upper CC scenario of 85% for flows and 45% for rainfall intensity;
- 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 AP2 amendment (AP2-006-010). These tests will be undertaken once the models are fully converted to 1D-2D during design progression.

6.4.3 Modelling demonstrates the existing culvert sizes are key structures influencing flood levels and flood extents upstream and downstream of the AP2 revised scheme. The existing design is considered precautionary. During design progression, surveys will be carried out including topographic surveys of the channel and existing structures and the design will then be updated to ensure that there is no increase in flood flows downstream, and no increase in flood risk upstream of the Mid-Cheshire Line.

6.4.4 Sensitivity tests indicate that the current AP2 revised scheme hydraulic design is not unduly sensitive to changes in key input parameters apart from increasing the flows due to CC from 53% to 85%.

6.5 Blockage analysis

6.5.1 No blockage analysis has been undertaken at this stage.

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 Existing channels have been represented in 2D. Therefore, channel conveyance may 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 Calibration was not possible due to a lack of available historical data.

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 direct rainfall of the hydrology for the tributaries of Birkin Brook is a 45% increase in peak rainfall intensity and a 53% increase in the peak river flow hydrographs.

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 SES2 and AP2 ES Volume 5, Water Resources Map Book, Map Series WR-05 and WR-06, maps WR-05-320/WR-05-321 and WR-06-320/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:

- a reduction in peak flood level of up to 50mm on the Mid-Cheshire Railway, to the north of the diverted Tributary of Birkin Brook 1;
- a reduction in peak flood level of the order of 50mm upstream of the Mid-Cheshire Line offline North culvert, in the area where the diverted channel runs in the vicinity of the Mid-Cheshire Railway embankment; and
- a reduction of flood depth of more than 100mm adjacent to the Mid-Cheshire Railway embankment, on the field further to the south of the Mid-Cheshire Line offline north culvert up to the Mid-Cheshire Line offline south culvert. There is also a reduction in flood depth along the overflow channel up to the confluence with the diverted channel.

8.1.6 The reduction in flood risk to the Mid-Cheshire Railway and adjacent fields, is due to flood flow being diverted into the southern channel. This reduction in flood risk can be adjusted to ensure no increase in flood flows downstream by adjusting the height of the overflow weir to balance the flood flows between the two channels.

8.1.7 Sensitivity tests indicate that the current AP2 revised scheme hydraulic design is not unduly sensitive to changes in key input parameters apart from the increase in flows due to CC from 53% to 85%. The modelling is sensitive to the assumptions on the size of the existing culverts. The AP2 design is considered conservative, as there is sufficient space and culverts included in the design to allow for reasonable worst case flood flows. During design development, surveys will be carried out including topographic surveys of the channel and existing structures and the design will then be updated to ensure that there is no increase in flood flows downstream, and no increase in flood risk upstream of the Mid-Cheshire Line.

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: Birkin Brook impact map for 5.0% AEP (1 in 20 year) with AP2 revised scheme

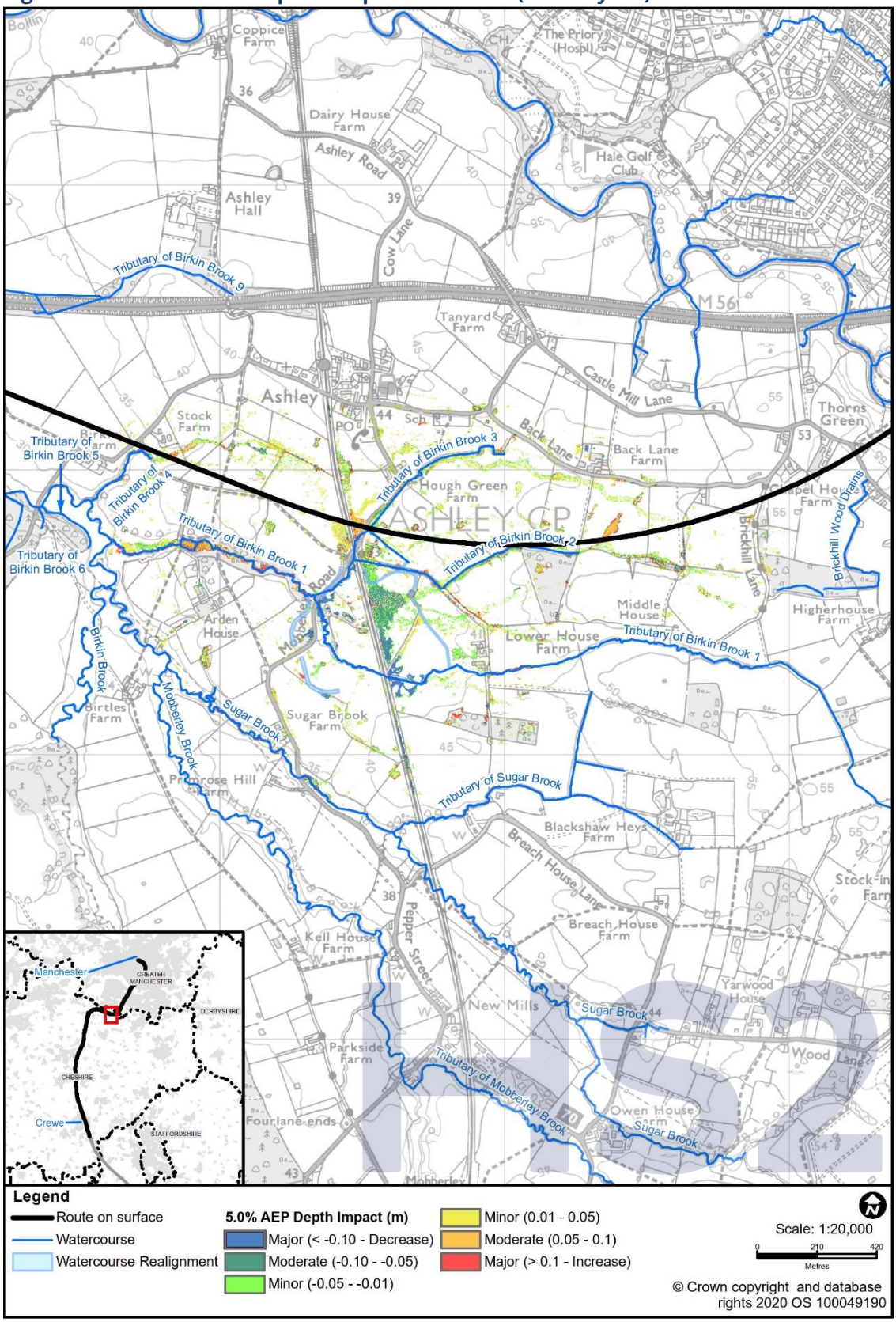
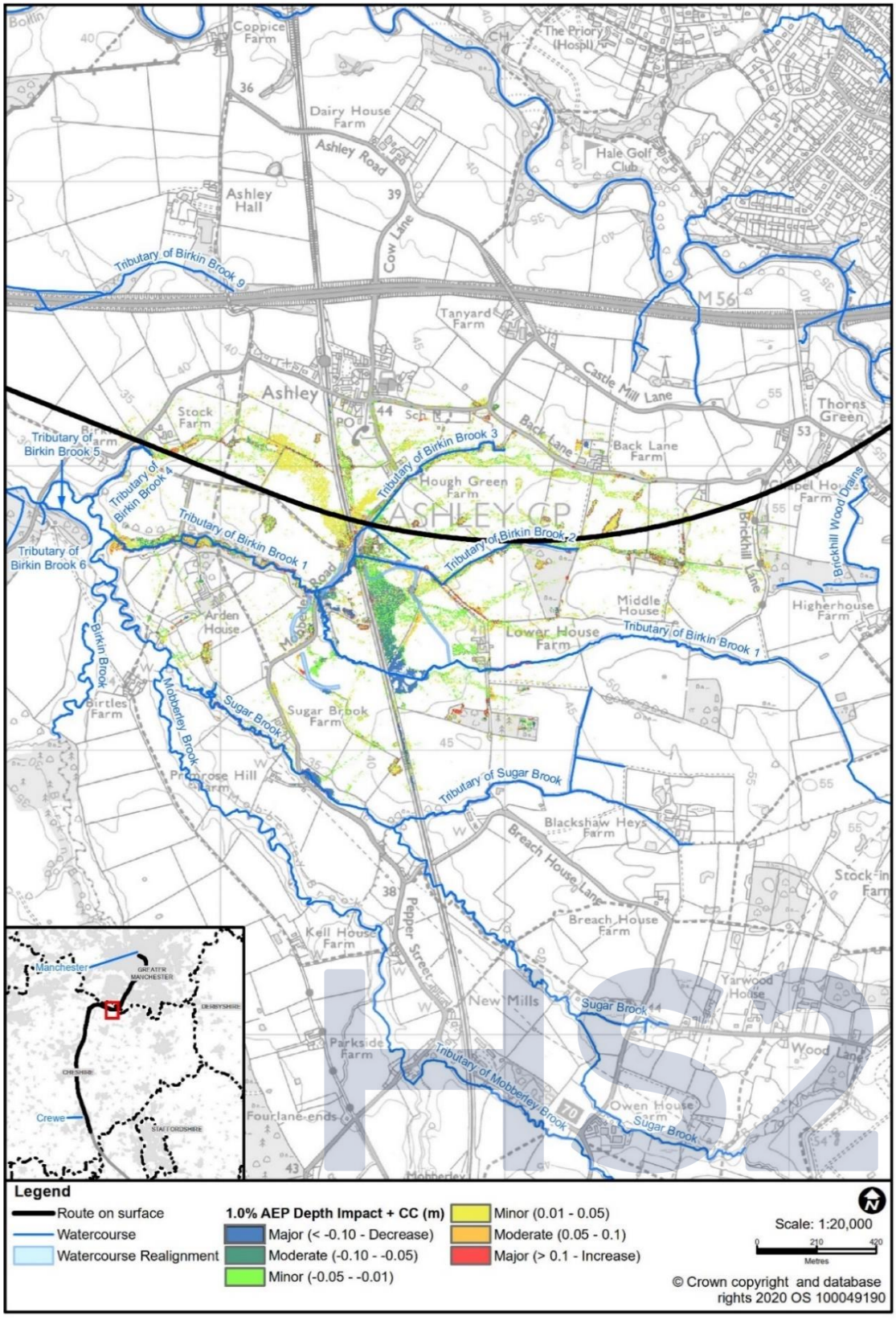


Figure A2: Birkin Brook impact map for 1.0% AEP + CC event (1 in 100 year plus CC) with AP2 revised scheme



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