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HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix WR-005-0MA01

Water resources and flood risk

MA01: Hough to Walley's Green

Flood risk assessment

M324

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Department for Transport

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1 Introduction

1.1.1 This report is an appendix to the water resources and flood risk assessment. It presents the flood risk assessment for the Proposed Scheme in relation to the Hough to Walley's Green area (MA01).

1.1.2 This appendix should be read in conjunction with:

- Volume 2, Community Area reports;
- Volume 3, Route-wide effects;
- Volume 4, Off-route effects; and
- Volume 5, Appendices.

1.1.3 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 flood risk operation and maintenance plan (Volume 5: Appendix WR-007-00000).

1.1.4 For the Hough to Walley's Green area, the water resources assessment (Volume 5: Appendix WR-003-0MA01) should also be referred to.

1.1.5 Additional information relevant to this assessment is set out in Background Information and Data (BID):

- Water resources assessment baseline data (BID WR-004-0MA01)[1]; and
- Water Framework Directive compliance assessment baseline data (BID WR-002-00001)[2].

1.1.6 Maps referred to throughout this assessment are contained in the Volume 2, MA01 Map Book: Map Series CT-05 and CT-06.

1.1.7 Issues associated with the Sequential Test and Exception Test in the National Planning Policy Framework (NPPF) are discussed on a route-wide basis in Volume 3.

1.2 Scope, assumptions and limitations

1.2.1 The purpose of this flood risk assessment is to consider the flood risk implications of the permanent works associated with the Proposed Scheme within Hough to Walley's Green

[1] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Background Information and Data, Water resources assessment baseline data*, BID WR-004-0MA01. Available online at: http://www.gov.uk/government/collections/hs2–phase–2b–crewe–manchester–environmental–statement.

[2] High Speed Two Ltd (2017), High Speed Rail (West Midlands – Crewe), *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.

area. The route of the Proposed Scheme will connect to HS2 Phase 2a at the Crewe tunnel south portal. The Proposed Scheme will include changes to the design of Phase 2a Crewe tunnel south portal, to enable the connection between the two schemes, and these are considered in this assessment.

1.2.2 Temporary works have not been assessed unless they are of a significant scale compared to the permanent works proposed and have the potential to adversely affect flood risk.

1.2.3 The risk of flooding to site compounds and stockpiles will be managed through the draft Code of Construction Practice (CoCP) (see Volume 5: Appendix CT-002-00000). A sequential approach will be applied to the allocation of use within the compounds, seeking primarily to avoid using areas at flood risk wherever practical, but where this is unavoidable using areas at risk of flooding for the least vulnerable components and those that will avoid/limit the potential for off-site impacts. The site will be registered with the Environment Agency Flood Warning and Flood Alert service, if available.

1.2.4 All sources of flood risk are considered, other than tidal flooding.

1.2.5 Receptors considered in this assessment include the Proposed Scheme itself, other existing infrastructure assets, residential, commercial and agricultural buildings and property potentially affected by the Proposed Scheme.

1.2.6 The assessment has involved an initial scoping study using existing available information, including data provided by statutory consultees and stakeholders. Visual surveys have been undertaken of accessible water features to verify the dimensions of key hydraulic structures. Not all structures have been visually surveyed due to access constraints. Hydraulic modelling techniques, or other suitable quantitative methods, have been adopted in locations where the potential for adverse impacts on flood risk were identified in the scoping study. Details of the modelling decision tree process are provided in the Environmental Impact Assessment Scope and Methodology Report (SMR) Technical Note: Flood risk (see Volume 5: Appendix CT-001-00001). Hydraulic modelling has made best use of existing models provided by the Environment Agency. No new channel survey data have been obtained. Floodplain geometry was, however, updated using Light Detection and Ranging (LiDAR) data.

1.2.7 The hydraulic analysis work is based on conservative assumptions about the potential hydraulic impacts of the structures proposed. All hydraulic calculations will require refinement during the design development stage using additional topographical survey data. The models will then require further development to reflect the design development of hydraulic structures and flood risk mitigation measures.

1.2.8 The Volume 2, Community Area report for the Hough to Walley's Green area describes the avoidance strategy and mitigation measures included in the design to limit the temporary and permanent effects of the Proposed Scheme as far as is reasonably practicable. This flood risk assessment therefore assesses the impacts and effects arising following the implementation of the avoidance and mitigation measures, and reports on whether any additional mitigation may be needed where the Proposed Scheme may result in significant effects.

1.3 Location and extent

1.3.1 The location and extent of the MA01 study area is shown in Figure 1 and Figure 2.

1.3.2 The study area extends 1km from the Proposed Scheme. All flood risk receptors have been identified within these limits.

1.3.3 The extent of the land required during construction of the Proposed Scheme, Environment Agency Flood Zones 2 and 3[3], as well as the areas at risk from surface water flooding are shown on Volume 5, Water resources and flood risk Map Book, Map Series WR-01 Surface Water Baseline. The flood zone information is based on the Environment Agency's Flood map for planning (rivers and sea) and the risk of flooding from surface water maps (RoFSW)[4].

[3] Flood Zone 2 comprises land assessed as having between a 1 in 100 (1.0%) and 1 in 1,000 (0.1%) annual probability of river flooding; Flood Zone 3 comprises land assessed as having a 1 in 100 (1.0%) or greater annual probability of river flooding.

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

Figure 1: Location and extent of the study area (southern extent)

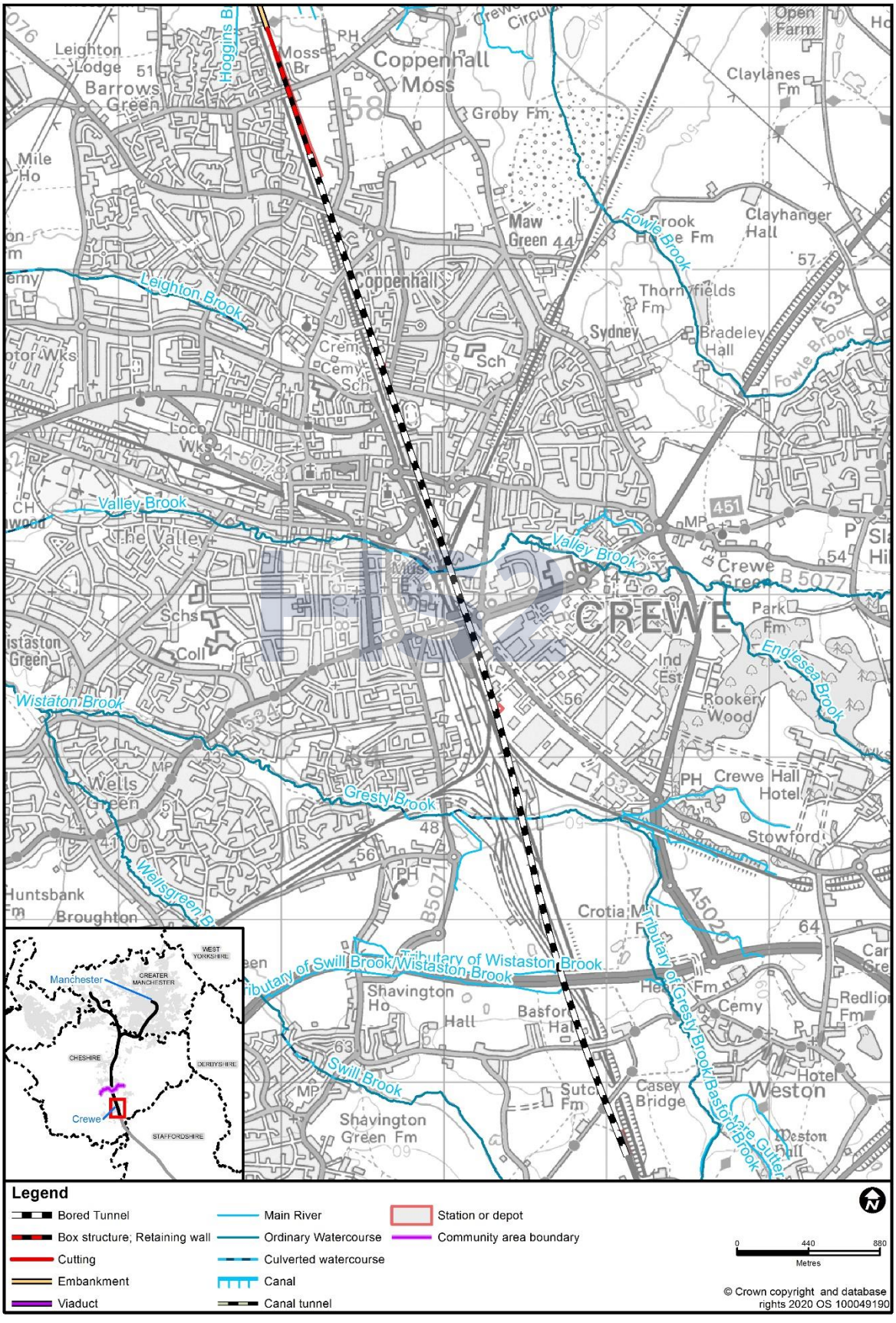
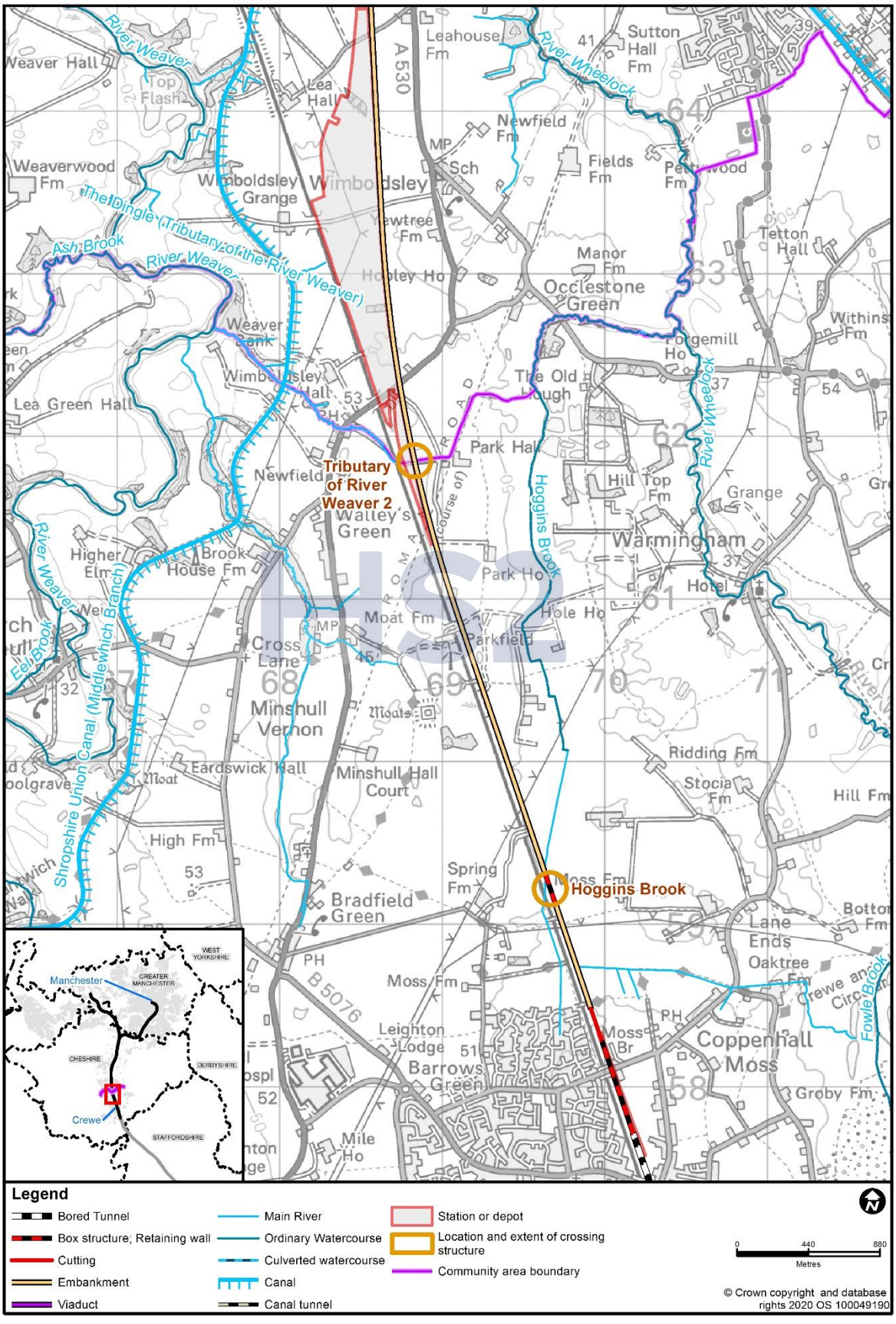


Figure 2: Location and extent of the study area (northern extent)



2 Policy context and consultation

2.1 National

2.1.1 The Proposed Scheme design has been developed in general accordance with the requirements of the NPPF. This aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe, will not increase flood risk elsewhere and, where possible, reduces flood risk overall. The Sequential Test and Exception Test in the NPPF aim to achieve these policy objectives.

2.1.2 The Flood and Water Management Act 2010 requires the Environment Agency to 'develop, maintain, apply and monitor a strategy for flood and coastal erosion risk management in England'. The Environment Agency therefore has oversight of all matters related to flood risk and is a statutory consultee for flood risks associated with main rivers and reservoirs. The Environment Agency has been consulted throughout the process of undertaking this assessment and has provided extensive data and guidance on the interpretation of policy.

2.2 Regional and local

2.2.1 Under the Flood and Water Management Act 2010, the statutory consultee for all matters related to local flood risk, including works affecting ordinary watercourses, is the Lead Local Flood Authority (LLFA). Cheshire East Council (CEC) is the LLFA in the Hough to Walley's Green area. No engagement has been undertaken with the LLFA, however discussions have been held with the Environment Agency to agree the principles related to the hydraulic design of the Proposed Scheme and the approach adopted for the assessment of flood risk on main rivers and ordinary watercourses.

2.2.2 The CEC Preliminary Flood Risk Assessment (PFRA)[5] was published in 2011, and the Local Flood Risk Management Strategy (LFRMS)[6] was published in 2015. The LFRMS contains a number of policies related to sustainable development, access to, and maintenance of, ordinary watercourses and the need to consider environmental opportunities that reinforce the objectives of the River Basin Management Plan (RBMP)[7]. The Proposed Scheme design has sought to align with these objectives where reasonably practicable.

[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] 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.

[7] Environment Agency (2015), *North West River Basin Management Plan.* Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/718335/North_West_RBD_Part_1_river_basin_management_plan.pdf.

2.2.3 CEC have produced a Strategic Flood Risk Assessment (SFRA)[8] that covers the Hough to Walley's Green area. The key flood risk objectives outlined in the SFRA are to reduce surface water runoff, support Water Framework Directive delivery and prevent new development within sensitive development locations. The Proposed Scheme design has sought to align with these objectives where reasonably practicable.

[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.

3 Flood risk baseline

3.1 Historical flooding incidents

3.1.1 The PFRA and SFRA published by CEC report no incidents of historical flooding from watercourses or surface water sources within 1km of the Proposed Scheme.

3.1.2 A review of the Section 19[9] historical flood reports in the Hough to Walley's Green area showed no recorded historical flooding within 10km of the Proposed Scheme.

3.2 Risks associated with main rivers and ordinary watercourses

3.2.1 The key flood risk from main rivers and ordinary watercourses is that associated with Hoggins Brook ordinary watercourse, north of Crewe.

3.2.2 The areas at risk of flooding from this watercourse, the receptors potentially affected, and the climate change allowances used in the design and assessment of impacts and effects are considered below. Receptors have been identified based on OS mapping and committed development information[10].

3.2.3 An area to the north of Crewe (near to Spring Plantation) is shown to be at risk of flooding by the Environment Agency's RoFSW dataset for the 1 in 1,000 (0.1%) annual exceedance probability (AEP) flood event (see Figure 3). Field surveys were unable to identify a culvert structure beneath the existing West Coast Main Line (WCML) that would allow this water to discharge to Tributary of Fowle Brook 1. Therefore, this assessment assumes that this flood water would drain to the Hoggins Brook and that Tributary of Fowle Brook 1 is not crossed by the Proposed Scheme. This assumption will be confirmed during design development.

3.2.4 The Proposed Scheme will pass beneath Valley Brook and Gresty Brook in bored tunnel; therefore, flood risk in these areas will be unchanged. These watercourses and the receptors identified will undergo no further assessment.

Hoggins Brook

3.2.5 The Hoggins Brook ordinary watercourse flows from south to north and has mapped flood zones indicated by the Environment Agency Flood map for planning (rivers and sea) dataset[4]. Elements of the Proposed Scheme fall within the Flood Zone 3 (see Figure 3). The flood zone

[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.

[10] Provided by the local authorities in November 2019.

dataset used for Hoggins Brook has been derived from broadscale modelling, which uses a coarse model grid wider than the width of the watercourse. The flood zone extent is wide and straight at the upstream extent, and then abruptly stops after approximately 2km, which is likely to be the end of the modelled extent. Hoggins Brook is in the upper reaches of the catchment and the watercourse closely follows surface water flow paths shown by the Environment Agency's RoFSW dataset. It is therefore considered that the Environment Agency's RoFSW dataset for the 1 in 1000 (0.1%) AEP flood event is more reliable for assessing the risk from flooding from this watercourse in the vicinity of the Proposed Scheme. The RoFSW dataset was therefore used to identify the receptors at potential risk from flooding (see Figure 3). No additional hydraulic modelling has been undertaken for the Hoggins Brook.

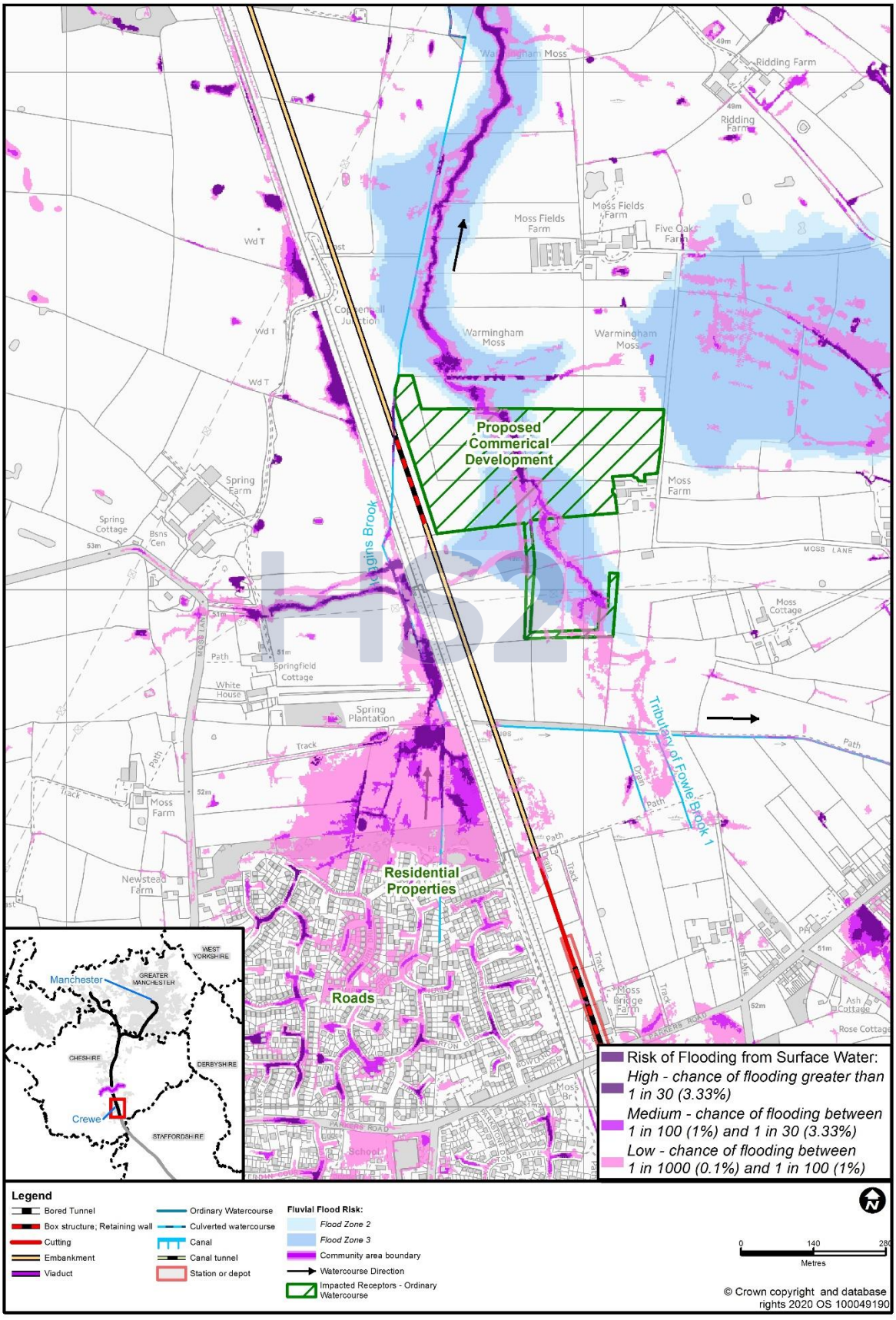
3.2.6 The receptors upstream and downstream of the Proposed Scheme that are potentially at risk of flooding from Hoggins Brook are listed below and are shown on Figure 3. The relative vulnerability to flooding of each receptor (as defined in NPPF and Table 55 of the SMR) is also indicated. It should be noted that the existing railway line is on an embankment approximately 1m above the surrounding ground level and is therefore not considered to be at risk from flooding, and not listed as a receptor.

- a solar farm commercial development site close to Moss Lane (planning application[11] 7/2007/CCC/13) (essential infrastructure);
- residential properties along Lambourn Drive and Perry Fields (more vulnerable); and
- roads north of Parker's Road (less vulnerable).

3.2.7 In line with the SMR, a climate change allowance has been adopted to assess the future flood risk to receptors associated with each watercourse crossing using the Environment Agency guidelines. For catchment areas less than 5km^2 in size the guidance recommends that a peak rainfall intensity allowance is used. The percentage uplift in peak rainfall intensity used to assess flood risk to receptors reflects the location of the receptor in the floodplain (flood zone) and its flood risk vulnerability classification. The upper end allowance of 40% increase has been adopted on a precautionary basis for this assessment.

[11] Further details of these planning applications can be found in Volume 5: Appendix CT-004-00000, Planning data.

Figure 3: Extent of the Environment Agency's Flood Zones 2 and 3, Hoggins Brook



3.3 Risks associated with surface water

3.3.1 This section describes the risk associated with surface water as shown by the Environment Agency's RoFSW dataset for the 1 in 1000 (0.1%) AEP flood event. This dataset indicates where surface water flow paths cross the proposed scheme.

3.3.2 No further surface water flow paths have been identified in the Hough to Walley's Green area. No further assessment is required.

3.4 Risks associated with groundwater

3.4.1 The British Geological Survey (BGS) susceptibility to groundwater flooding dataset[12] provides the main dataset used to scope the future risk of groundwater flooding. The assessment of susceptibility is based on rock type and estimated groundwater levels during periods of extended intense rainfall. The dataset shows groundwater flooding susceptibility, on a 50m grid, using the following three classes:

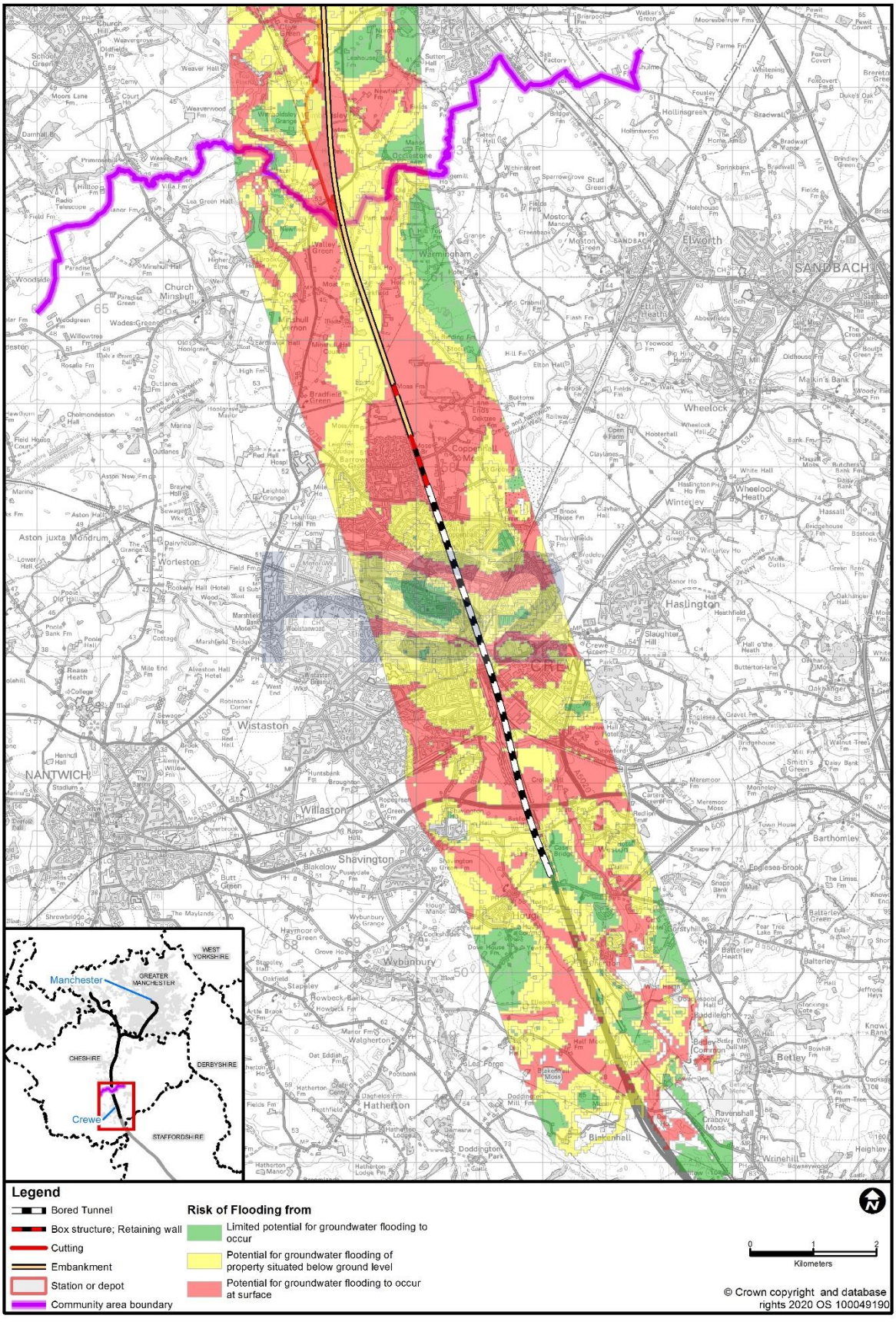
- A – limited potential for groundwater flooding to occur;
- B – potential for groundwater flooding of property situated below ground level; and
- C – potential for groundwater flooding to occur at the surface.

3.4.2 The BGS susceptibility to groundwater flooding dataset is a hazard dataset based on favourable geological conditions for groundwater flooding. The dataset is not based on risk and as such does not show the likelihood of a groundwater flooding event actually occurring.

3.4.3 The BGS susceptibility to groundwater flooding dataset indicates that there is some potential for groundwater flooding to occur at Crewe along the route of the Proposed Scheme due to the nature of the superficial deposits (glacial till) and the underlying Mercia Mudstone (see Figure 4). The SFRA does not report any historic groundwater flooding incidents within the study area.

[12] British Geological Survey (2018), *BGS susceptibility to groundwater flooding dataset*. Available online at: http://www.bgs.ac.uk/products/hydrogeology/groundwaterFlooding.html.

Figure 4: Risk of flooding from groundwater through the study area



3.5 Risks associated with artificial sources

3.5.1 Flooding from artificial water bodies may occur due to failure of an impounding structure, such as a dam or canal embankment. No impounding features have been identified within the study area that are a potential source of flood risk.

3.5.2 Major water supply pipelines and sewerage (foul and surface water) infrastructure has potential to cause flooding should it fail. However, this infrastructure, and its potential failure, is accounted for in the assessment of surface water flooding and in the design of the Proposed Scheme, the latter of which is shown in Volume 2, MA01 Map Book: Map Series CT-05 and CT-06.

3.6 Summary of baseline flood risk

3.6.1 Table 1 provides a summary of all the relevant sources of flood risk identified, the receptors potentially affected, their relative vulnerability and the climate change allowances used in the modelling assessments and calculations.

Table 1: Summary of baseline flood risk

Source / pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
Hoggins Brook	Solar farm site close to Moss Lane (currently under development) (essential infrastructure)	Environment Agency Flood Zones 2 and 3 and RoFSW 0.1% AEP flood	Essential infrastructure	40% (increase in peak rainfall intensity)
	Residential properties along Lambourn Drive and Perry Fields (more vulnerable)			
	Roads north of Parkers Road (less vulnerable)			
Groundwater	Solar farm site close to Moss Lane (currently under development) (essential infrastructure)	BGS Susceptibility to groundwater flooding	Essential infrastructure	N/A
	Residential properties along Lambourn Drive and Perry Fields (more vulnerable)			
	Roads north of Parkers Road (less vulnerable)			
	Agricultural land (less vulnerable)			

4 Flood risk impacts and effects

4.1 Rivers and ordinary watercourses

Culverts and channel realignments

4.1.1 The Proposed Scheme crosses Hoggins Brook ordinary watercourse that has not been hydraulically modelled or mapped as part of the Environment Agency Flood map for planning (rivers and sea) dataset[4]. The RoFSW[4] dataset has therefore been used to indicate the potential flood extent generated and the receptors affected along this ordinary watercourse.

4.1.2 The Hoggins Brook ordinary watercourse is to be realigned for a distance of 1,425m along the side of the Proposed Scheme before crossing the Proposed Scheme from west to east through the existing Coppenhall Moss culvert which will be extended to accommodate the Proposed Scheme. It will then flow through Warmingham Moss to join its existing flow path. The channel will be designed to replicate the current flow regime to ensure that flood risk upstream or downstream is not increased. Hydraulic modelling of the realigned watercourse will be undertaken at design development stage to demonstrate that flood risk elsewhere is not increased.

4.1.3 At the location where this ordinary watercourse crosses the Proposed Scheme, the extended Coppenhall Moss culvert is required to convey the water under the route. Coppenhall Moss culvert consists of three culverts in series. Figure 5 shows the location of proposed culvert. Two further offline culverts are also required as part of the Proposed Scheme. The following calculation procedure has been undertaken to size all three of the culverts:

- use of the Revitalised Rainfall-Runoff Model version 2.2 (ReFH2)[13] to determine the peak flow generated during the 1.0% AEP storm event;
- determination of the appropriate climate change allowance to be applied following the procedure outlined in the SMR;
- determination of the existing gradient of the watercourse or proposed realigned watercourse using Ordnance Survey Mapping and LiDAR data;
- determination of the roughness characteristics of the culvert; and
- selection of a cross sectional area with the capacity to convey the 1.0% AEP peak flow, incorporating the appropriate allowance for climate change (CC), whilst ensuring approximately 300mm freeboard to the culvert soffit above this design flood level. The culvert structure will include an additional 300mm to allow for bed reinstatement and natural sedimentation.

[13] Wallingford HydroSolutions (2016), *Revitalised Flood Hydrograph Model ReFH2: Technical Guidance*.

4.1.4 The details of the culvert design applied to the ordinary watercourses are provided in Table 2.

Table 2: Details of culvert design at ordinary watercourse crossings

Watercourse / location	Structure name	Estimated 1.0% AEP peak flow (m^3/s)	Climate change allowance (increase in peak rainfall intensity)	Estimated 1.0% AEP + CC peak flow (m^3/s)	Culvert dimensions of opening (m)	Culvert capacity (m^3/s)[14]
Hoggins Brook	Coppenhall Moss culvert	2.61	40%	3.89	3 culverts in a dog leg each consisting of 2 box culverts 1.35m high x 1.35m wide	8.04
Hoggins Brook – offline	Footpath Crewe 29/1 offline culvert	0.03	40%	0.04	2 box culverts 1.35m high x 1.35m wide	3.57
Hoggins Brook – offline	Warmingham Moss offline culvert	2.52	40%	3.76	2 box culverts 1.35m high x 1.35m wide	7.47

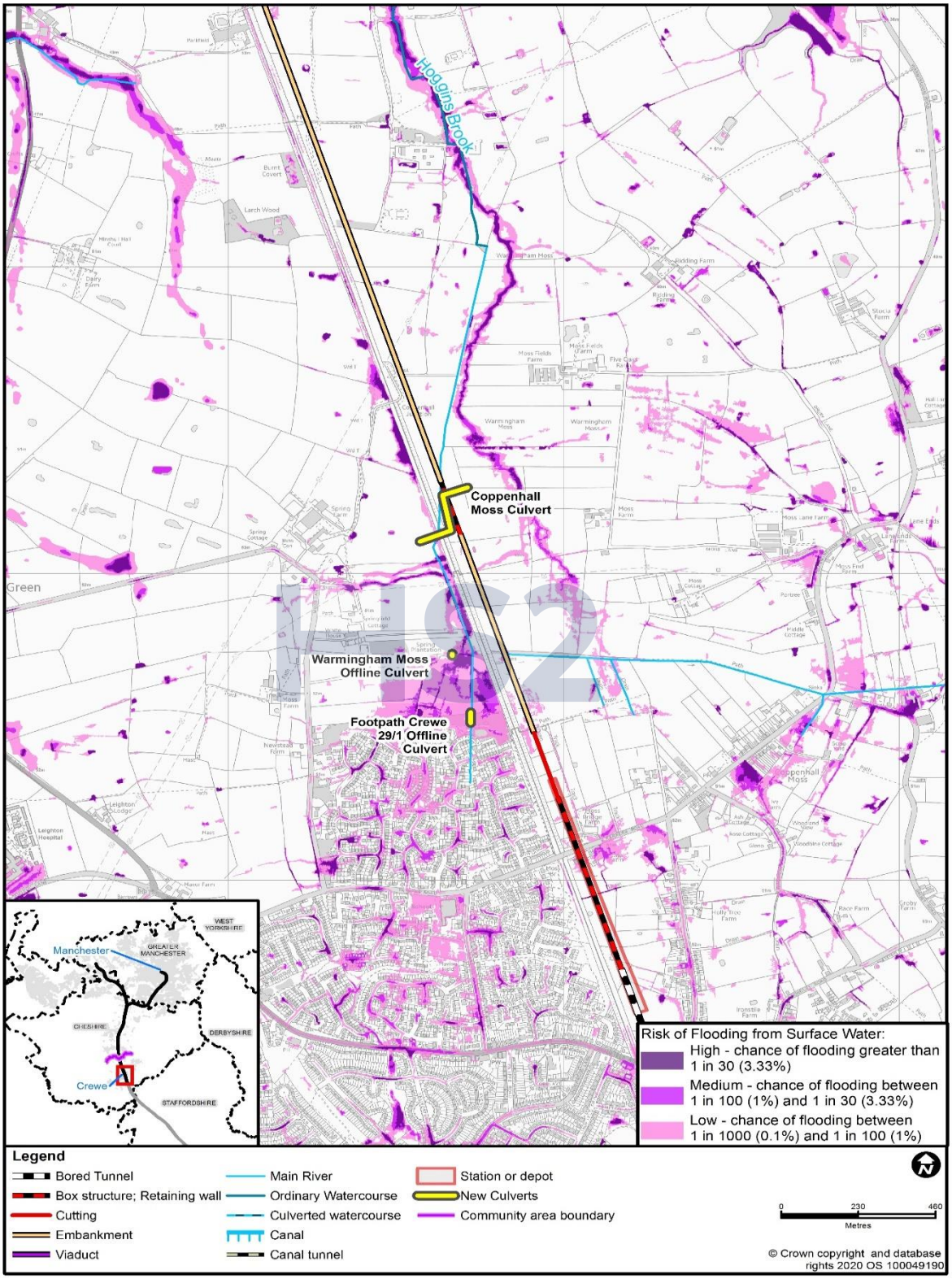
4.1.5 By following this design approach, the flood risk to the receptors identified is unlikely to be changed.

4.1.6 Each of the ordinary watercourse crossings in Table 2 is associated with a channel realignment to reduce the length of culvert required as far as is reasonably practicable. The realigned channels will have the same hydraulic capacity as the existing channel unless it is identified at the design development stage that a change in size is required to ensure no adverse impacts on flood risk.

4.1.7 There are two culvert crossings of the Tributary of River Weaver 2 located in MA01. The source of this tributary is in the Wimboldsley to Lostock Gralam area (MA02), therefore these crossings are assessed in the Flood risk assessment, Volume 5: Appendix WR-005-0MA02.

[14] Culvert may be designed to contain not only flow for the watercourse but also for provision of other services, such as a footpath or ecological reasons. This results in a culvert size larger than that required to convey just the flow from the watercourse.

Figure 5: Proposed culverts (northern extent)



Temporary construction compounds and stockpiles

4.1.8 Table 3 highlights the temporary site compounds and stockpiles located in areas at risk of flooding. A temporary satellite compound and stockpile are proposed which are almost entirely located in Flood Zones 2 and 3 of Hoggins Brook.

4.1.9 The risk of flooding to these compounds will be managed through the draft CoCP. A sequential approach will be applied to the allocation of use within the compounds, seeking primarily to avoid using areas at flood risk wherever practical, but where this is unavoidable using areas at risk of flooding for the least vulnerable components and those that will avoid/limit the potential for off-site impacts. The site will be registered with the Environment Agency Flood Warning and Flood Alert service, if available.

Table 3: Details of temporary site compounds and stockpiles at risk of flooding

Watercourse/ location	Construction compound	Flood zone	Risk of flooding from surface water	Potential mitigation
Hoggins Brook close to Moss Lane	Satellite compound	Majority of site within Flood Zone 2 and 3	1 in 1000 (0.1%) AEP event flow path through the compound	Compound formation, surface and drainage would be designed to mitigate potential flooding Existing site levels retained to preserve floodplain functionality. Ensure site welfare is raised above the flood level.
	Stockpile	Approximately 70% of the site within Flood Zone 2 and 3	Small encroachment on the stockpile boundary from the 1 in 1000 (0.1%) AEP event	Runs parallel to permanent embankment earthworks. Drainage designed to ensure no additional impact from stockpile.
	Stockpile	Approximately 20% of the site within Flood Zone 2 and 3	Approximately 30% of the stockpile within the 1 in 1000 (0.1%) AEP event extent	Shape of stockpile will be adjusted, along with the use of perimeter drainage to ensure no additional impact from stockpile.
Broughton Road Drain	Main compound	N/A	Northern end of the compound affected by the 1 in 100 (1%) AEP and 1000 (0.1%) AEP events	Compound formation, surface and drainage would be designed to mitigate potential flooding. Existing site levels retained to preserve floodplain functionality

Watercourse/ location	Construction compound	Flood zone	Risk of flooding from surface water	Potential mitigation
				Ensure site welfare is raised above the flood level.

4.2 Surface water

4.2.1 As outlined previously the RoFSW[4] dataset and inspection of topographical survey information has identified surface water flow paths that are not represented by any formal channel feature and so are not watercourses.

4.2.2 This dataset has been used to indicate the receptors affected along the upper reach of Hoggins Brook, an ordinary watercourse, which is covered in Section 4.1. No further surface water flow paths have been identified.

4.3 Groundwater

4.3.1 The principal mechanism by which the Proposed Scheme could increase groundwater flood risk is where sub surface structures of lower permeability than the existing geology, such as lined tunnels or pile walls, may act as a barrier to groundwater flow. These barriers have the potential to cause a rise in groundwater level in the vicinity of the structures.

4.3.2 To assess the possible changes to groundwater levels and flow, and the associated change in groundwater flood risk, a high-level assessment of the groundwater conditions along the route has been undertaken to understand where the Proposed Scheme is likely to interact with groundwater. The high-level assessment identified where elements of the scheme design such as cuttings, retaining walls, viaduct and bridge foundations, basements, excavations and temporary works intercept aquifers which pose a groundwater flood risk. An assessment has been made of the degree to which the design features encroach on the aquifer and the potential changes in groundwater level and restrictions on groundwater flow. Receptors within the area at risk of potential changes in groundwater level or flow were then identified. The likely maximum zone of influence from any dewatering taking place has also been assessed.

4.3.3 In the Hough to Walley's Green area, there is a bored tunnel beneath Crewe. There is no groundwater level information in this area. If groundwater levels are below the base of the tunnel, there will be no flood risk posed to the Proposed Scheme. If the tunnel intersects groundwater, there is potential for local changes in groundwater levels, and a potential localised increase in risk of groundwater flooding. The tunnels have an external diameter of 8.8m, in the Mercia Mudstone Group Secondary B aquifer. This aquifer has an area of several hundred square kilometres and extends vertically below the tunnel for at least 100m, sometimes significantly more. Therefore, there is sufficient thickness of the aquifer to enable water to flow around the tunnel and not causing a groundwater level rise on the upgradient

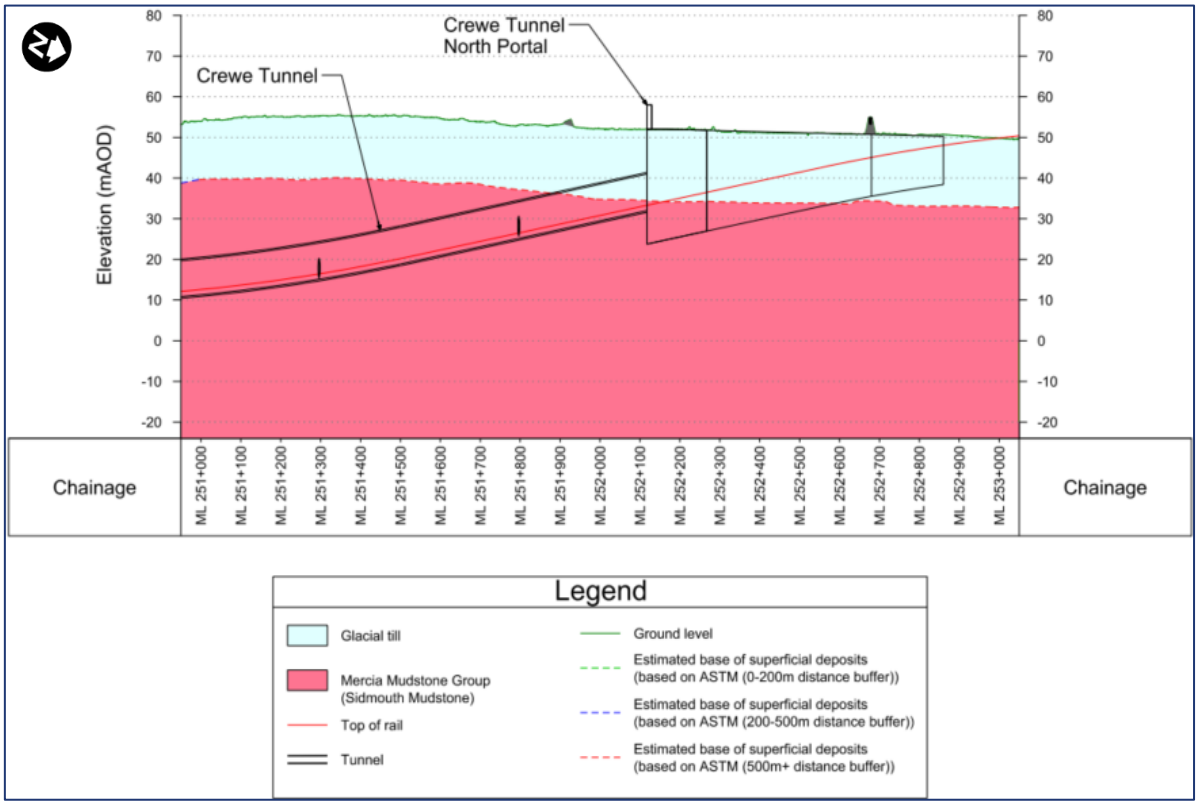
side of the tunnel. The impact of the tunnels has been assessed as having a negligible impact on the risk of groundwater flooding, leading to a negligible effect which is not significant.

4.3.4 As the Crewe tunnel rises towards the Crewe tunnel north portal, it passes from the Mercia Mudstone into the glacial till superficial deposits. A schematic geological cross section of the Crewe tunnel and north portal is provided in Figure 6. There is the potential that the passage of the tunnel through the glacial till could lead to an increased risk of groundwater flooding. Land drainage will be provided around the tunnel portal structure, to drain any groundwater rise which may occur as the route gets closer to the surface.

4.3.5 The glacial till is highly layered with sandy bands present that can contain groundwater. This layered geology leads to differences in permeability which restrict the vertical movement of groundwater. Therefore, although groundwater levels in the sandy bands could rise, the clayey layers in the till will restrict this rise closer to the surface. Therefore, it is unlikely that there would be an increase in risk of groundwater flooding.

4.3.6 The proposed route of the Crewe tunnel and north portal is located within fields adjacent to an existing railway track, and the residential area of Coppenhall is located within 200m of the route of the Proposed Scheme. Considering the restricted vertical permeability for groundwater movement and the lower value receptors in the immediate proximity to the Proposed Scheme, the tunnel and north portal are considered to have a negligible impact on the risk of groundwater flooding, leading to a negligible effect, which is not significant.

Figure 6: Geological cross section of the Crewe tunnel and north portal



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4.3.7 The assessment has shown that there are no other features of the Proposed Scheme in the Hough to Walley's Green area that will act as a significant barrier to groundwater flow. Therefore, there are unlikely to be any significant increases in groundwater levels across the aquifers which could lead to increased risks of groundwater flooding as a result of the Proposed Scheme. Further details of potential groundwater level changes are set out in the Water resources assessment, Volume 5: Appendix WR-003-0MA01.

4.4 Artificial sources

4.4.1 There are no artificial water bodies with potential implications for flood risk within the study area.

4.4.2 Major water supply pipelines and sewerage (foul and surface water) infrastructure has been identified and are accounted for in the Volume 2, MA01 Map Book: Map Series CT-05 and CT-06. This infrastructure has been identified and diverted where appropriate. Measures will be taken to safeguard the local receptors during this diversion process.

4.4.3 The Proposed Scheme does not change the flood risk posed by failure of artificial water sources.

4.5 Off-site impacts and effects (surface water management)

4.5.1 Runoff from the footprint of the Proposed Scheme could occur more rapidly post-construction due to steeper slope angles and the permeability of the newly-created surfaces.

4.5.2 The design aim of drainage systems is to ensure that there will be no significant increases in flood risk, during storms up to and including the 1.0% AEP + CC event, as set out in the SMR.

4.5.3 Balancing ponds for new sections of highway and railway drainage have been sized on a precautionary basis, pending more detailed information about the permeability and runoff characteristics of existing and proposed ground surfaces[15].

[15] High Speed Two Ltd (2022), *Phase 2b Western Leg Information Paper E21: Balancing ponds and replacement flood storage areas.*

5 Additional flood risk management measures

5.1.1 The next stage of the design process will involve incorporation of topographical survey information into new hydraulic models to support design activities.

5.1.2 The above activities will be undertaken in close consultation with the Environment Agency and the LLFA. If any residual effects are identified, the affected landowners will also be consulted. The aim will be to ensure that no parties are affected by unacceptable increases in flood risk.

6 Summary of significant flood risk effects

6.1.1 Due to the flood risk management measures embedded in the design, there are no significant effects on flood risk.

6.2 Conclusions

6.2.1 This flood risk assessment presents the impacts and effects of the Proposed Scheme, taking into account avoidance and mitigation measures described in Volume 2, Community Area report for the Hough to Walley's Green area. Additional mitigation measures have been developed to further reduce the temporary and permanent impacts of construction stage activities, where there is potential for the Proposed Scheme to result in significant effects.

6.2.2 The assessment indicates that, subject to the implementation of the avoidance and mitigation measures identified, and the measures included in the Draft water resources flood risk operation and maintenance plan the Proposed Scheme will not result in any significant adverse effects on flood risk in MA01.

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