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HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix WR-006-00001

Water resources and flood risk

MA03: Pickmere to Agden and Hulseheath

Hydraulic modelling report -

Millington Clough and tributaries

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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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1 Introduction

1.1 Background

1.1.1 This appendix presents the results of the hydraulic modelling carried out for Millington Clough, its tributaries (tributaries of Millington Clough 1, 2, 3 and 4) and the upper reaches of Agden Brook. These watercourses are collectively referred to hereon as Millington Clough and tributaries. Millington Clough becomes known as Agden Brook around Millington Hall. The tributaries of Millington Clough run through the Pickmere to Agden and Hulseheath community area (MA03). Agden Brook runs through the Hulseheath to Manchester Airport community area (MA06).

1.1.2 The hydraulic modelling has been used to inform the Flood risk assessment (Volume 5: Appendices WR-005-0MA03 and WR-005-0MA06) for these community areas.

1.1.3 There are no other hydraulic modelling reports relevant to this area.

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 each community area the Water resources assessments (Volume 5: Appendix WR-003-0MA03) 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 per community area (BID WR-004-0MA03)[1]; and
- Water Framework Directive compliance assessment baseline data for the Proposed Scheme (BID WR-002-00001)[2].

1.2 Aims

1.2.1 The aim of this study was to develop a hydraulic model for tributaries of Millington Clough in the vicinity of the Proposed Scheme crossings to simulate peak flood levels, with and without

[1] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Background Information and Data, Water resources assessment baseline data,* BID WR-004-0MA03. 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 baseline data,* BID WR-002-00001. Available online at: http://www.gov.uk/government/collections/hs2-phase-2b-crewe-manchester-environmental-statement.

the Proposed 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 Pickmere to Agden and Hulseheath area and the Hulseheath to Manchester Airport area, that are reported in Volume 5 of the Environmental Statement. The hydraulic model has also informed the preliminary design of the Proposed Scheme, with the specific objectives of ensuring that the design of hydraulic structures, such as viaducts, bridges and culverts take account of flood risk issues, as detailed in the Environmental Impact Assessment Scope and Methodology Report (SMR) Technical Note: Flood risk (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% AEP, 1.0% AEP, 1.0% + 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 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 Millington Clough is a main river with vulnerable receptors (residential properties) located both upstream and downstream of the Proposed Scheme crossing. A combination of direct rainfall and inflow boundaries has been applied in a 2D hydraulic model. Direct rainfall has been applied in the vicinity of the scheme crossing, with input hyetographs derived using Revitalised Flood Hydrograph 2 (ReFH2) software. Upstream of the 2D direct rainfall domain, three inflow boundaries have been included in the baseline model to allow for the flows coming from three upstream sub-catchments (refer to Figure 3).

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 locations, the management of flood risk and correct sizing of crossing structures.

1.5.2 This report focuses on a 1.6km reach of Millington Clough/Agden Brook and its tributaries, extending upstream and downstream of the crossings of the HS2 Manchester spur. The Proposed Scheme crossing comprises of a culvert crossing for the Millington Clough main river on the Manchester spur line. A second crossing of the Millington Clough main river is by a culvert for a new access road immediately downstream of the Manchester spur crossing. A third crossing of Agden Brook main river is by viaduct (Agden Brook viaduct). 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:

- Cheshire East Council (CEC) Preliminary Flood Risk Assessment (PFRA) (2011)[5];
- CEC Strategic Flood Risk Assessment (SFRA) (2013)[6]; and
- CEC Local Flood Risk Management Strategy (LFRMS) (2015)[7].

2.2 Description of the study area

Study area

2.2.1 Approximately 500m downstream of the first Proposed Scheme crossing of Millington Clough by the HS2 Manchester spur, Millington Clough becomes Agden Brook.

2.2.2 Figure 1 shows the 1.9km long reach of Millington Clough and its tributaries in the study area and the Environment Agency risk of flooding from surface water maps (RoFSW)[8]. The upstream boundary of the hydraulic model is located to the south and in vicinity of Little Moss Farm. The downstream boundary of the hydraulic model is located at the outlet of Agden Brook beneath the M56.

[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.

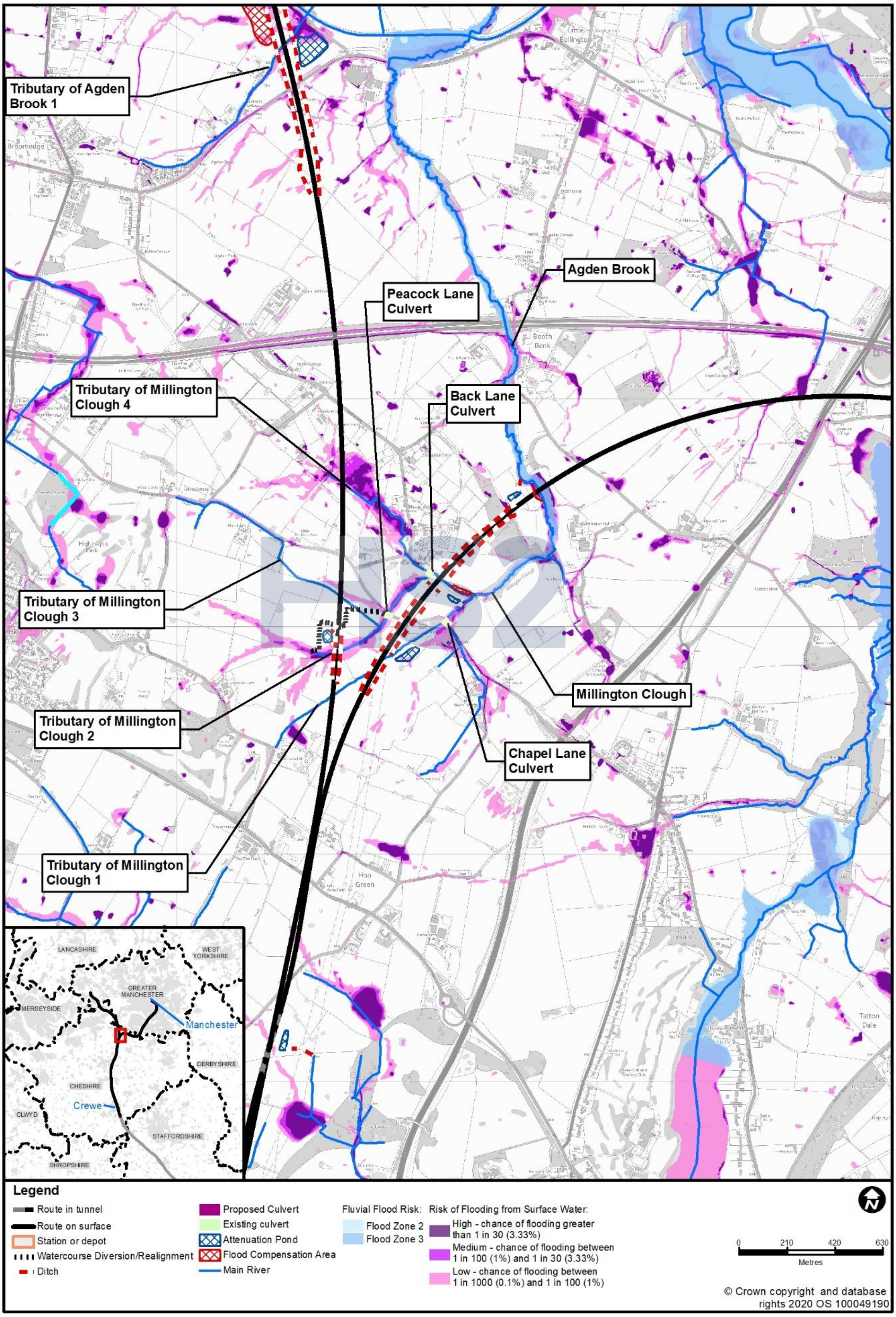
[5] Jacobs (2011), *Cheshire East Council Preliminary Flood Risk Assessment*. Available online at: https://moderngov.cheshireeast.gov.uk/ecminutes/documents/s13286/Cheshire%20East%20PFRA%20-%20Final%20version%20issued%2021st%20June%202011.pdf.

[6] 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.

[7] 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.

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

Figure 1: Study area, Environment Agency flood zones and RoFSW (0.1% AEP) at Millington Clough



2.2.3 The primary hydraulic control of Millington Clough is the existing culvert beneath Back Lane, located between the two routes of the Proposed Scheme. Flood levels at the Proposed Scheme crossing are unlikely to be influenced by Agden Brook, that is located approximately 500m downstream of the crossing and a difference in ground level of approximately 3m based on the available DTM data.

Hydrological description

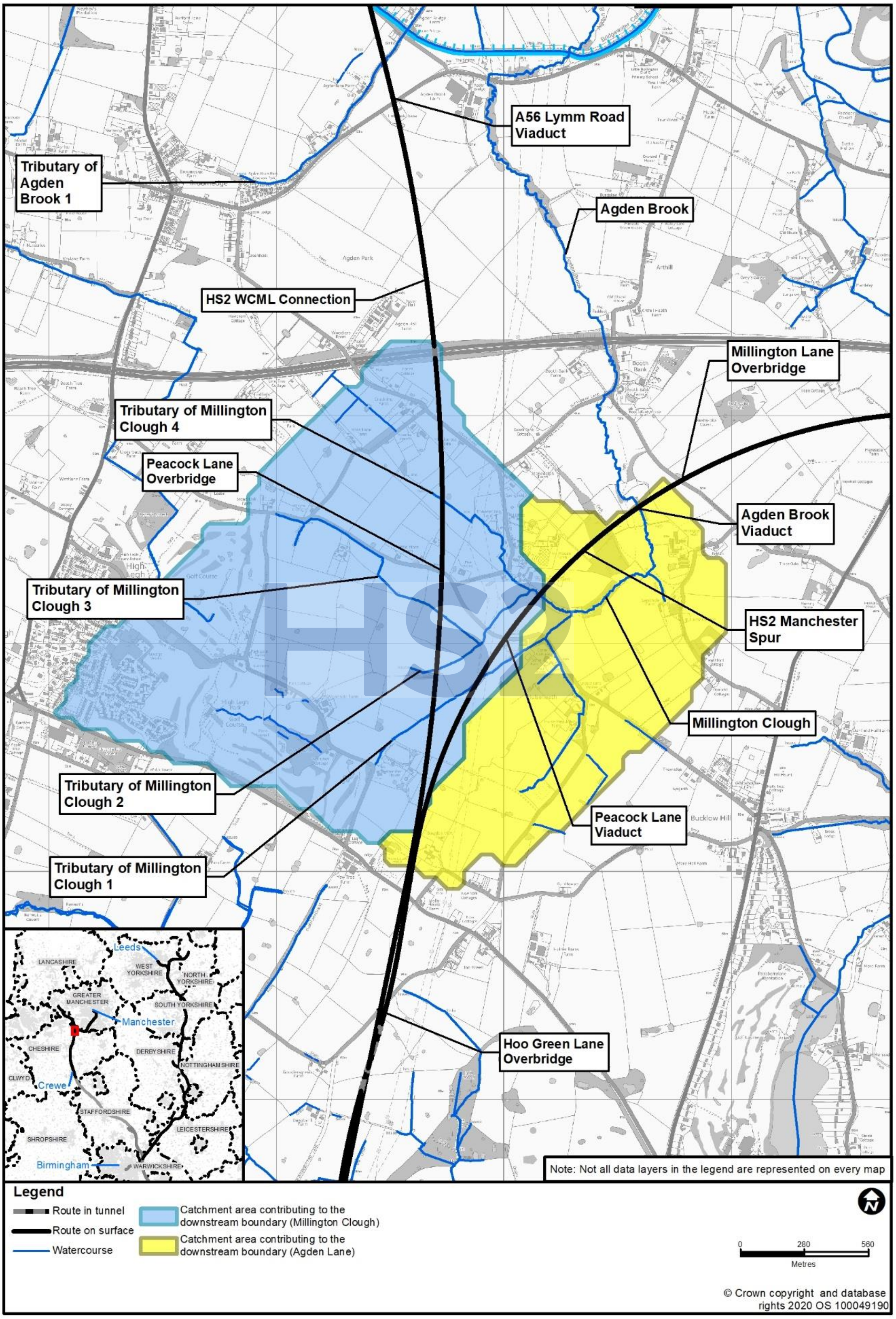
2.2.4 Millington Clough originates approximately 480m south of Little Moss Farm and is fed by tributaries of Millington Clough 1, 2, 3 and 4. Figure 2 shows the Millington Clough catchment (in blue) contributing to the crossing of the HS2 Manchester spur of the Proposed Scheme. Downstream of this point (the yellow catchment) the catchment contributes to the Agden Brook viaduct crossing of the HS2 Manchester spur.

2.2.5 There are no gauging stations present within the catchment[9].

2.2.6 Standard annual average rainfall for the catchment is 824mm[9].

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

Figure 2: Millington Clough catchment area



Proposed Scheme

2.2.7 The HS2 Manchester spur crosses Millington Clough main river with the Millington Clough underbridge. A second crossing of Millington Clough is proposed approximately 17m downstream where the river passes beneath a new access road under the Millington Clough offline overbridge. The Proposed Scheme crosses Agden Brook, 500m downstream on the Agden Brook viaduct.

2.2.8 Crossings of the tributaries of Millington Clough 1, 2, 3 and 4 on the HS2 West Coast Main Line (WCML) connection are not considered in this modelling assessment due to realignments of these tributaries as part of the Proposed Scheme. Further details on the Proposed Scheme can be found in Volume 2, MA03 Map Book: map CT-06-321 and CT-06-351.

Features of note

2.2.9 Tributary of Millington Clough 2 appears to be a spring that feeds into a series of four ponds. Approximately 350m downstream from this source, Tributary of Millington Clough 3 converges with Tributary of Millington Clough 2. The source of Millington Clough is at the confluence of Tributary of Millington Clough 4 and Tributary of Millington Clough 2. Tributary of Millington Clough 1 converges with Millington Clough approximately 230m downstream of the source of Millington Clough.

2.3 Existing understanding of flood risk

Flood mechanisms

2.3.1 The Environment Agency flood map[10] are only available for the catchment approximately 240m downstream of the Proposed Scheme crossing of the HS2 Manchester Spur. Where available, the Environment Agency Flood Zones appear to be confined within the banks of Millington Clough. The RoFSW dataset shows a similar extent to the flood zones along this reach.

2.3.2 Upstream of the Proposed Scheme crossing of the Manchester spur, the RoFSW indicates 50m to 100m wide flood extents following the approximate alignment of the Millington Clough tributaries, as shown in Figure 1. It also highlights the local depressions within the topography. The 50m to 100m wide flood extent is likely due to the insufficient channel capacity in the 1.0% flood event.

[10] Environment Agency (2021), *Flood Map for Planning (Rivers and Sea) - Areas Benefiting from Defences*. Available online at: https://data.gov.uk/dataset/eaa328e7-2eea-4cbf-bd6b-c66121981ba1/flood-map-for-planning-rivers-and-sea-areas-benefiting-from-defences.

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 local SFRA, PFRA, or Section 19[11] flood investigation reports.

Availability of existing hydraulic models

2.3.5 Available information, that includes information from the Environment Agency, does not indicate the existence of fluvial hydraulic models for Millington Clough and its tributaries.

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 at the detailed design stage, in accordance with HS2 Ltd requirements, a site visit will be undertaken by a hydraulic modeller to ensure a site-specific topographic survey can be developed.

[11] *Flood and Water Management Act 2010*, Section 19. London. Her Majesty's Stationary Office. Available online at: http://www.legislation.gov.uk/ukpga/2010/29/contents.

3 Model approach and justification

3.1 Model conceptualisation

3.1.1 A 2D hydraulic modelling approach was chosen for the Millington Clough study area as no channel survey data was available to be able to model the watercourses in 1D.

3.1.2 Where an existing culvert could impact on the sizing of the Proposed Scheme crossings or the impact from the Proposed Scheme could be affected by these existing culverts, the culverts were modelled with assumed dimensions. This approach was based on engineering judgment, using 1.2m pipe sizes. Sensitivity tests were undertaken to assess the significance of the assumed existing culvert sizes by increasing the culvert sizes to 1.4m, and by assuming the culverts were completely blocked. The results indicate that the modelling results are not sensitive to the assumed existing culvert size. There is no increase in flood risk to nearby property or the Proposed Scheme and increases to peak flood levels only occur in the immediate vicinity of the blocked culvert with the effects quickly attenuated by the floodplain.

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

3.1.4 1D elements have been included in the hydraulic model for the existing culverts beneath Back Lane and Peacock Lane.

3.1.5 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 Proposed Scheme.

3.1.6 High resolution 0.2m to 1m LiDAR (Light Detection and Ranging) data have 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, underestimated peak flows at the crossing but higher modelled peak water levels, as well an overestimation of out-of-bank flooding. The latter could lead to an overestimation of potential flood storage attenuation (if required). However, this overestimation applies to both the baseline and scheme modelling, and are such the relative changes would still be reliable. This is a conservative approach that 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 4.0.3.8010) has been used. The use of Infoworks ICM is in line with standard practice to use the latest available software at the time modelling commenced. 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 the detailed design stage.

3.4 Input data

3.4.1 The elevation data for the study area was produced using 0.2m grid LiDAR DTM flown specifically for HS2 Ltd and covers 500m either side of the route of the Proposed Scheme. Where required, additional 1m and 5m grid LiDAR data provided by the Environment Agency was 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 Millington Clough and its tributaries. Given the small catchment size (2.6km2) at the Proposed Scheme crossings of the Manchester spur, a surface water modelling approach has been adopted, where direct net rainfall is applied to the 2D domain. The small upstream catchments for tributaries of Millington Clough 1, 2, 3 and 4 have not been modelled in the 2D domain. In the baseline model these inflows have been included as four sub-catchment point inflows. For the purpose of investigating channel diversion options for the Proposed Scheme, three of the four inflows (tributaries of Millington Clough 1, 2 and 3) have been combined to a single inflow and inserted just upstream of Peacock Lane.

4.1.2 The critical ReFH2 storm duration of 5.5hrs for the catchment upstream of the Proposed Scheme crossing has been used for estimating the rainfall hyetographs and point inflows. A winter profile has been adopted throughout the Proposed Scheme as it gives conservative estimates of peak water levels. ReFH2 uses the recently updated FEH9 rainfall database and parameters.

4.1.3 A hydrological verification has been undertaken by estimating catchment hydrology ReFH2 peak flow estimates at the Proposed Scheme crossing. This is to check that the surface water modelled peak flows are similar or greater, than the ReFH2 peak flow estimates. ReFH2 flow calculations are based on relevant catchment descriptors, that were obtained from the FEH Web Service database9.

4.1.4 In order to obtain similar peak flows between the modelled and ReFH2 estimates, a runoff coefficient of 0.85 was applied in the hydraulic model. Although this is higher than the FEH standard percentage runoff (SPRHOST) value of 0.38 for the catchment and leads to a greater volume of water in the watercourse, it provided the best correlation between the modelled and ReFH2 peak flows. The high runoff coefficient value applied in the modelling likely represents limitations in the definition of the channel bathymetry, causing reduced channel conveyance (as discussed in Section 3.1).

4.1.5 Table 1 shows the peak flows derived from the surface water modelling with Infoworks ICM at the proposed crossing (Location A in Figure 3) and their comparison with the ReFH2 peak flow estimates.

Table 1: Peak flows at the Millington Clough crossing

AEP	Return period	InfoWorks Peak flow (m^3/s)	ReFH2
5.0%	20 year	1.3	1.5
1.0%	100 year	2.3	2.3
1.0% + CC	100 year + CC	3.9	3.3
0.1%	1000 year	4.9	4.1

4.1.6 It is concluded that the adopted surface modelling approach produces a more conservative estimate of peak river flow than the estimates from the ReFH2. As this assessment is precautionary, further assessment at the detailed design stage will include refining the understanding of the flood risks and impacts and reducing the conservatism within the precautionary approach.

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 number of culverts are located within the 2D domain and these 1D elements have been modelled for the existing tributary culverts beneath Back Lane, Peacock Lane and Chapel Lane.

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 $4m^2$. 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 The four upstream catchment areas (tributaries of Millington Clough 1, 2, 3 and 4) have been modelled as point inflows in the baseline model. In the Proposed Scheme model, the catchments for tributaries of Millington Clough 1, 2 and 3 have been combined into a single inflow. This is to allow for realignments/diversions of the watercourses as part of the Proposed Scheme. In addition, a sub-catchment inflow for Tributary of Millington Clough 4 is entered as a separate inflow.

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.

Key structures

4.2.6 The review of the model impact on peak flood depths in and Figure A 1 and Figure A 2 indicates that there are no key structures where the size of the Proposed Scheme crossing could be affected or the outcome of the impact assessment could be affected as a result of the Proposed Scheme. This is the case firstly because the Proposed Scheme crossings have not been sized for capacity but are much larger, to allow for vehicular access. Secondly the only location where there is a major increase in peak flood depth is caused by the Proposed Scheme embankment.

4.2.7 Modelled structures and their dimensions that have been included in the hydraulic model 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: Key structures included within the modelled extent

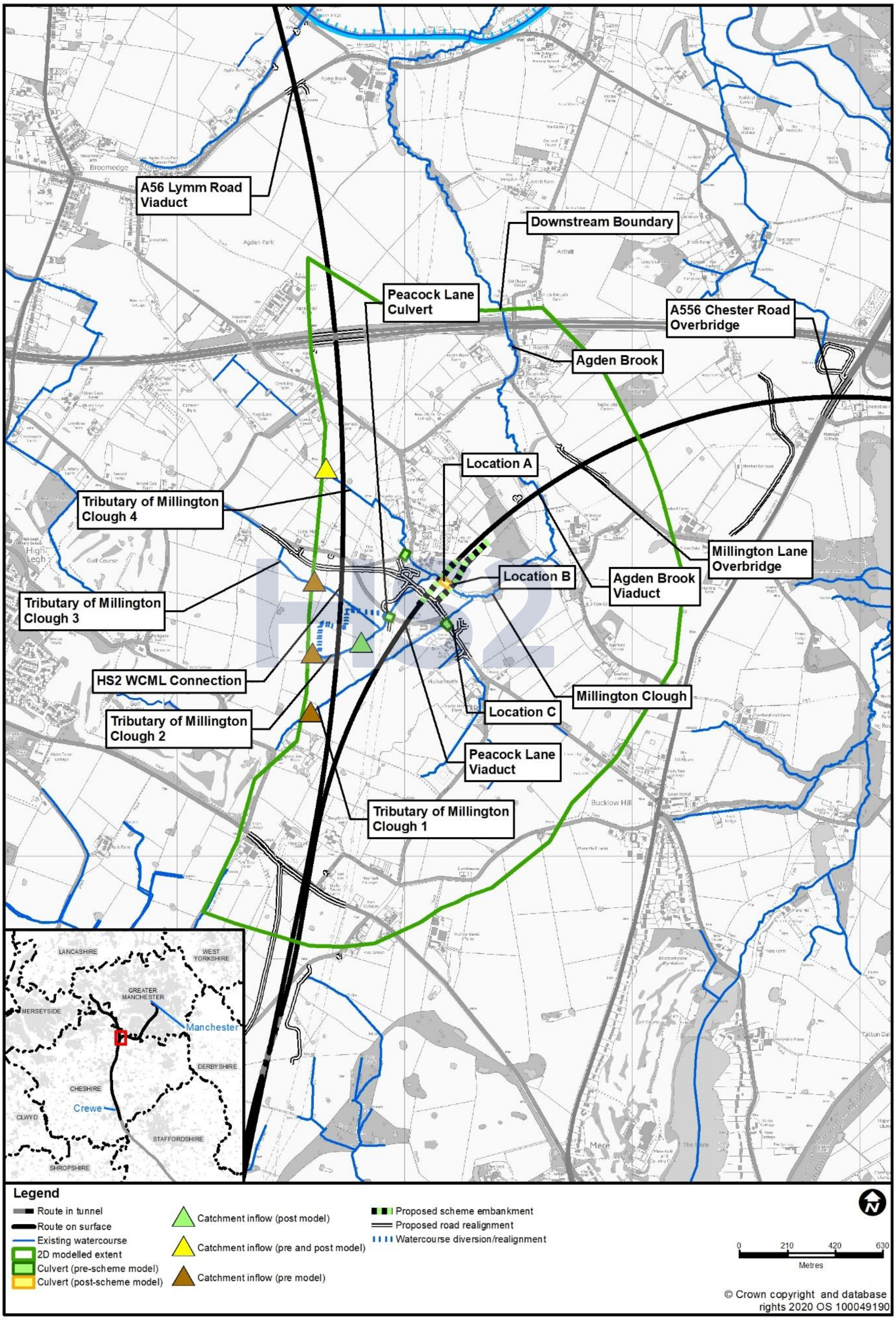
Structure reference	Structure description	Modelling representation and justification
Tributary of Millington Clough 2 beneath Peacock Lane	0.9m diameter	Culvert modelled as a circular pipe. Dimensions assumed from LiDAR and aerial photography
Tributary of Millington Clough 4, that runs parallel to Thowler Lane and crosses Back Lane	0.9m diameter	Culvert modelled as a circular pipe. Dimensions assumed from LiDAR and aerial photography
Tributary of Millington Clough 1 beneath Chapel Lane	0.9m diameter	Culvert modelled as a circular pipe. Dimensions assumed from LiDAR and aerial photography

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].

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

Figure 3: Model schematic



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.

4.3.3 The Proposed Scheme embankment has been modelled as a raised 2D impermeable wall along the Proposed Scheme footprint for the purpose of impeding overland flows.

4.3.4 At the Manchester spur crossing of Millington Clough immediately south of Moss House Farm (Location A in Figure 3), an opening in the Proposed Scheme embankment wall was made. The modelling of the crossing as an open area instead of a culvert is considered acceptable as the Proposed Scheme crossing is 5m wide and free flow conditions take place through the culvert for all the modelled events. Immediately downstream of the HS2 Manchester spur crossing (Location B in Figure 3) Millington Clough will intersect a new road link via a twin box structure, each box culvert being 7m wide and this has been modelled as a 'cut' in the DTM.

4.3.5 Approximately 150m downstream of the existing Peacock Lane culvert, a new culvert will be required to convey water under the realigned Peacock Lane and it will be designed to HS2 Technical Standards. The realignment and the new crossing have not been modelled.

4.3.6 The Chapel Lane highway realignment will cross Tributary of Millington Clough 1 (at location C in Figure 3). The baseline and Proposed Scheme models include the existing culvert with its current dimensions. The model will be updated with the Proposed Scheme culvert dimensions at the detailed design stage.

Viaduct

4.3.7 At the viaduct crossing of Agden Brook by the HS2 Manchester spur, north-west of Millington Hall, an opening in the Proposed Scheme embankment wall was made. The modelling of the crossing as an open span for the viaduct is adequate as the proposed crossing is 120m wide. Viaduct piers have not been modelled at this stage as any impact from these will be minimal and replacement floodplain storage calculated to compensate for the loss of floodplain caused by the piers has been incorporated in the design.

Topographic changes

4.3.8 The Proposed Scheme embankment has been modelled as a high impermeable wall that approximately follows the centre line of the Proposed Scheme and proposed width of the Scheme based on the details shown in Volume 2, MA03 Map Book: map CT-06-321 and CT-06-351.

Channel realignments and diversions

4.3.9 No realignment of Millington Clough is required at the HS2 Manchester spur crossing or at the downstream crossing at Agden Brook viaduct.

4.3.10 However, tributaries of Millington Clough 1, 2, 3 and 4 will be subject to realignment and diversion with the same capacity as the existing reaches, to accommodate the proposed HS2 WCML connection and HS2 Manchester spur crossings. The realignments and diversions consist of:

- west of the HS2 WCML connection, Tributary of Millington Clough 1 will be diverted north through a drain to the headwaters of Tributary of Millington Clough 2;
- Tributary of Millington Clough 3 will be diverted south through a drain to the headwaters of Tributary of Millington Clough 2;
- Tributary of Millington Clough 2 will be realigned through a culvert under the HS2 WCML connection, then through an extended 210m long culvert north to a realigned open channel, to eventually join its original alignment approximately 40m north-east of Peacock Lane; and
- Tributary of Millington Clough 4 will cross the HS2 WCML connection under a bridge adjacent to its current crossing location, through a land drain in a southerly direction, to join its original alignment approximately 100m east of the route.

4.3.11 The realignments have not been modelled at this stage due to the 2D nature of the modelling approach. To account for the change in flows due to the watercourse realignments, the point inflow boundaries in the baseline model were combined upstream of the existing culvert at Peacock Lane. For the model schematisation please refer to

Production of flood extents

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

Modelling assumptions made

4.3.13 The Proposed Scheme crossings of Tributary of Millington Clough 1 (WCML connection and HS2 Manchester spur crossings) and tributaries of Millington Clough 2 and 3 (HS2 WCML connection crossings) have not been modelled. These crossings are located at the top of the catchment and minimal culvert sizing will be sufficient to convey peak flows from the upper catchment. There is therefore unlikely to be any significant changes in flows downstream or water levels upstream.

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

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

4.3.16 The dimensions of key structures are not based on visual inspection or survey. However, they are considered reasonable when compared to the channel cross section understood from LiDAR and aerial photography.

4.4 Climate change

4.4.1 The climate change allowance for the direct rainfall and point inflow components of the hydrology for the tributaries of Millington Clough is a 40% increase in peak rainfall intensity and peak river flow, as the catchment is less than $5km^2$ in size.

4.4.2 The H++ allowance for Millington Clough is a 60% increase in input peak rainfall intensity and peak river flows for the purpose of sensitivity analysis.

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 input peak rainfall intensity and peak river inflows.

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 5.0% AEP and the 1.0% AEP + CC events are presented in the Volume 5, Water Resources Map Book: maps WR-05-319/WR-05-312a and WR-06-319/ WR-06-312a respectively.

5.1.4 The modelled impact of the Proposed Scheme, without mitigation, on peak flood levels for the 1.0% AEP + CC indicates the potential for:

- a decrease of less than 10mm in peak flood level on tributaries of Millington Clough 2 and 3 between the proposed HS2 WCML connection and HS2 Manchester spur;
- an increase of up to 600mm on the north side of the HS2 Manchester spur at Moss House Farm;
- an increase of approximately 360mm, 100m to the south-west of the proposed Agden Brook viaduct;
- an increase in peak flood level of up to 50mm as a result of combining the flows from tributaries of Millington Clough 1, 2 and 3. This is not in the vicinity of the Proposed Scheme and is not an impact of the Proposed Scheme; and
- a decrease of up to 14mm in peak flood level in Agden Brook upstream and downstream of the proposed Agden Brook viaduct.

5.1.5 The decreases in peak flood levels at Agden Brook viaduct are due to runoff being intercepted by the Proposed Scheme embankment upstream of the viaduct, on the north side of the HS2 Manchester spur. The runoff is cut off at the embankment, which results in less floodwater reaching the Agden Brook viaduct. It should be noted that the intercepted runoff will be intercepted by a proposed 5m wide ditch at the toe of the embankment, which will discharge just downstream of the Agden Brook viaduct. It is anticipated therefore that the land drain ditch will result in the removal of the ponding shown in the model and also there will be no longer a reduction in flood risk at the Agden Brook viaduct.

5.1.6 Model results indicate that the current proposed design achieves the freeboard requirements for both the top of rail level and Proposed Scheme watercourse crossing soffits. This has been confirmed by checking the design peak water level (51.07m AOD) against the culvert soffit (53.2m AOD) and the top of rail level (63m 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 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 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 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 No sensitivity tests have 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 at the detailed design stage.

6.4.3 Existing culverts were modelled with assumed dimensions at locations where there was a possibility that a culvert would influence the sizing of the Proposed Scheme crossings or if the impact from the Proposed Scheme would be affected by the presence of the culvert. This approach was based on engineering judgment, using 1.2m pipe sizes. To test the significance of this assumption, sensitivity tests have been undertaken by changing the pipe sizes of existing culverts to 1.4m and also by assuming that all these are blocked. The results indicate that there is no increase in flood risk to with only the immediate vicinity of the blockage location experiencing an increase in flood level with effects quickly attenuated by the floodplain without affecting any nearby property or the Proposed Scheme crossing.

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

6.5 Blockage analysis

6.5.1 Blockage of 50% at the upstream and downstream crossings of Millington Clough was simulated by reducing the width of the crossings 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 an increase in peak water levels of 27mm at the crossings of Millington Clough.

6.5.2 The blockage test confirms that the Proposed Scheme design ensures a freeboard of a minimum of 1m to the rail track in a 0.1% AEP event, both upstream and downstream of the Millington Clough crossing. Water levels of 51.27mAOD upstream and 50.89mAOD downstream of the Proposed Scheme crossing were modelled, compared to a track level of approximately 63mAOD, giving an approximate freeboard of 12m.

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 The model does not include the proposed highway realignment of Peacock Lane between the HS2 WCML connection and HS2 Manchester spur. Therefore, potential flood impacts caused by the new road are not assessed.

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

8 Conclusions and recommendations

8.1.1 The model results indicate that there will be an approximate 10mm decrease in peak flood levels on tributaries of Millington Clough 2 and 3, between the HS2 WCML connection and HS2 Manchester spur.

8.1.2 Localised increases in peak flood levels (of up to 600mm) occur on the northern side of the Proposed Scheme as runoff from the land to the north is interrupted by the Proposed Scheme embankment. This results in less runoff reaching the Millington Clough/Agden Brook watercourse and being conveyed downstream. As a result of this, the model shows a decrease in the peak flood levels of up to a 14mm upstream and downstream of the Agden Brook viaduct. These flow paths that are not associated with a watercourse and result in a build-up of water at the Proposed Scheme embankment. These will be mitigated by the toe drains at the foot of the embankment, with the flows passed forward into Agden Brook just upstream of the Agden Brook viaduct.

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

8.1.4 The model results indicate that the Proposed Scheme achieves the freeboard requirements for both the top of rail level and the Proposed Scheme watercourse crossing soffits.

8.1.5 At detailed design stage, 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 as described in Section 5, see Figure A 1 and Figure A 2.

Figure A 1: Millington Clough impact map for 5.0% AEP (1 in 20 year)

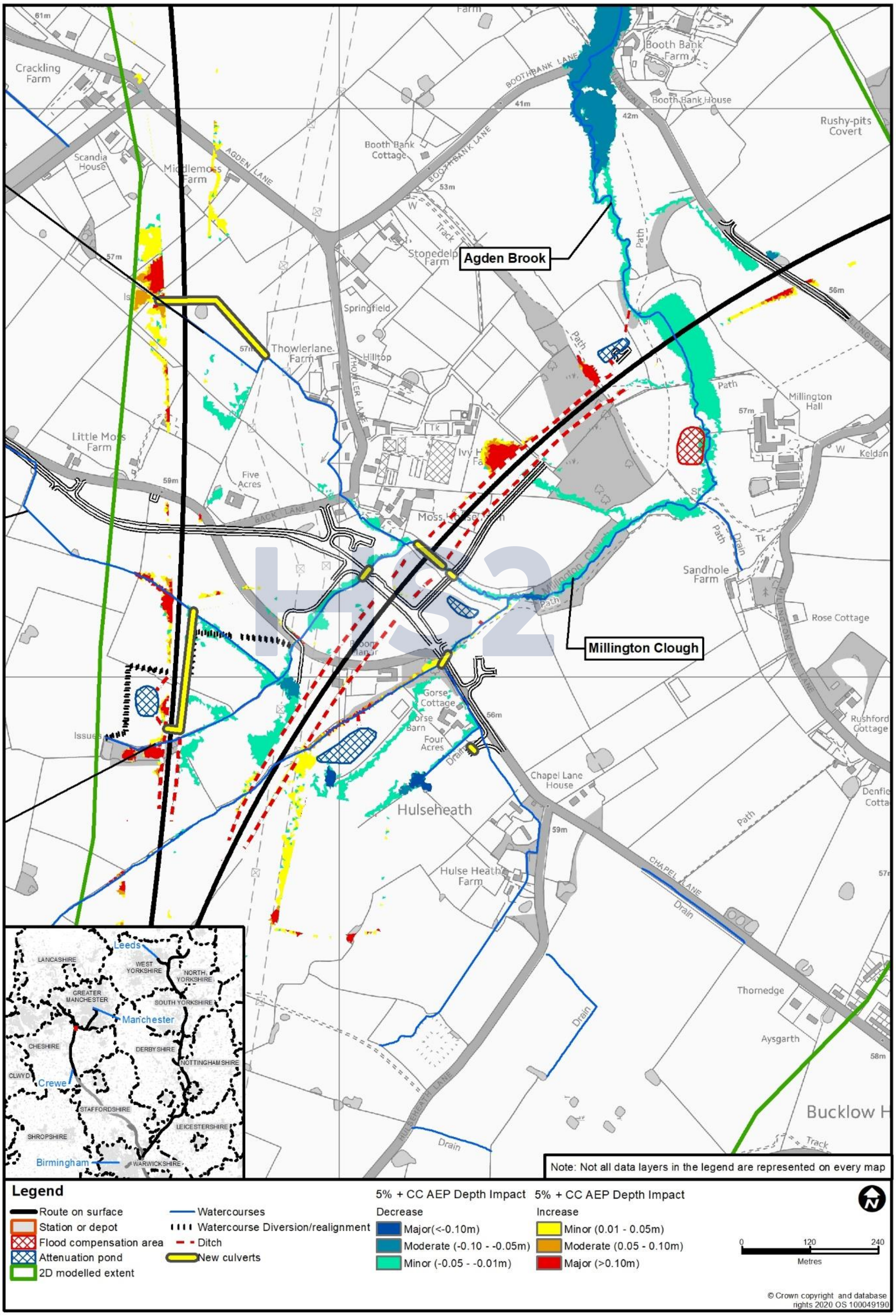
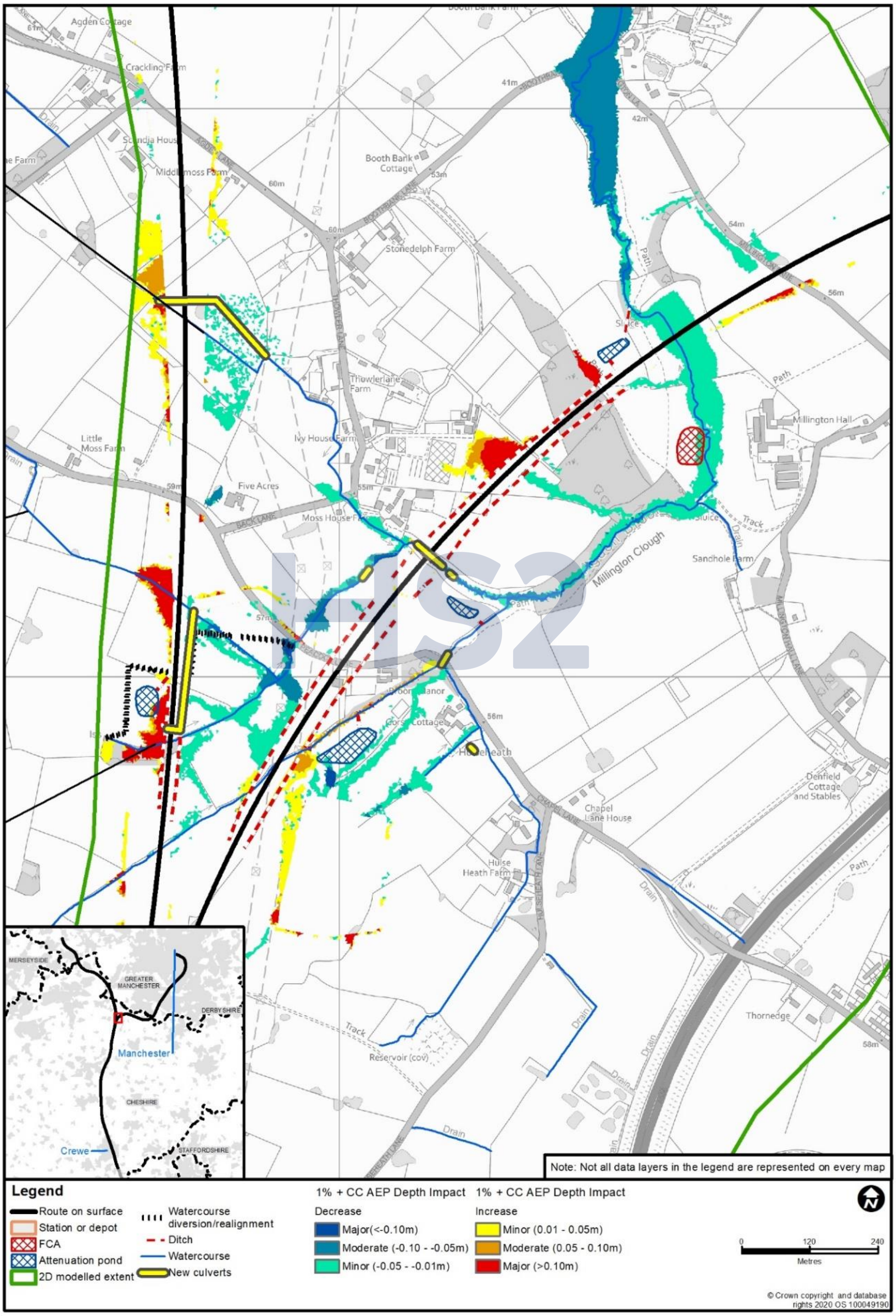


Figure A 2: Millington Clough impact map for 1.0% AEP + CC event (1 in 100 year plus climate change)



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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