In Parliament – Session 2021 - 2022

HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix WR-006-00006

Water resources and flood risk

MA05: Risley to Bamfurlong

Hydraulic modelling report - Hey Brook

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Department for Transport

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1 Introduction

1.1 Background

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

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

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

- hydraulic modelling report – Tributaries of Holcroft Lane Brook 2 to 4 (Volume 5: WR-006-00003);
- hydraulic modelling report – Small Brook (Volume 5: WR-006-00004); and
- hydraulic modelling report – Carr Brook (Volume 5: WR-006-00005).

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

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

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

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

- water resources assessment baseline data that is reported per community area (BID WR-004-0MA05)[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 Hey Brook in the vicinity of the A573 Wigan Road realignment to simulate peak flood levels, with and without the Proposed

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

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

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

1.2.2 The outputs from the study have been used to inform the flood risk assessment for the Risley to Bamfurlong area, that is reported in Volume 5 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 (for example: viaducts, bridges, culverts etc) takes account of flood risk issues, as detailed in the Environmental Impact Assessment Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-00001) Technical Note: Flood risk.

1.3 Objectives

1.3.1 The objectives of this study were to:

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

1.4 Justification of approach

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

1.4.2 Hey Brook runs to the east of the Proposed Scheme. The watercourse is classified as a main river with associated Environment Agency flood zone information available. The Environment Agency flood zones are approximately 165m wide at the proposed crossing of the A573 Wigan Road realignment.

1.4.3 The A573 Wigan Road and agricultural land are the receptors upstream and downstream of the proposed A573 Wigan Road realignment. Due to the large size of the catchment, an upstream inflow to the model, representing the contribution of the Hey Brook catchment, has been applied. This is combined with direct rainfall in the 2D domain in the vicinity of the proposed crossing of the A573 Wigan Road realignment.

1.4.4 The upstream inflow has been estimated using the Flood Estimation Handbook (FEH) Revitalised Flood Hydrograph 2 (ReFH2) software with the direct rainfall hyetograph consistent with the hyetograph used to derive the upstream inflow. The floodplain on the right bank of Hey Brook in the vicinity of the A573 Wigan Road realignment has the potential to convey significant out-of-bank flows during high flow events as well as provide significant additional flood storage. The ReFH2 peak flow estimates generated in this area are likely to not account for this flow attenuation and will therefore be overestimated when compared to the modelled flows in Hey Brook.

1.5 Scope

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

1.5.2 This report focuses on a 1.5km reach of Hey Brook extending upstream and downstream of the proposed crossing of the A573 Wigan Road realignment. The proposed crossing comprises a bridge for the A573 Wigan Road realignment with a number of piers, located within the floodplain. A description of the location and type of scheme is provided in Section 2.

1.5.3 The scope of the report includes:

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

2 Qualitative description of flood response

2.1 Sources of information

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

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

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

- Wigan Preliminary Flood Risk Assessment (PFRA) (2011)[5];
- Wigan Strategic Flood Risk Assessment (SFRA) (2010)[6]; and
- Wigan Local Flood Risk Management Strategy (LFRMS) (2014)[7].

2.2 Description of the study area

Study area

2.2.1 Hey Brook discharges into Pennington Flash that is located approximately 2.5km downstream from the proposed crossing of the A573 Wigan Road realignment.

2.2.2 Figure 1 shows the 1.4km long reach of Hey Brook in the study area. The upstream model boundary is located 400m downstream from the A58. The downstream boundary is located immediately upstream of the confluence with Nan Holes Brook. Based on a review of structures and engineering judgement the boundaries are anticipated to be sufficiently up and downstream so as not to unduly affect model results.

2.2.3 The primary hydraulic control is the existing A573 Wigan Road, that is located approximately 200m downstream of the proposed A573 Wigan Road realignment crossing. The proposed A573 Wigan Road realignment is at a sufficient distance upstream of the downstream

[3] Environment Agency (2021), *Flood map for planning*. Available online at: https://flood-map-for-planning.service.gov.uk.
[4] Environment Agency (2021), *Long-term flood risk information.* Available online at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map.
[5] JBA Consulting (2011), *Wigan Preliminary Flood Risk Assessment.* Available online at: https://www.wigan.gov.uk/Resident/Crime-Emergencies/Flooding/Flood-investigations.aspx.
[6] JBA Consulting (2010), *Wigan Strategic Flood Risk.* Available online at: *https://www.wigan.gov.uk/Council/Strategies-Plans-and-Policies/Planning/Local-plan/Background/Key-Local-Studies/StrategicFloodRiskAssessment.aspx*.
[7] Wigan Council (2014), *Wigan Local Flood Risk Management Strategy.* Available online at: https://www.wigan.gov.uk/Resident/Crime-Emergencies/Flooding/Local-Flood-Risk-Management-Strategy.aspx.

boundary that the water levels will not be influenced by backwater effects from Pennington Flash.

Hydrological description

2.2.4 Hey Brook originates north of Westhoughton. There are no gauging stations present within the Hey Brook catchment[8].

2.2.5 Standard annual average rainfall for the catchment (Figure 2) at the model downstream boundary is 921mm[8].

2.2.6 The catchment area for Hey Brook as shown in Figure 2 is 23.63km^2. The large catchment area contributing to the upstream end of the model results in a significant flow input into the Hey Brook model[8].

Proposed Scheme

2.2.7 The proposed A573 Wigan Road realignment crosses Hey Brook with a new bridge, west of the Leeds and Liverpool Canal and east of the Proposed Scheme alignment. Further details of the Proposed Scheme can be found in the Volume 2, MA05 Map Book, Map Series CT-06-333.

Features of note

2.2.8 Inspection of the Environment Agency flood zones and Light Detection And Ranging (LiDAR) data suggest that Hey Brook is likely to overtop the existing A573 Wigan Road for a distance of approximately 250m in the 1.0% AEP and 0.1% AEP events. This is because the road is at grade and within a large floodplain.

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

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

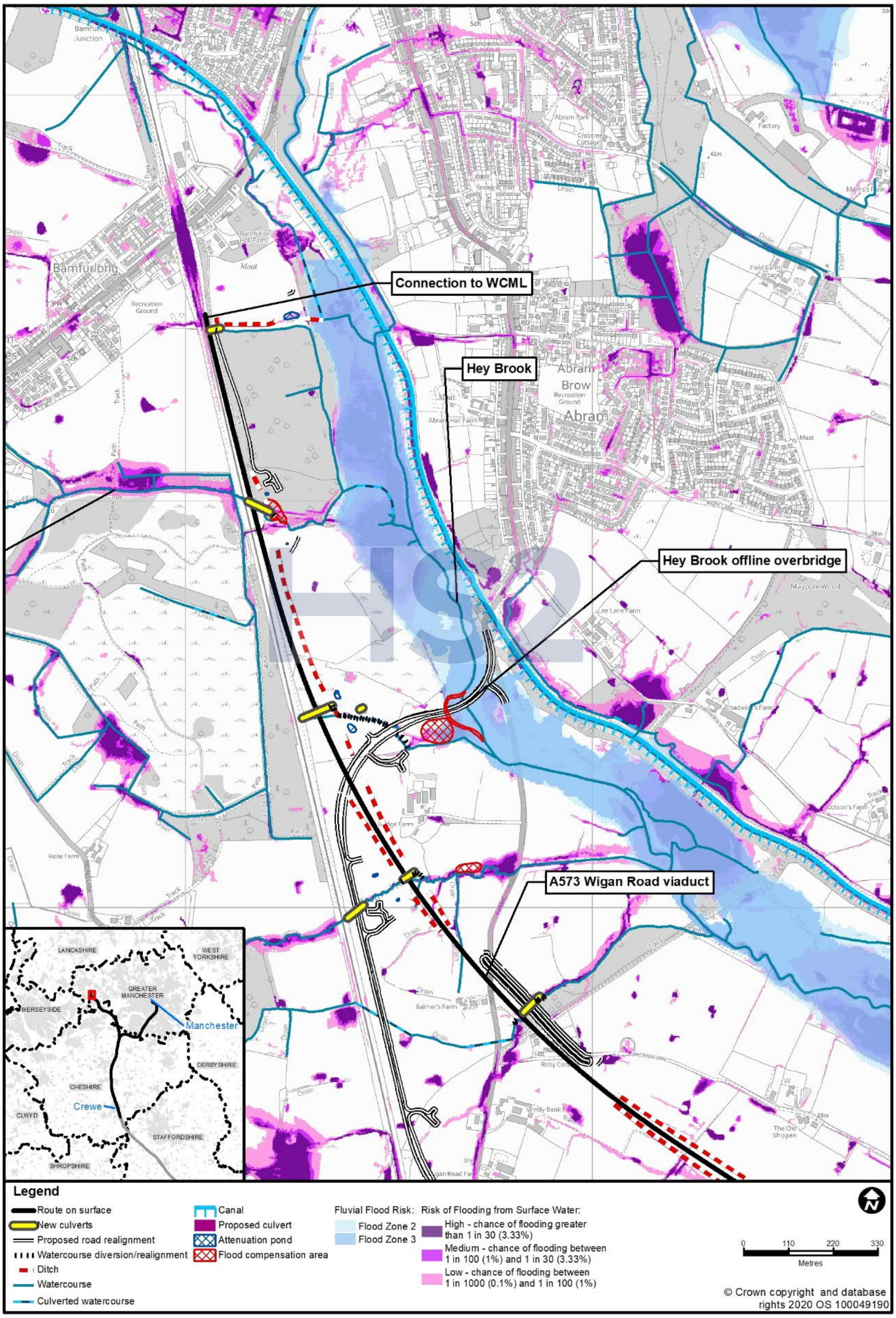
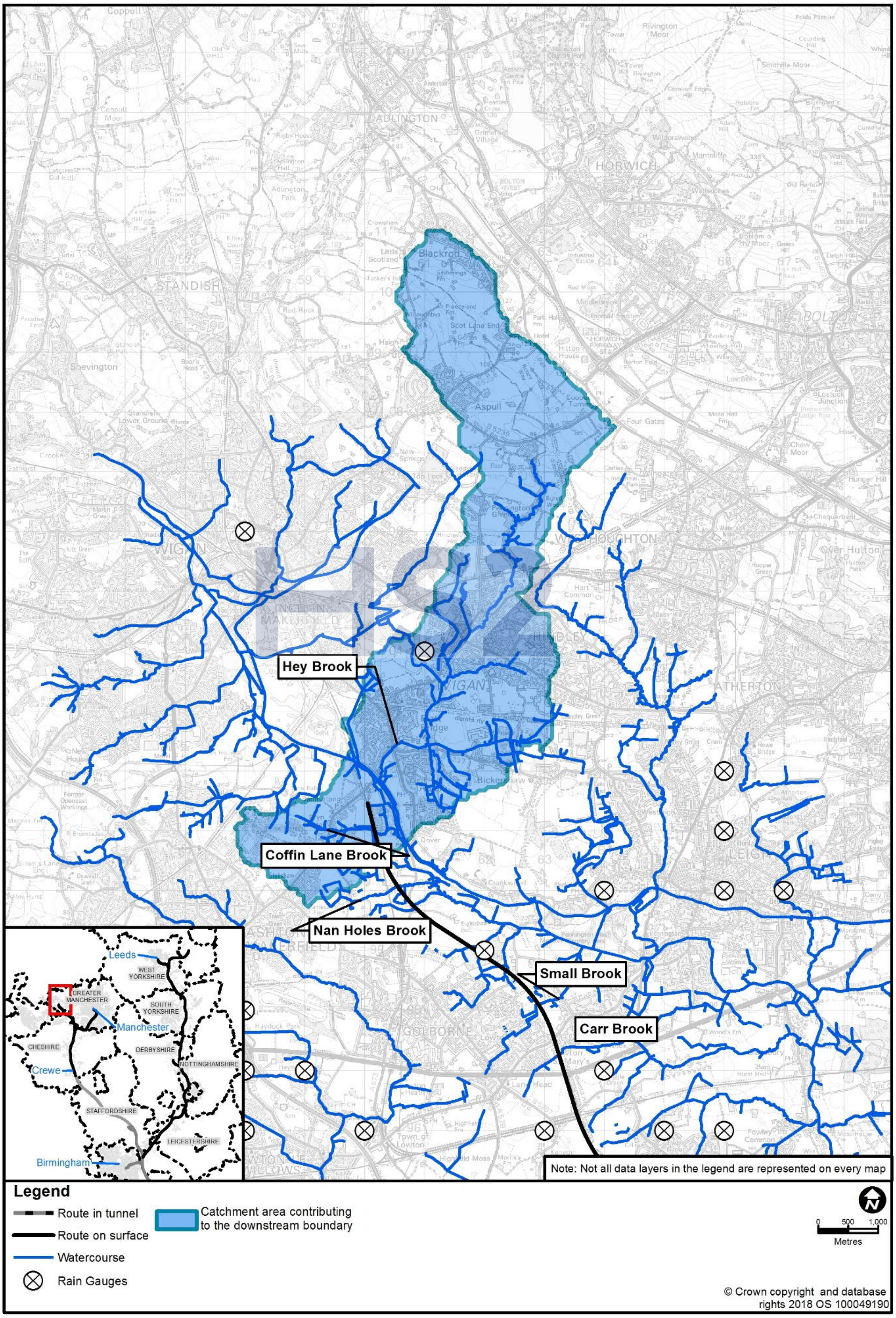


Figure 2: Hey Brook river catchment area



2.3 Existing understanding of flood risk

Flood mechanisms

2.3.1 Based on the Environment Agency flood zone data and the modelling undertaken for the baseline 1.0% AEP and 0.1% AEP events, predicted flooding is not confined to the channel but propagates across the Hey Brook floodplain as the channel is unable to convey the high flows, as shown Figure 1.

2.3.2 Figure 3 presents cross-sections of Hey Brook and its floodplain surrounding the A573 Wigan Road realignment (presented from left to right bank). This shows the Hey Brook right bank floodplain to be approximately 150m wide.

2.3.3 The RoFSW dataset indicates a similar flood pattern to the Environment Agency flood zones and modelled results.

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

Analysis of historical flooding

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

Availability of existing hydraulic models

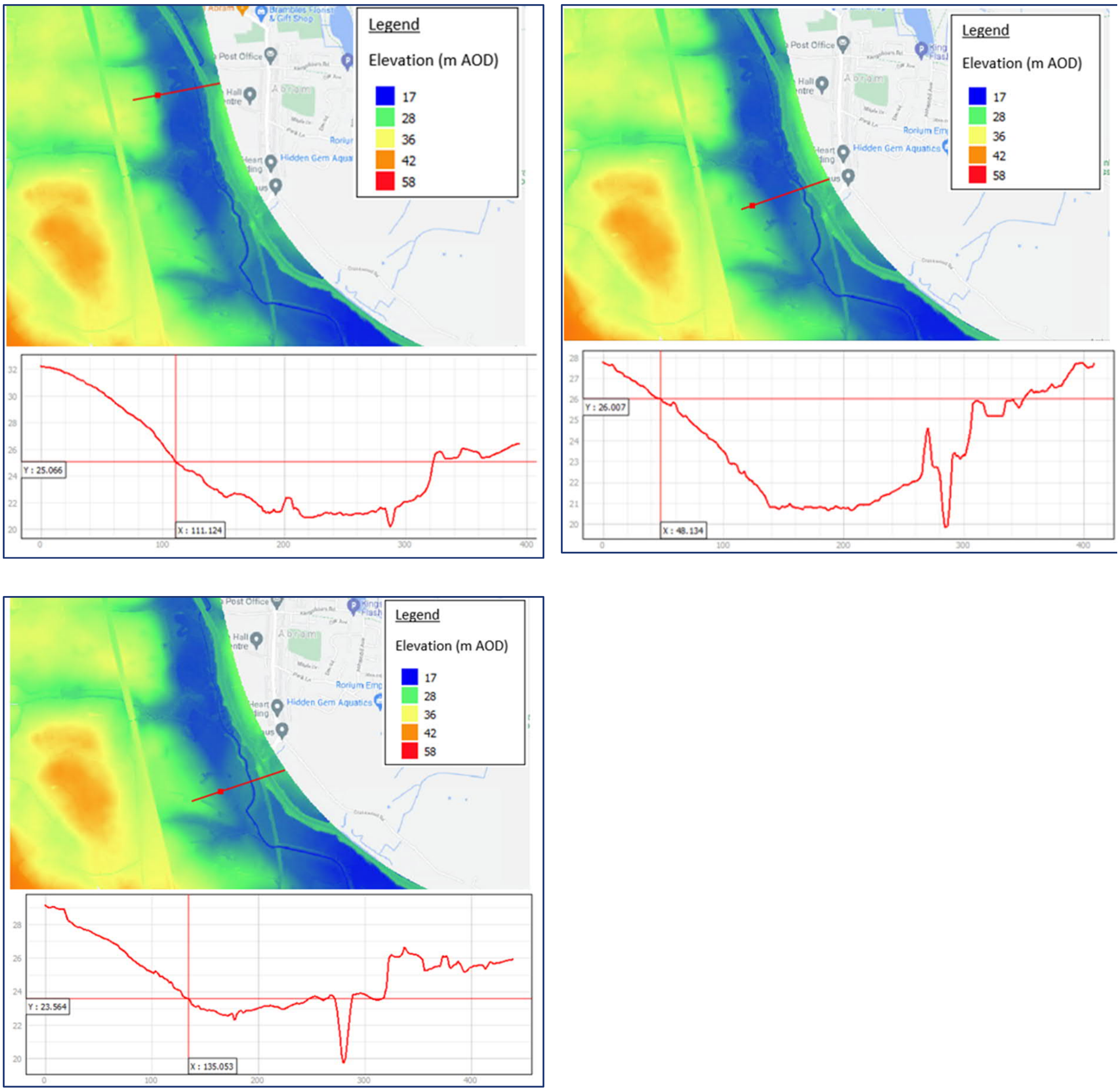
2.3.6 The Environment Agency model for Hey Brook was not available at the time of assessment.

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 the HS2 Ltd requirements, a site visit will be undertaken by a hydraulic modeller to ensure a site-specific survey brief can be developed.

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

Figure 3: Cross-section profiles of Hey Brook surrounding the road realignment



3 Model approach and justification

3.1 Model conceptualisation

3.1.1 A 2D hydraulic modelling approach was chosen for Hey Brook within a localised area ($0.58km^2$) surrounding the crossing of the A573 Wigan Road realignment. No 1D survey data was available to inform the model build.

3.1.2 Due to the large size of the Hey Brook catchment ($23.6km^2$), an upstream point inflow has been applied to represent the flow contribution of the catchment upstream of the localised 2D domain.

3.1.3 The 2D model domain has been extended sufficiently downstream to ensure that any effects caused by the model boundary do not impact water levels in the area of the Proposed Scheme. Similarly, the upstream model boundary is sufficiently far from the Proposed scheme to ensure the model accurately simulates out of bank flows as they approach the crossing.

3.1.4 High resolution 0.2m to 1m LiDAR data has been used to define the channel and to take account of the watercourse capacity and conveyance in the 2D model domain. 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 leading to an overestimation of potential flood storage attenuation (if required). 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 4.03.8010) has been used to apply the 2D modelling methodology. This methodology is in line with standard practice to use the latest available build at the time modelling commenced, while Inforworks ICM is industry standard software.

3.3 Topographic survey

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

3.4 Input data

3.4.1 The elevation data for the study area was produced using 0.2m grid LiDAR Digital Terrain Model (DTM) flown specifically for HS2 Ltd. Where required, additional 1m grid LiDAR DTM data provided by the Environment Agency was used in areas further away from the proposed crossing 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 Hey Brook. Within the 2D domain, rainfall hyetographs have been defined according to the latest FEH guidance. The point inflow that represents the Hey Brook catchment upstream of the 2D domain has been estimated using ReFH2 software. Considering the uncertainty in the ReFH2 flow estimates and the data limitations on the Hey Brook channel, no infiltration losses have been considered for the direct rainfall model domain.

4.1.2 The ReFH2 critical winter storm duration of 3.5 hours for the catchment upstream of the proposed crossing of the A573 Wigan Road realignment has been used for estimating both the rainfall hyetographs and the point inflow. A winter profile is considered a reasonable assumption in rural areas.

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

4.1.4 Table 1 shows the peak flows at the proposed crossing derived from modelling in Infoworks ICM and their comparison with the ReFH2 peak flow estimates. The results show that the calculated ReFH2 peak flows are 15% to 25% larger than the modelled peak flows that is due to the following factors:

- limitations in the representation of the channel geometry in the model as there is no detailed 1D survey data (therefore the capacity of the channel is underestimated resulting in more out-of-bank flow, bypassing the channel);
- exclusion of flow attenuation on the Hey Brook floodplain in the ReFH2 estimates; and
- to a smaller extent the effect of the attenuation of the proposed diversion which is a bridge and piers.

Table 1: Peak flows at the Hey Brook crossing

AEP	Return period	Peak flow (m^3/s)	
		Modelled	ReFH2
5.0%	20 year	17.0	19.6
1.0%	100 year	22.9	28.5
1.0% + CC (70% rainfall and flow)	100 year + CC (70% rainfall and flow)	40.8	48.3
0.1%	1000 year	40.9	48.5

4.1.5 The level of variation between the approaches is not considered significant due to the nature of this crossing (a free span bridge and bypass channel, which ensures the attenuation effect of the crossing is minimal). This variation is within the level of uncertainty based on the assumptions applied within the method, e.g. model resolution. The parameters used in this assessment will be refined during the detailed design stage when a greater understanding of the flood risks and impacts will be achieved.

4.2 Hydraulic model build - baseline model

4.2.1 Figure 4 shows the existing and proposed model schematic.

1D representation

4.2.2 1D elements were not required to represent the baseline model.

2D representation

4.2.3 The element size of the model is variable with the minimum and maximum element area set to $10m^2$ and $510m^2$ respectively. Element size and alignment for the 2D model mesh were optimised to ensure appropriate representation of the flow pathways whilst maintaining reasonable run times.

Inflow boundaries

4.2.4 An inflow boundary has been included to account for the Hey Brook catchment upstream of the proposed A573 Wigan Road realignment.

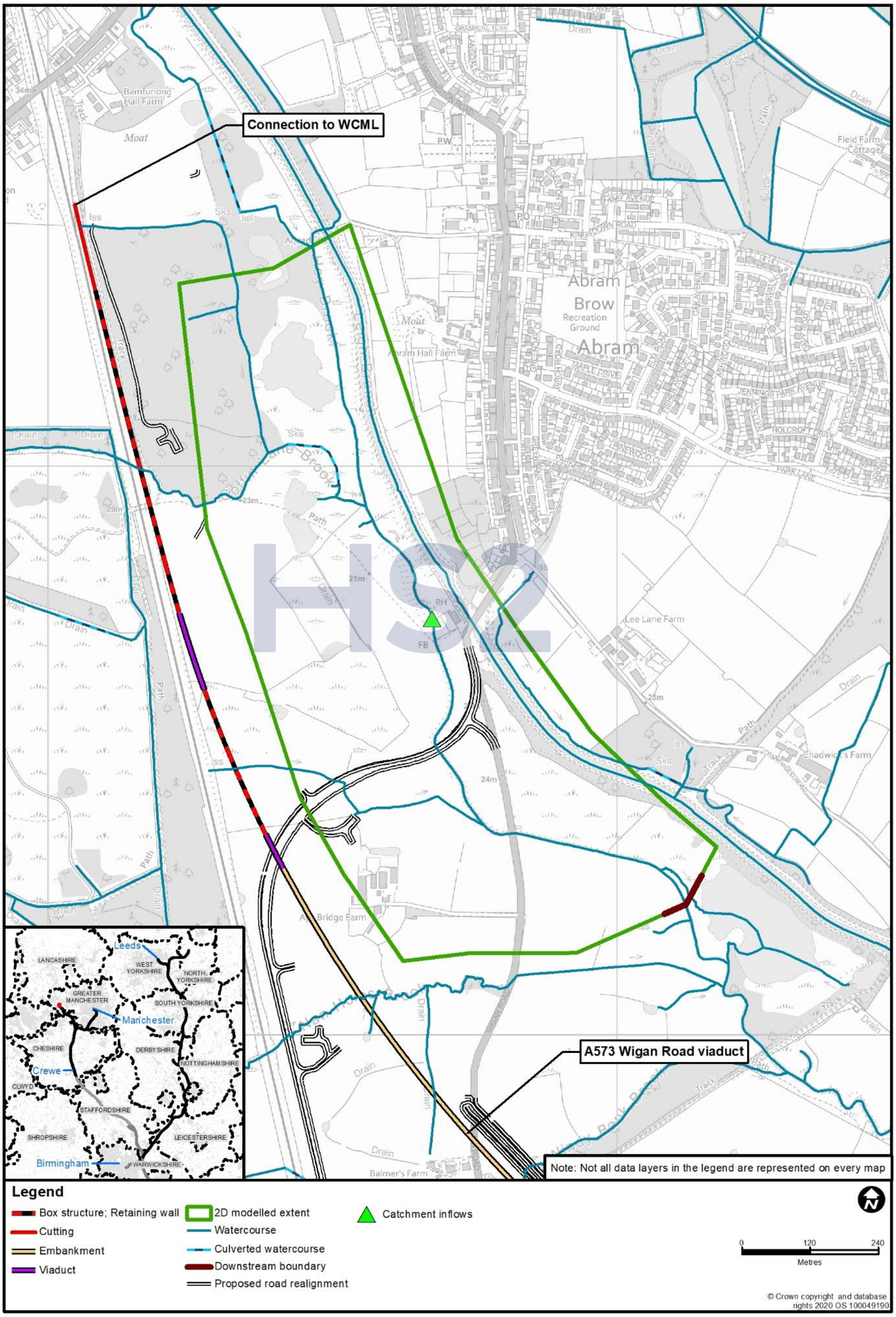
Downstream boundary

4.2.5 The downstream boundary is located immediately upstream of the confluence with Nan Holes Brook. Unrestricted flow out of the 2D domain has been set based on inspection of the LiDAR and mapping along the 2D domain boundary. The downstream boundary is a sufficient distance from the Proposed Scheme that flood waters cannot backup and impact on the zone of influence.

Key structures

4.2.6 No existing structures within the watercourses have been represented in the hydraulic model as these features are likely to be drowned out during relatively frequent flood events and therefore will not impact on the peak flood levels for the return periods assessed.

Figure 4: Model schematic



Roughness

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

4.3 Hydraulic model build – Proposed Scheme

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

Bridge

4.3.2 The A573 Wigan Road realignment bridge structure has not been modelled at this stage, as the effect of the bridge piers in terms of localised increases in flood levels is likely to be negligible. In addition, the bridge soffit is designed to be significantly above the required freeboard allowance to prevent any risk of surcharged conditions for the design event.

Topographic changes

4.3.3 There are two embankments, one on each side of the bridge structure that partially encroach into the floodplain and the associated Environment Agency flood zones. These have been modelled as raised 2D impermeable walls along the footprint of the embankment to prevent propagation of flood waters.

Channel realignments and diversions

4.3.4 A bypass channel has been considered at the proposed bridge crossing, although it has not been modelled at this stage. The purpose of the bypass channel would be to partially or fully counteract the small, localised increases in flood levels of up to 5mm as a result of the bridge piers and the partial encroachment of the bridge embankments into the floodplain established from the hydraulic modelling studies.

4.3.5 A realignment of Tributary of Hey Brook 5 will run parallel along the upstream face of the road embankment and will connect to the bypass channel. This ditch has not been modelled however it will be sized convey all flood flow and will therefore mitigate the major increase in modelled flood depth around the Tributary of Hey Brook 5 shown in Figure A 2.

Production of flood extents

4.3.6 Flood extents have been derived using the direct output option available in Infoworks ICM, producing maximum flood depth and stage. The outputs have undergone a Proposed

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

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

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

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

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

4.4 Climate change

4.4.1 The climate change allowance for the peak rainfall intensity and peak river flow components of the hydrology for Hey Brook is a 70% increase, due to the presence of less vulnerable flood sensitive receptors in Flood Zone 3b in the vicinity of the crossing.

4.4.2 The H++ allowance for Hey Brook is a 95% increase in peak rainfall intensity and peak river inflow, and this has been used 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 70% increase in peak rainfall intensity and peak river flow.

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 and flood risk, Map Book: maps WR-05-318 and WR-06-318 respectively.

5.1.4 The modelled impact of the Proposed Scheme, without mitigation, on peak flood levels indicates the potential for:

- an increase in peak flood level of approximately 5mm upstream of the proposed highway realignment crossing;
- an increase in peak flood level over 100mm upstream of the proposed highway which will be mitigated by realigning the Tributary of Hey Brook 5; and
- a decrease in peak flood level of less than 6mm downstream of the proposed highway realignment crossing.

5.1.5 Peak flood levels downstream of the culvert are reduced when compared to the baseline for all events modelled and therefore the Proposed Scheme provides some form of betterment to receptors downstream.

5.1.6 Model results indicate that the current proposed design achieves the freeboard requirements for the A573 Wigan Road realignment.

6 Model proving

6.1 Run performance

6.1.1 A time-step of 30 seconds was applied in the model with a cumulative mass balance error within +/-1.0% for all model runs undertaken.

6.2 Calibration and verification

6.2.1 There is no river 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 flood zones for the 1.0% and 0.1% AEP events providing confidence that the approach and underlying data is consistent.

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 95% for rainfall and flow;
- increase in roughness (channel, structures and floodplain) (Manning's n) by 20%; and
- decrease in roughness (channel, structures and floodplain) (Manning's n) by 20%.

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

6.4.3 The flood extents in the area around the Hey Brook crossing do not change significantly as a result of H++ climate change (1.0% AEP + 95% climate change allowance) event as the land rises quickly on both sides of the floodplain.

6.4.4 Sensitivity tests indicate that the Proposed Scheme hydraulic design is not unduly sensitive to changes in roughness. In all cases, changes in peak water levels are lower than 100mm. The increases in flood depth identified from the sensitivity tests could be greater if the higher REFH2 flows were used in the model. However, the flood extents would not change significantly when compared to the baseline due to the steep sided nature of the floodplain.

6.5 Blockage analysis

6.5.1 Blockage of the in-bank channel of 50% at the A573 Wigan Road realignment crossing was simulated by reducing the width of the underbridge crossing by half. The blockage scenario results were compared to the 1.0% AEP + CC results for the Proposed Scheme model. This comparison indicated that there was no increase in peak water level at the crossing of Hey Brook. This is because there is sufficient capacity between the piers outside the in-bank channel.

6.5.2 The blockage test confirms that the Proposed Scheme design ensures a freeboard of a minimum of 1m to the Proposed Scheme rail track in a 1.0% AEP + CC event is still maintained.

6.6 Run parameters

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

7 Limitations

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

7.1.2 All channels have been represented in 2D as the 0.2m LiDAR data captures the channel width but not the full depth of the channel. Channel conveyance will therefore not be fully represented in the model. This is likely to have resulted in a conservatively high estimate of peak flood levels.

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

8 Conclusions and recommendations

8.1.1 The model results indicate that there will be an increase in peak flood levels from construction of the Proposed Scheme, without mitigation upstream of the Proposed Scheme crossing of 5mm on the channel but more than 100mm on the floodplain, around Tributary of Hey Brook 5.

8.1.2 Blockage and sensitivity analyses indicate that the results are not unduly sensitive to changes in the key input variables of less than 100mm increases. These changes in flood depth could increase if the larger ReFH2 flows were used in the model; however, the flood extents would remain similar to the baseline due to the steep sided nature of the floodplain in the vicinity of the Proposed road realignment.

8.1.3 Model results indicate that the current proposed design achieves the freeboard requirements for the A573 Wigan Road realignment whilst not increasing flood risk downstream.

8.1.4 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 the 5.0% AEP and 1.0% AEP + CC events described in Section 5, see Figure A-1 and Figure A-2.

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

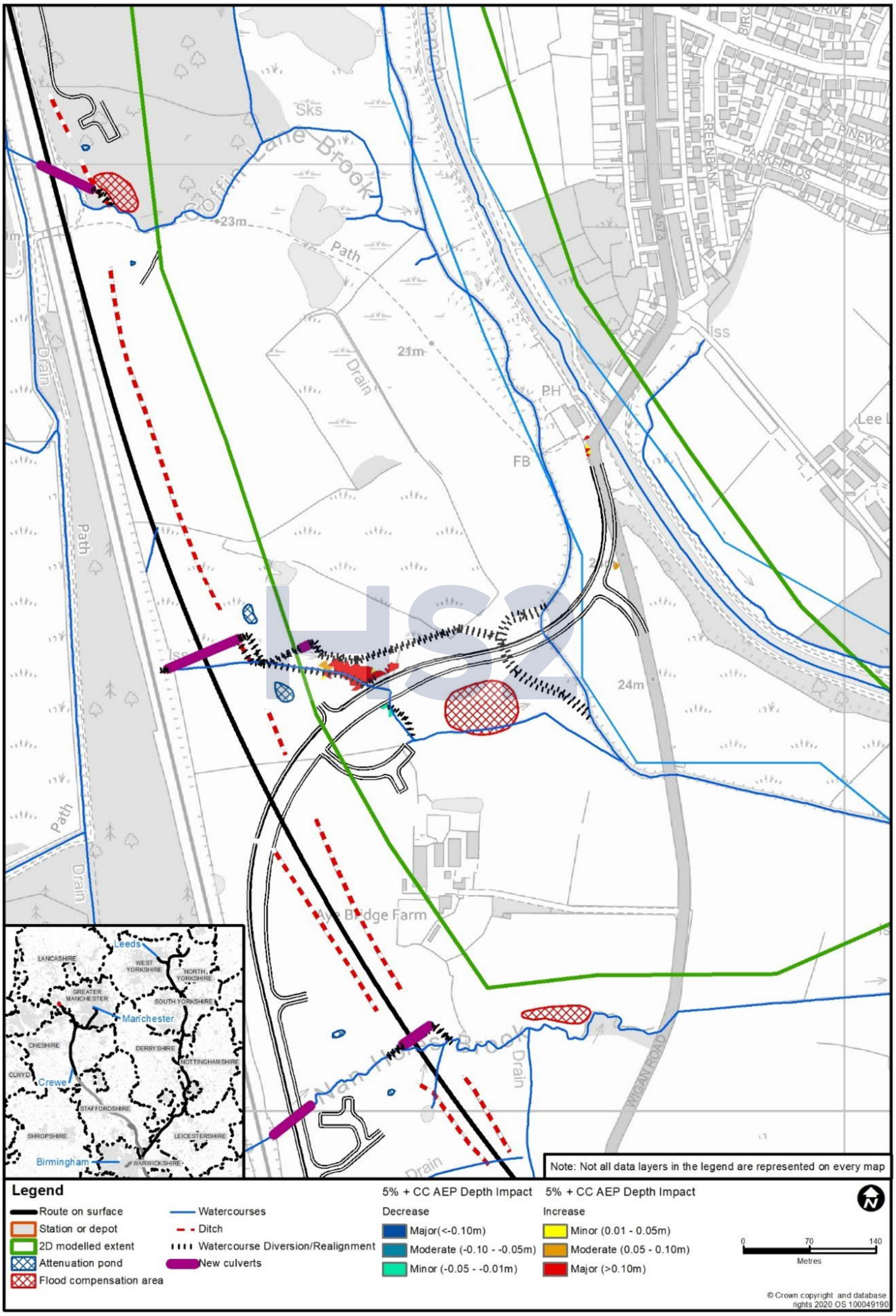
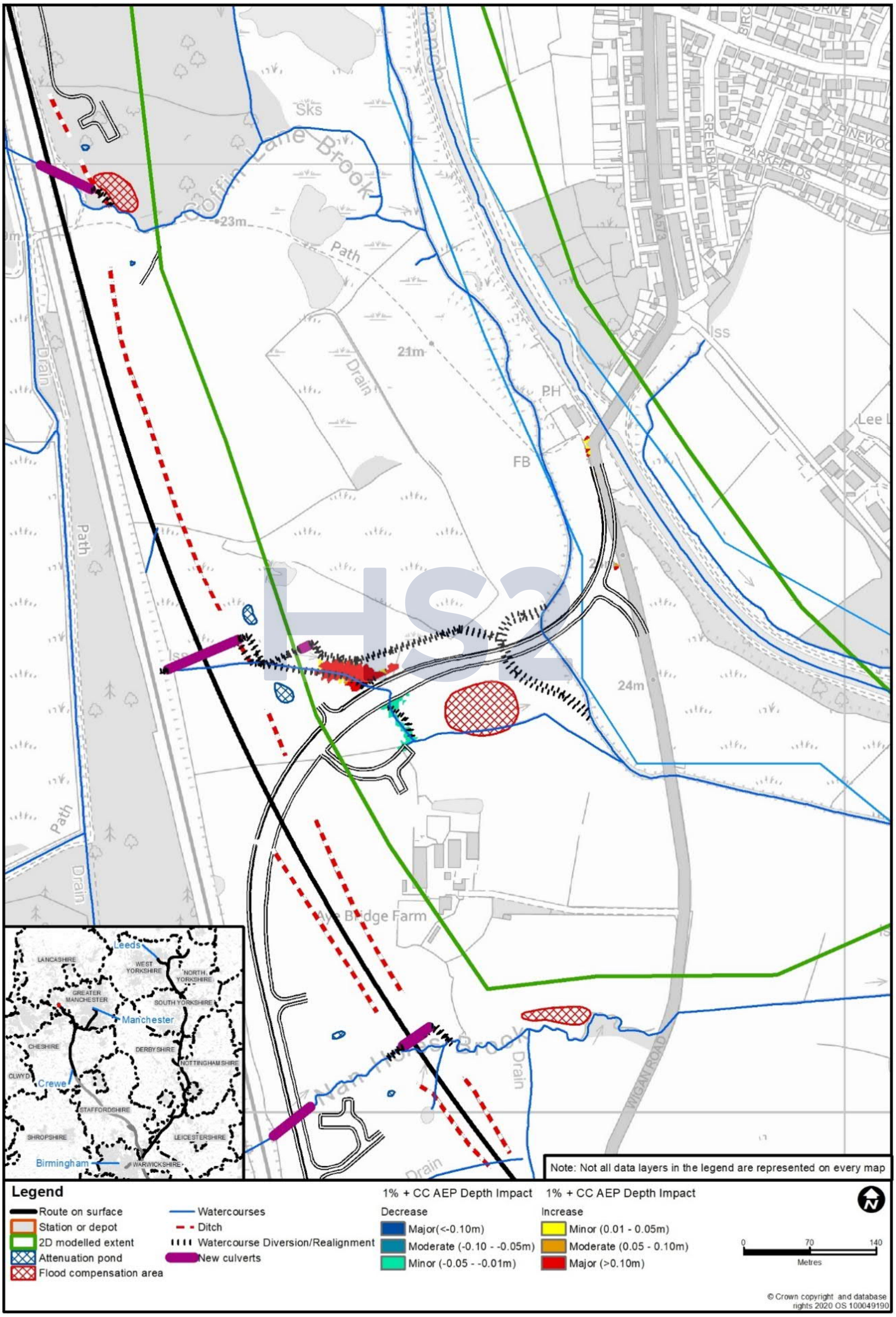


Figure A-2: Hey Brook impact map for 1.0% AEP (1 in 100 year plus climate change)



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