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HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix WR-005-0MA03

Water resources and flood risk

MA03: Pickmere to Agden and Hulseheath

Flood risk assessment

M326

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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 Pickmere to Agden and Hulseheath area (MA03).

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

1.1.4 For the Pickmere to Agden and Hulseheath area, the relevant Hydraulic modelling report (Volume 5: Appendix WR-006-00001) as well as the Water resources assessment (Volume 5: Appendix WR-003-0MA03) 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-004-0MA03)[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, MA03 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)[3] are discussed on a route-wide basis in Volume 3.

[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.

[3] Department for communities and local government (2019), *National Planning Policy Framework.* Available online at: https://www.gov.uk/government/publications/national-planning-policy-framework--2.

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 the Pickmere to Agden and Hulseheath area.

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 construction compounds will be managed through draft Code of Construction Practice (CoCP) (see Volume 5: Appendix CT-002-00000). As far as practicable, site compounds have been located outside of Flood Zone 3. However, where this is not possible, 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. It is recommended that the Environment Agency Flood Warning and Flood Alerts service is signed up to, if applicable.

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

1.2.5 The flood risk assessment considers the impact of the Proposed Scheme during the 1 in 100 year event plus an allowance for climate change as set out in the Environmental Impact Assessment Scope and Methodology Report (SMR) (Volume 5, Appendix CT-001-00001).

1.2.6 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.

1.2.7 The assessment has involved an initial scoping study using existing available information, including data provided by statutory consultees and stakeholders. 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 SMR: Technical Note: Flood risk. 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.

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

1.2.9 The Volume 2, Community Area report for the Pickmere to Agden and Hulseheath 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 MA03 study area is shown in Figure 1 and Figure 2.

1.3.2 The study area extends 1km from the Proposed Scheme. In the Pickmere to Agden and Hulseheath area, the study area has been extended to include The Mere, Mere SSSI (which is also part of the Midland Meres and Mosses Phase 1 Ramsar site) to the east, as the Proposed Scheme may alter groundwater flows within its topographic catchment. All flood risk receptors have been identified within these limits. If modelling assessments identified potential impacts beyond these limits, the study area has been extended accordingly.

1.3.3 The extent of the land required during construction of the Proposed Scheme, Environment Agency Flood Zones 2 and 3[4], 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. 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)[5].

[4] 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.

[5] 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)

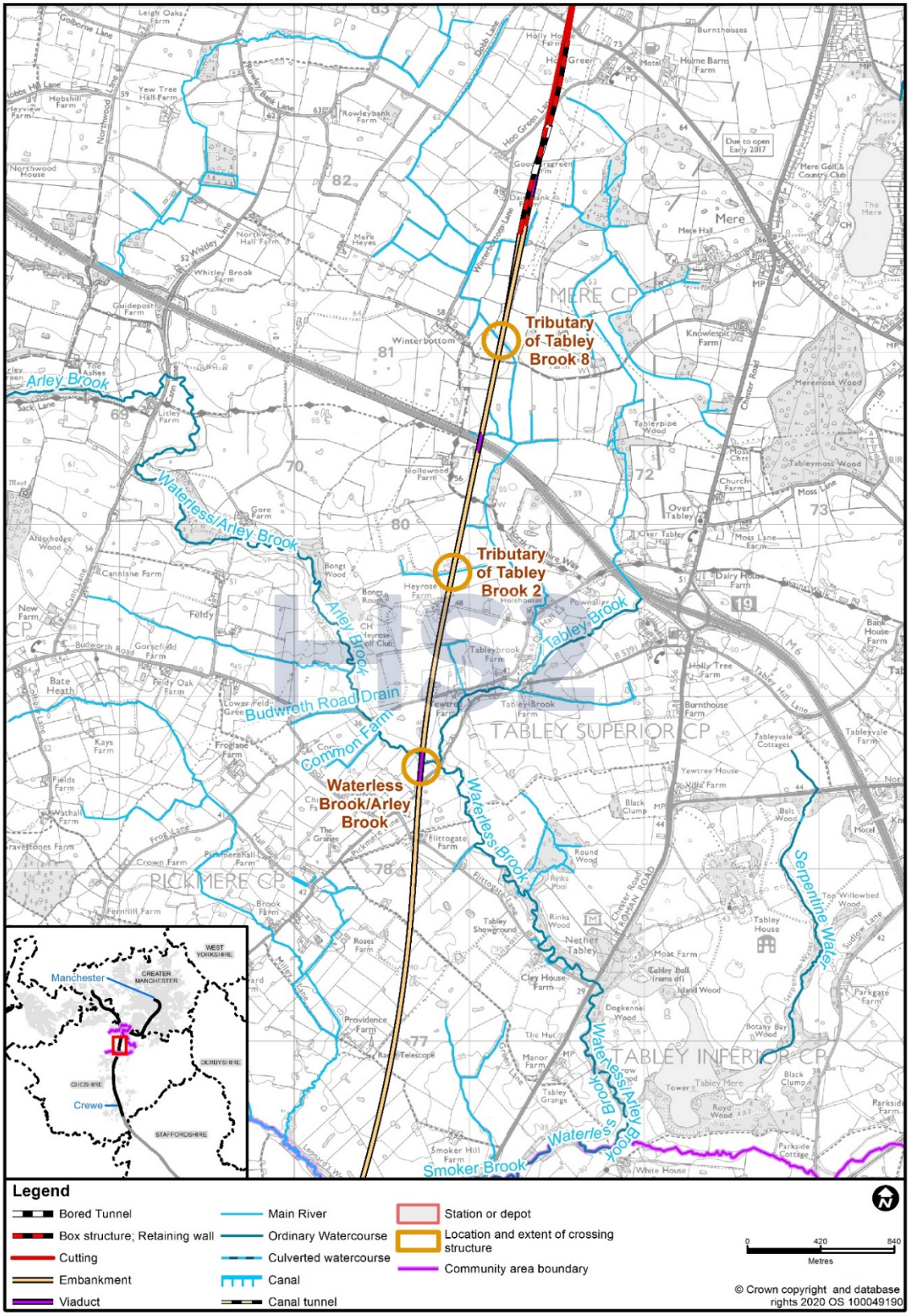
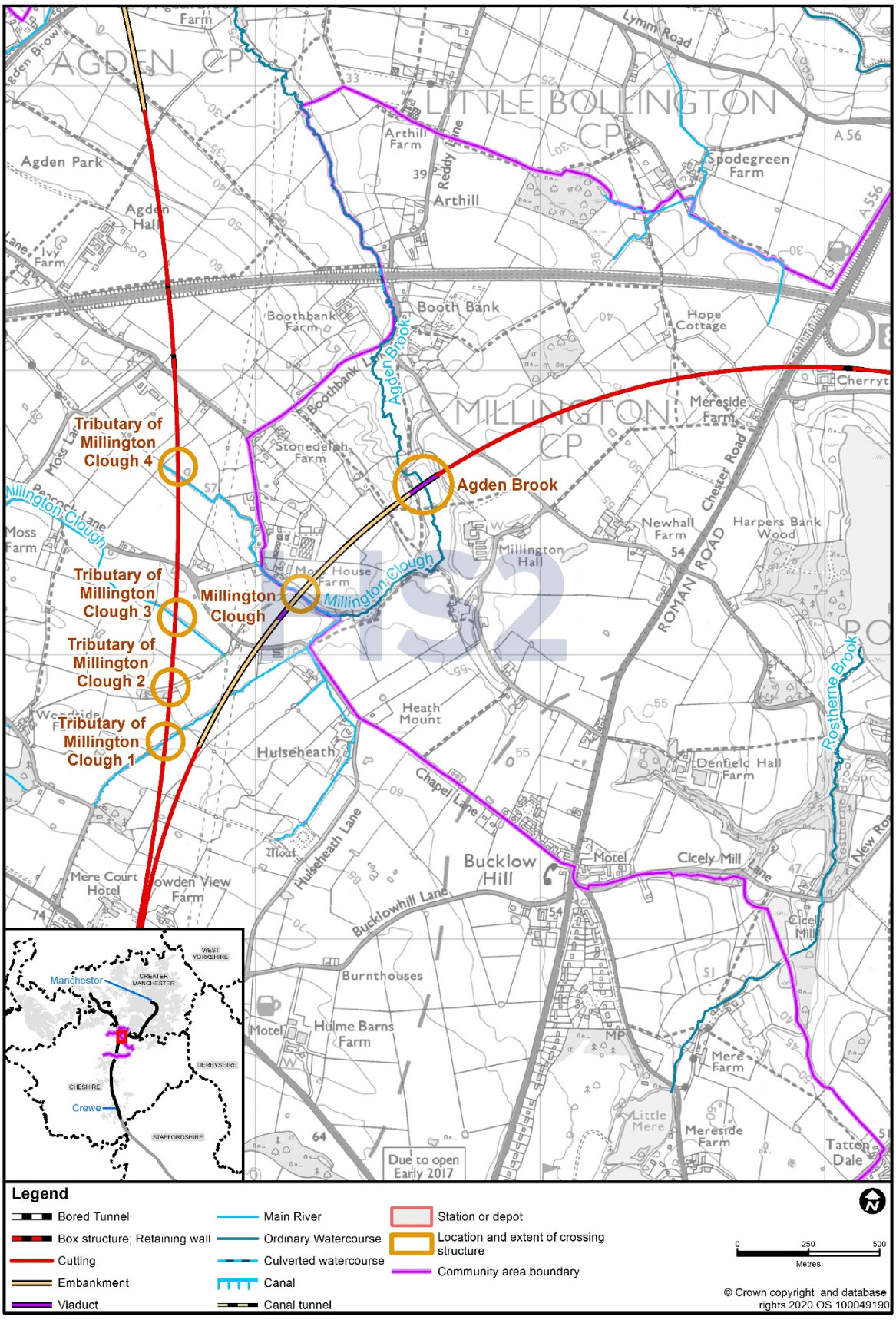


Figure 2: Location and extent of the study area (northern extent)



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 Pickmere to Agden and Hulseheath area. No engagement has been undertaken with the LLFA, however discussions have been held with the Environment Agency technical specialists 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. The modelling is presented in the Hydraulic modelling report – Millington Clough (Volume 5: Appendix WR-006-00001).

2.2.2 The CEC Preliminary Flood Risk Assessment (PFRA)[6] was published in 2011, the CEC Local Flood Risk Management Strategy (LFRMS)[7] 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)[8]. The Proposed Scheme design has sought to align with these objectives where reasonably practicable.

[6] Jacobs (2011), *Cheshire East Council Preliminary Flood Risk Assessment*. Available online at: http://www.cheshireeasthighways.org/Uploads/Cheshire_East_PAR.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 (2015), *North West River Basin Management Plan.* Available online at: https://www.gov.uk/government/publications/north-west-river-basin-district-river-basin-management-plan.

2.2.3 CEC have produced a Strategic Flood Risk Assessment (SFRA)[9] that covers the Pickmere to Agden and Hulseheath 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.

2.2.4 The Canal & River Trust has been consulted to provide input on the design of the crossings. The Canal & River Trust has also provided information on dimensions for existing culverts.

[9] JBA Consulting (2013), *Cheshire East Council Strategic Flood Risk Assessment*. Available online at: Cheshire-East-Council-SFRA-Final-Report-v4.0 (cheshireeast.gov.uk).

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[10] historical flood reports in the Pickmere to Agden and Hulseheath 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 the following:

- main rivers:
  - Waterless Brook/Arley Brook; and
  - Millington Clough.
- ordinary watercourses:
  - Tributaries of Millington Clough 1 to 4;
  - Tributary of Tabley Brook 2; and
  - Tributary of Tabley Brook 8.

3.2.2 The areas at risk of flooding from these watercourses, 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 (Volume 5: Appendix CT-004-00000, Planning data).

Risk from main rivers

Waterless Brook/Arley Brook

3.2.3 This watercourse has mapped flood zones indicated by the Environment Agency Flood map for planning (rivers and sea)[5] dataset. This dataset was used to assess the receptors at potential risk from flooding. As this watercourse has a viaduct crossing that does not affect the floodplain other than at the viaduct piers, it was determined through the decision tree

[10] *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.

process that modelling was not required at this stage. Details of the modelling decision tree process are provided in the SMR: Technical Note: Flood risk.

3.2.4 The receptors upstream and downstream of the Proposed Scheme that are at potential risk from this watercourse are listed below. The relative vulnerability to flooding of each receptor (as defined in NPPF and Table 55 of the SMR) is also indicated. Undeveloped agricultural land (less vulnerable[11]) is the most common receptor for these watercourses:

- agricultural land (less vulnerable); and
- Pickmere Lane Bridge and Budworth Road Bridge (less vulnerable) (Figure 3).

3.2.5 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 greater than or equal to 5km^2 in size the guidance recommends that a peak river flow allowance is used. The percentage uplift in peak river flow 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 70% increase in peak river flow has been adopted on a precautionary basis for this assessment.

Millington Clough and its tributaries 1, 2, 3 and 4

3.2.6 A 2D hydraulic model of Millington Clough and its tributaries 1, 2, 3, and 4 has been developed to define the peak flood levels and extents associated with a range of annual probabilities, and details are reported in the Hydraulic modelling report, Volume 5: Appendix WR-006-00001. The inundation extents for the 1 in 100 (1.0%) annual exceedance probability (AEP) plus climate change (CC) flood are shown in Figure 4.

3.2.7 The receptors that are at potential risk from Tributaries of Millington Clough 1, 2, 3, and 4 are listed below. The relative vulnerability to flooding of each receptor (as defined in NPPF and Table 55 of the SMR) is also indicated:

- residential property west of Thowler Lane (more vulnerable);
- commercial property west of Thowler Lane (less vulnerable);
- Peacock Lane north of Hulseheath (less vulnerable);
- residential property in Hulseheath (more vulnerable);
- commercial property in Hulseheath (less vulnerable); and
- agricultural land (less vulnerable).

3.2.8 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

[11] Agricultural land is assessed to be a less vulnerable receptor irrespective of the agricultural land quality classification. The assessment of agriculture land quality is set out in Volume 2, Community Area report: Pickmere to Agden and Hulseheath, (MA03), Section 4.

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.

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

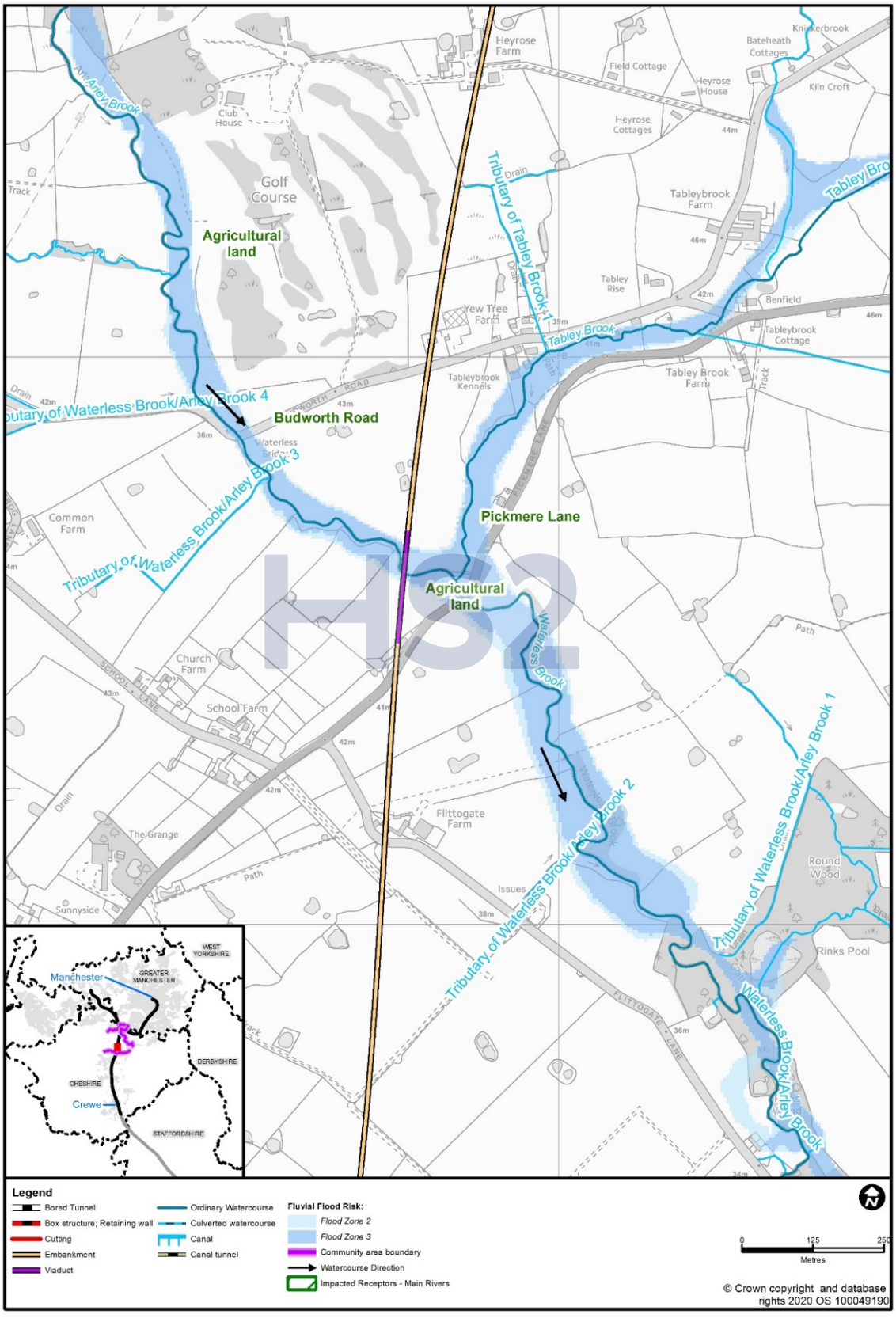
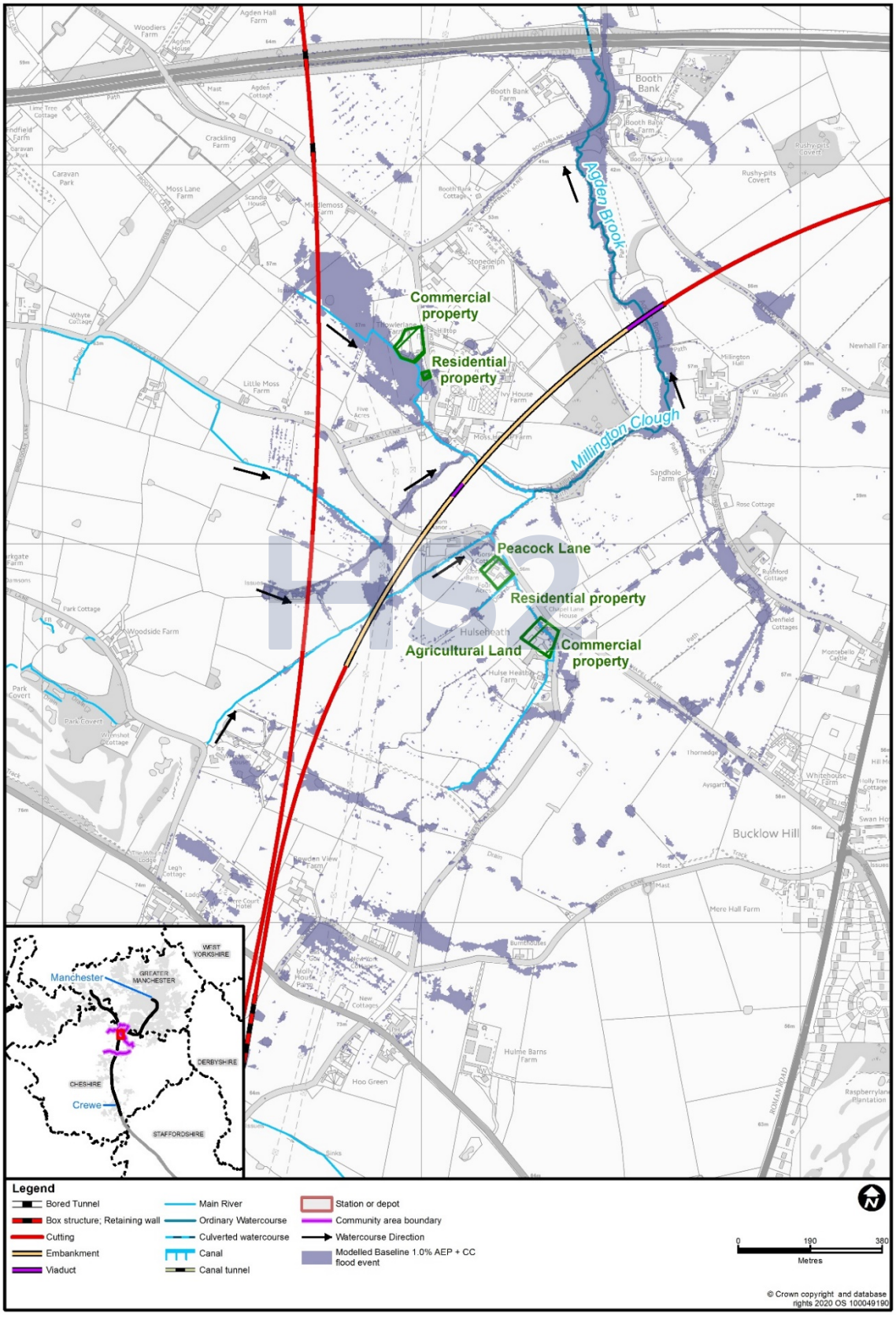


Figure 4: Extent of modelled 1.0% AEP + CC flood event, Millington Clough and its tributaries 1, 2, 3 and 4



Other watercourses

3.2.9 Other ordinary watercourses located within the Pickmere to Agden and Hulseheath area include:

- Tributary of Tabley Brook 2, north-west of Heyrose Golf Club; and
- Tributary of Tabley Brook 8, north-east of Over Tabley.

3.2.10 These ordinary watercourses do not have mapped flood zones indicated by the Environment Agency's Flood map for planning (rivers and sea) dataset, and so the RoFSW outputs were used to determine possible flood extents generated by these watercourses.

3.2.11 Figure 5 and Figure 6 indicate the receptors at risk for the surface water flow paths associated with these watercourses. Undeveloped agricultural land is the main receptor affected by these flowpaths.

3.2.12 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.

Figure 5: Extent of the Environment Agency's RoFSW dataset, Tributary of Tabley Brook 2

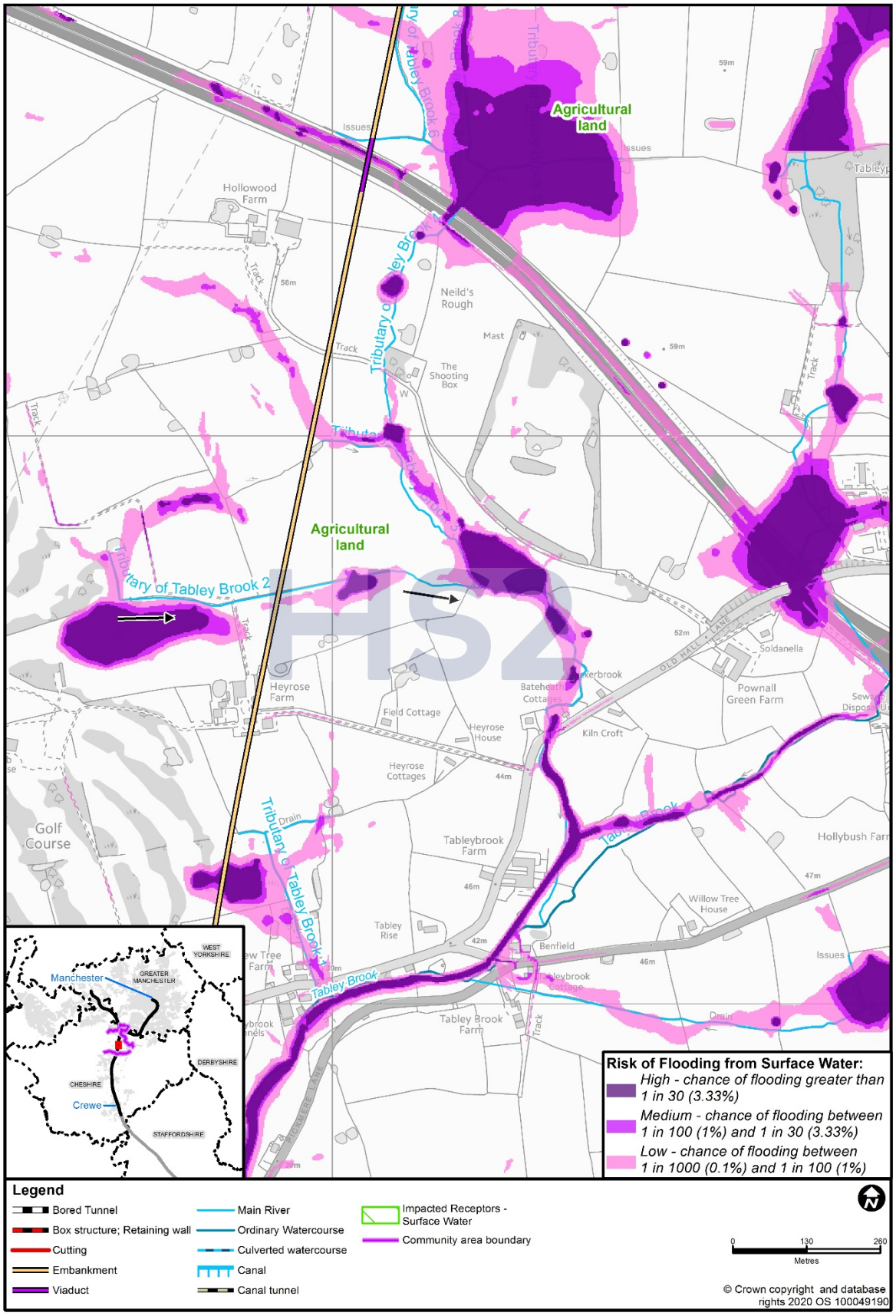
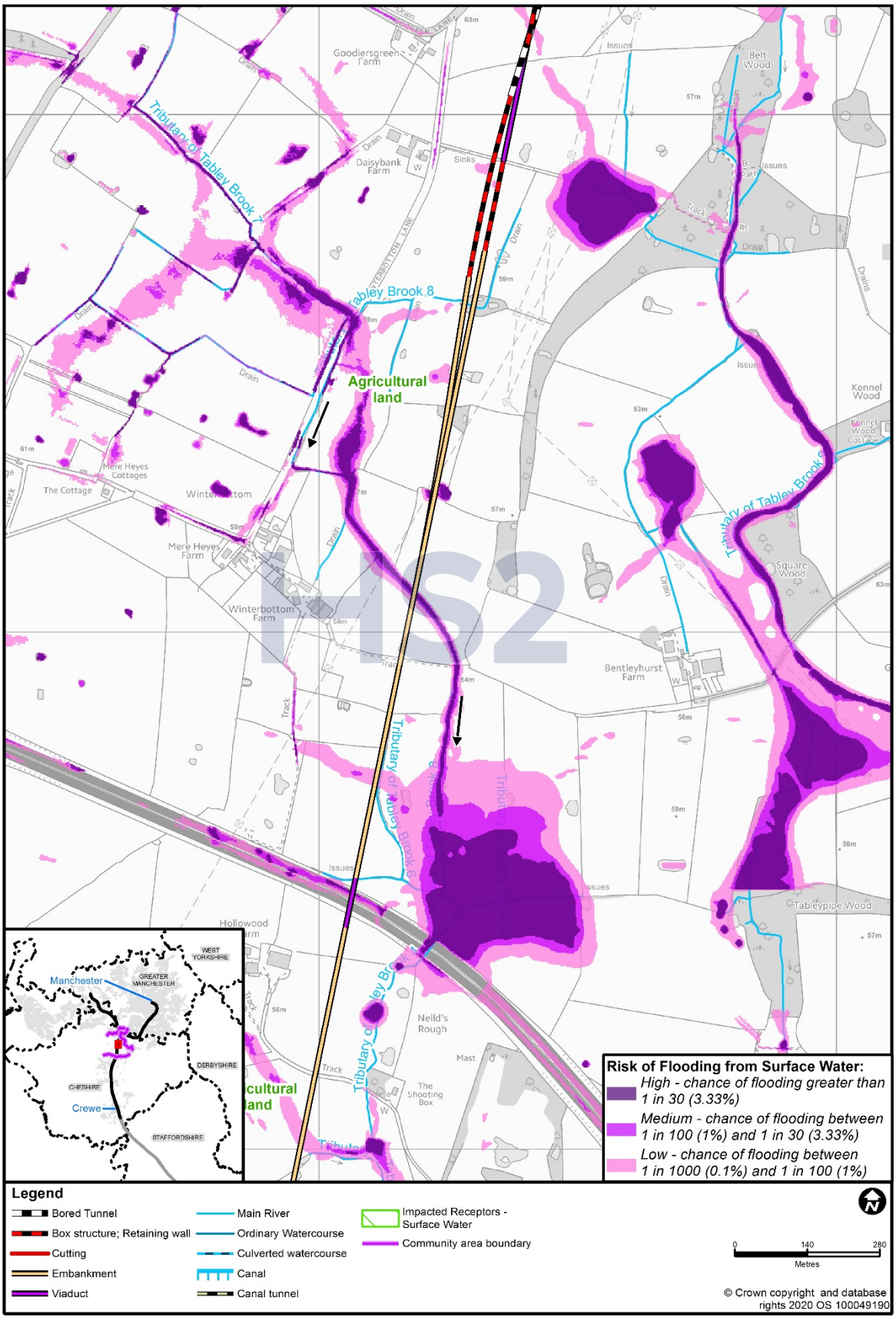


Figure 6: Extent of the Environment Agency's RoFSW dataset, Tributary of Tabley Brook 8



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 As indicated in Figure 5, agricultural land south of Hollowood Farm (less vulnerable) is the receptor at risk from a surface water flow path associated with Tributary of Tabley Brook 3. In addition, agricultural land north of Yew Tree Farm (less vulnerable) is the receptor at risk from a surface water flow path associated with Tributary of Tabley Brook 1.

3.3.3 As indicated in Figure 6, agricultural land south of Winterbottom Farm (less vulnerable) is the receptor at risk from a surface water flow path associated with Tributary of Tabley Brook 6.

3.4 Risks associated with groundwater

3.4.1 The British Geological Society (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 susceptibility to groundwater flooding, 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.

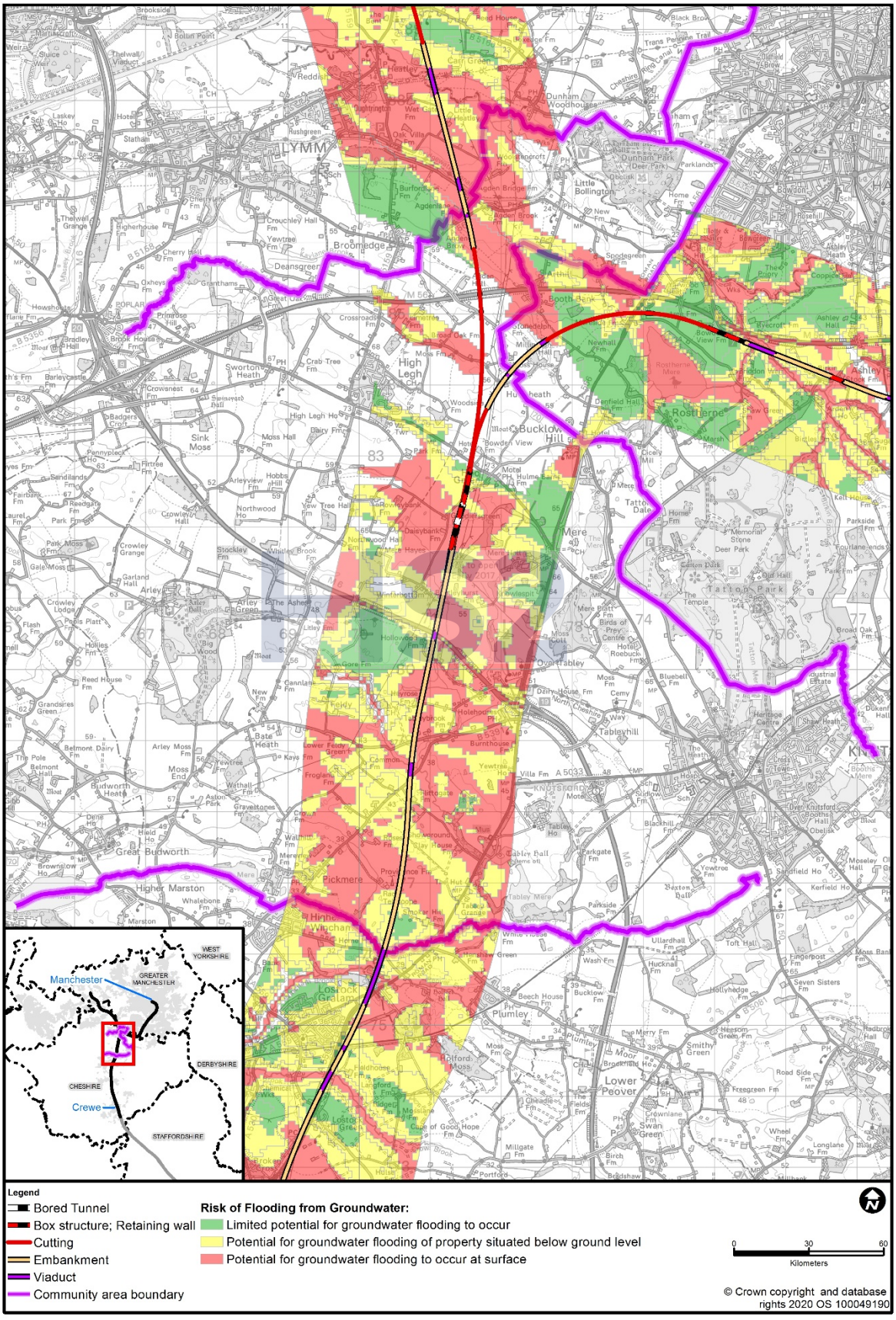
3.4.3 The BGS susceptibility to groundwater flooding dataset (presented in Figure 7) indicates that there is potential for groundwater flooding to occur at surface at the following locations:

- Pickmere;
- Tabley Superior;
- Mere; and
- Agden.

3.4.4 This is due to the nature of the superficial deposits (glacial till). The SFRA[9] does not report any historic groundwater flooding incidents within the study area. The main receptor affected by groundwater flooding is agricultural land (less vulnerable).

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

Figure 7: Susceptibility to groundwater flooding throughout 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 they 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, as shown in Volume 2, MA03 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 Error! Bookmark not defined.
Waterless Brook/Arley Brook	Agricultural land (less vulnerable)	Environment Agency Flood Zones 2 and 3	Less vulnerable	70% (increase to peak river flow)
	Pickmere Lane bridge and Budworth Road bridge (less vulnerable)			
Tributaries of Millington Clough 1, 2, 3 and 4	Residential property east of Thowler Lane (more vulnerable)	1.0% AEP + CC flood extent	More vulnerable	40% (increase in peak rainfall intensity)
	Commercial property east of Thowler Lane (less vulnerable)			
	Peacock Lane (less vulnerable)			
	Residential property at Hulseheath (more vulnerable)			
	Commercial property at Hulseheath (less vulnerable)			
	Agricultural land (less vulnerable)			
Tributaries of Tabley Brook 2 and 8	Agricultural land (less vulnerable)	RoFSW 0.1% AEP flood extent	Less vulnerable	40% (increase in peak rainfall intensity)
Groundwater	Agricultural land (less vulnerable)			Not defined

Source / pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment Error! Bookmark not defined.
	Pickmere Lane bridge and Budworth Road bridge (less vulnerable)	BGS Susceptibility to groundwater flooding dataset	Less vulnerable	

4 Flood risk impacts and effects

4.1 Rivers and ordinary watercourses

Viaducts

4.1.1 The Proposed Scheme within the Pickmere to Agden and Hulseheath area includes one viaduct crossing; Waterless Brook/Arley Brook. Hydraulic analysis of this watercourse has been used in the design and assessment of the Proposed Scheme to determine the likely impact on flood levels from intermediate piers, or any other permanent features associated with the Proposed Scheme that are within the flood zones or predicted flood extents.

4.1.2 The hydraulic analysis was undertaken using simplified 2D modelling with LiDAR data defining the 2D surface and refinements made to represent the watercourse and piers. This analysis has been used to provide greater certainty over the level of impacts the Proposed Scheme is likely to have on peak flood levels. The hydraulic analysis was used to define the impact on the 1.0% AEP plus an allowance for CC flood level.

Waterless Brook/Arley Brook

4.1.3 Arley Brook viaduct is approximately 200m in length. Hydraulic analysis of head loss associated with the piers indicates that without any mitigation measures the viaduct piers have the potential to cause highly localised (generally within 10m) increases in peak flood level of up to 80mm upstream of the piers and decreases in peak flood level of up to 20mm downstream of the piers. The increase in peak flood level is classified as a minor impact as it is a highly localised impact and will affect agricultural land (a moderate value receptor). This results in a minor adverse effect which is not significant.

4.1.4 Replacement floodplain storage (RFS) has been identified as a precautionary measure to address the loss of floodplain storage at this crossing (see Figure 8).

4.1.5 RFS has not been included in the hydraulic analysis at this stage and will be refined during design development to ensure that there is no net loss of floodplain storage. The RFS has an assumed excavation depth of 1m and has been designed with a high safety factor by doubling the calculated compensation volume required. The proposed RFS is located upstream of the Proposed Scheme.

4.1.6 Further topographical survey, other surveys as required, hydraulic modelling including incorporation of the proposed RFS, design development, and refinement of the mitigation measures will be undertaken during design development and will, far as reasonably practicable, ensure no impacts on peak flood level.

Culverts and channel realignments

4.1.7 The Proposed Scheme crosses a number of main rivers and ordinary watercourses via culverts. Hydraulic modelling of some of these watercourses has been used in the design and assessment of the Proposed Scheme to determine the likely impact on local peak flood levels. This was undertaken for Millington Clough and its tributaries, where Millington Clough and Tributary of Millington Clough 2 are main rivers, and Tributaries of Millington Clough 1, 3, and 4 are ordinary watercourses (see Figure 10).

4.1.8 Direct rainfall has been applied to the 2D model domain along with point inflows representing the upstream catchments for the Millington Clough tributaries calculated using ReFH2[13].

4.1.9 The Proposed Scheme model was edited to include the Millington Clough Underbridge and the Millington Clough Offline Underbridge described in Table 2.

4.1.10 Details of the hydraulic modelling assessment undertaken for these watercourses can be found in the supporting Hydraulic modelling report Volume 5: Appendix WR-006-00001.

Table 2: Details of culvert design at modelled 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]
Millington Clough	Millington Clough Offline Underbridge	2.3	40%	3.90	5m high x 3m wide	7.60
Millington Clough	Millington Clough Underbridge	2.3	40%	3.90	5m high x 3m wide	7.60

4.1.11 The following calculation procedure has been undertaken to size the remaining tributaries of Millington Clough culverts:

- determination of the appropriate climate change allowance to be applied following the procedure outlined in the SMR;
- use of the ReFH2[13] to determine the peak river flow generated during the 1.0% AEP storm event + CC;
- determination of the existing gradient of the watercourse using Ordnance Survey mapping and LiDAR data;
- determination of the roughness characteristics of the culvert; and

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

[14] Culvert may be designed to contain not only flow for the watercourse but 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.

- selection of a cross sectional area with the capacity to convey the 1.0% AEP peak river flow, incorporating the appropriate allowance for climate change, whilst ensuring a 300mm freeboard to the culvert soffit for ordinary watercourses and 600mm freeboard for main rivers, above this design flood level and allowing for 300mm substrate at the culvert invert.

4.1.12 The details of the culvert design applied to the watercourses are provided in Table 3.

Table 3: Details of culvert design at 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)[15]
Tributary of Millington Clough 3	Millington Clough culvert	0.38	40%	0.57	1.35m high x 1.5m wide	3.38
Tributary of Millington Clough 2	Millington Clough Offline culvert No.1	1.26	40%	1.85	1.65m high x 1.35m wide	6.06
Tributary of Millington Clough 1	Millington Clough Offline culvert No. 2	0.34	40%	0.50	1.35m high x 1.35m wide	7.08
Tributary of Millington Clough 1 – offline	Millington Clough Offline culvert No. 3	0.17	40%	0.25	1.35m high x 1.5m wide	4.66
Tributary of Millington Clough 4	Millington Clough aqueduct	1.24	40%	3.6	1.45m high x 2.6m wide	4.40

Tributaries of Millington Clough 1, 2, 3 and 4

4.1.13 Upstream of the Proposed Scheme crossing of the HS2 Manchester Spur, Tributaries of Millington Clough 1, 2, 3 and 4 will be subject to significant realignment and/or diversion to accommodate the proposed main line crossings (see Figure 9).

4.1.14 Tributary of Millington Clough 1 will be realigned through two culverts Millington Clough offline culvert No.2 and offline culvert No.3. Tributary of Millington Clough 2 will be realigned through a culvert under the route of the Proposed Scheme, then through an extended 210m long culvert (Millington Clough culvert) north to a realigned open channel. This realigned channel will eventually join its original alignment approximately 40m north-east of Peacock

[15] Culvert may be designed to contain not only flow for the watercourse but 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.

Lane. The watercourse then passes through a culvert (Tributary of Millington Clough offline culvert No.1) under a new access road to join Millington Clough.

4.1.15 Tributary of Millington Clough 4 will cross the route of the Proposed Scheme on an aqueduct (Millington Clough aqueduct) adjacent to its current crossing location, flow along a new channel in a southerly direction, to join its original alignment approximately 100m east of the route.

4.1.16 Millington Clough will cross the HS2 Manchester spur via a 5m wide culvert (Millington Clough underbridge) and then beneath a new road link via twin 7m wide underbridges (Millington Clough offline underbridge). No realignment of the Millington Clough main river is required at the Proposed Scheme crossing of the Manchester spur or at the downstream crossing at Agden Brook viaduct.

4.1.17 The Proposed Scheme embankment has been modelled as a raised impermeable area, covering the Proposed Scheme footprint for the purpose of impounding overland flows. The realignments and/or diversions have not been modelled at this stage due to the 2D nature of the modelling approach.

4.1.18 Three inflows to the hydraulic model for Tributaries of Millington Clough 1, 2 and 3 were calculated using Revitalised Rainfall-Runoff Model version 2.2 (ReFH2) hydrological modelling software. These catchments were combined and inserted into the Proposed Scheme model upstream of Peacock Lane. This is to allow for realignments and/or diversions of the watercourses as part of the Proposed Scheme.

4.1.19 The modelled impact of the Proposed Scheme on peak flood levels is shown in Figure 10. This indicates a decrease of less than 10mm in peak flood level on Tributary of Millington Clough 2 and 3, between the route of the Proposed Scheme and the HS2 Manchester spur.

4.1.20 Localised increases in peak flood levels up to 600mm occur north of Millington Clough on the northern side of the Proposed Scheme, shown on Figure 9 as runoff from the land (and not the Millington Clough watercourses) to the north is interrupted by the Proposed Scheme embankment. The increase in peak flood level of 600mm is classified as a major impact, affecting a moderate value receptor, agricultural land. This results in a moderate adverse effect which is significant. The water from this flow path is addressed using drains at the foot of the Proposed Scheme embankment (designed to HS2 Ltd technical standards), which are not currently included in the modelling. No further mitigation is required.

4.1.21 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.

Figure 8: Proposed culverts (Northern)

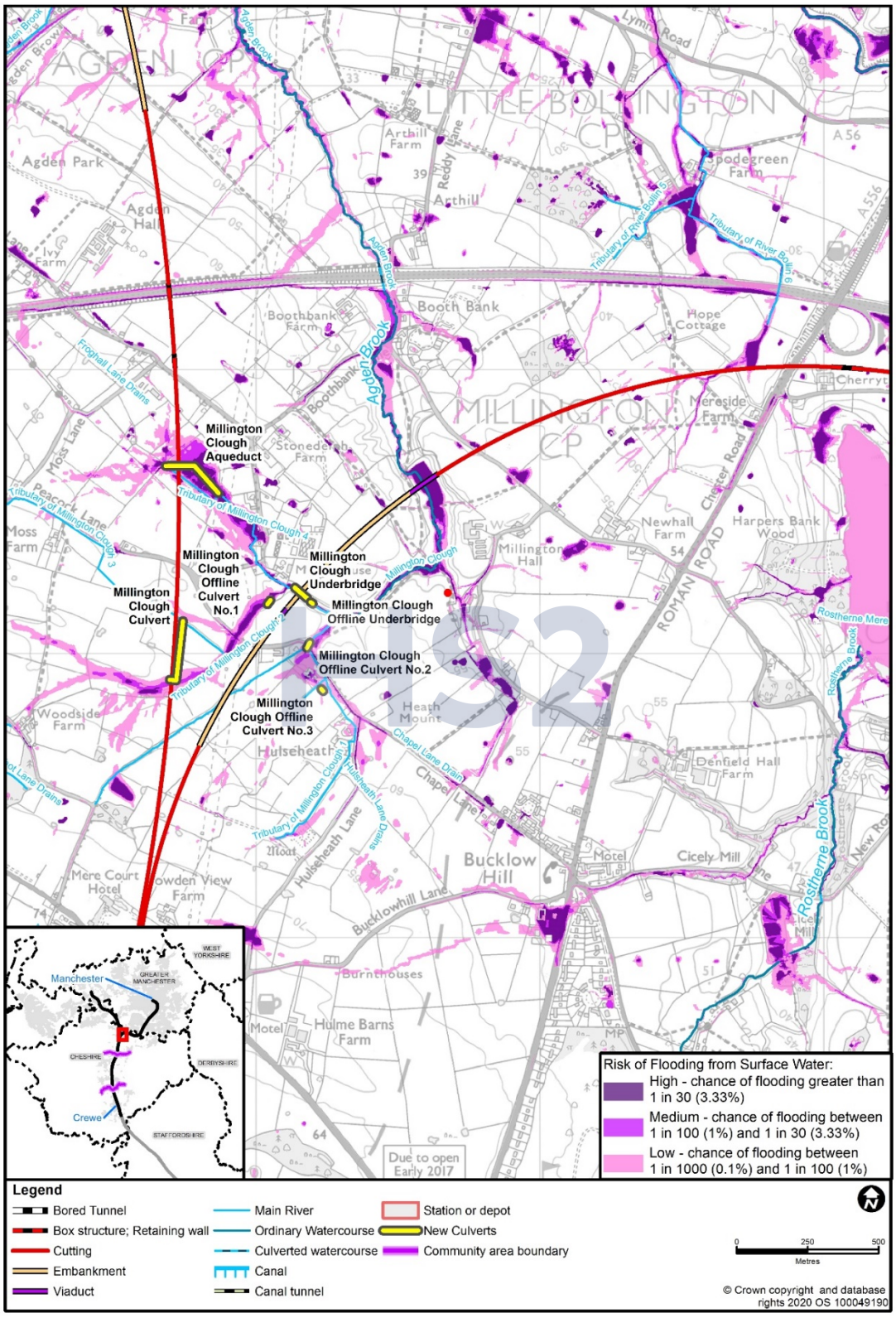
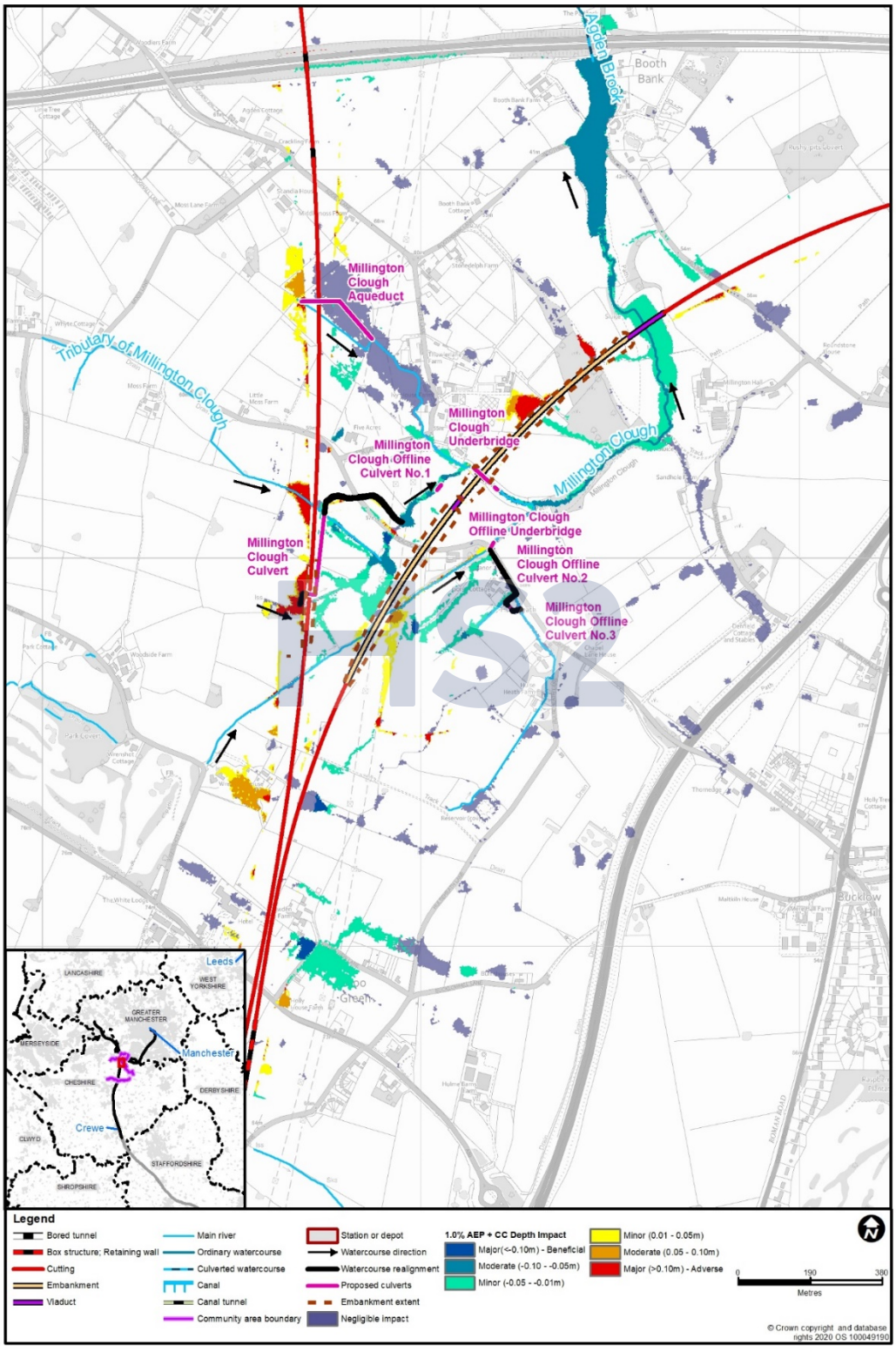


Figure 9: Tributaries of Millington Clough 1, 2, 3 and 4 impact map for the 1.0% AEP + CC event



Ordinary watercourses

4.1.22 The Proposed Scheme crosses a number of ordinary watercourses that have 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 these ordinary watercourses.

4.1.23 At the locations where these ordinary watercourses cross the Proposed Scheme, or offline features, culverts are required to convey the water under the route. Figure 10 shows the location of proposed culverts on ordinary watercourses. The following calculation procedure has been undertaken to size the culverts:

- determination of the appropriate climate change allowance to be applied following the procedure outlined in the SMR;
- use of the ReFH2[13] to determine the peak river flow generated during the 1.0% AEP storm event + CC;
- determination of the existing gradient of the 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 river flow, incorporating the appropriate allowance for climate change, whilst ensuring a 300mm freeboard to the culvert soffit above this design flood level and allowing for 300mm substrate at the culvert invert.

4.1.24 The details of the culvert design applied to the ordinary watercourses are provided in Table 4, unnamed culverts are listed in Table 5. The unnamed culverts will be sized during design development following the calculation procedure outlined in this section.

Table 4: Details of culvert design at ordinary watercourse crossings

Watercourse/ location	Structure name	Estimated 1.0% AEP peak river flow (m^3/s)	Climate change allowance (increase in peak rainfall intensity)	Estimated 1.0% AEP + CC peak river flow (m^3/s)	Culvert dimensions of opening (m)	Culvert capacity (m^3/s)[14]
Tributary of Tabley Brook 2	Bongs Wood culvert	0.34	40%	0.51	2 box culverts 1.35m x 1.35m	7.14
Tributary of Tabley Brook 8	Winterbottom culvert	2.12	40%	3.41	1.8m high x 2m wide	4.20

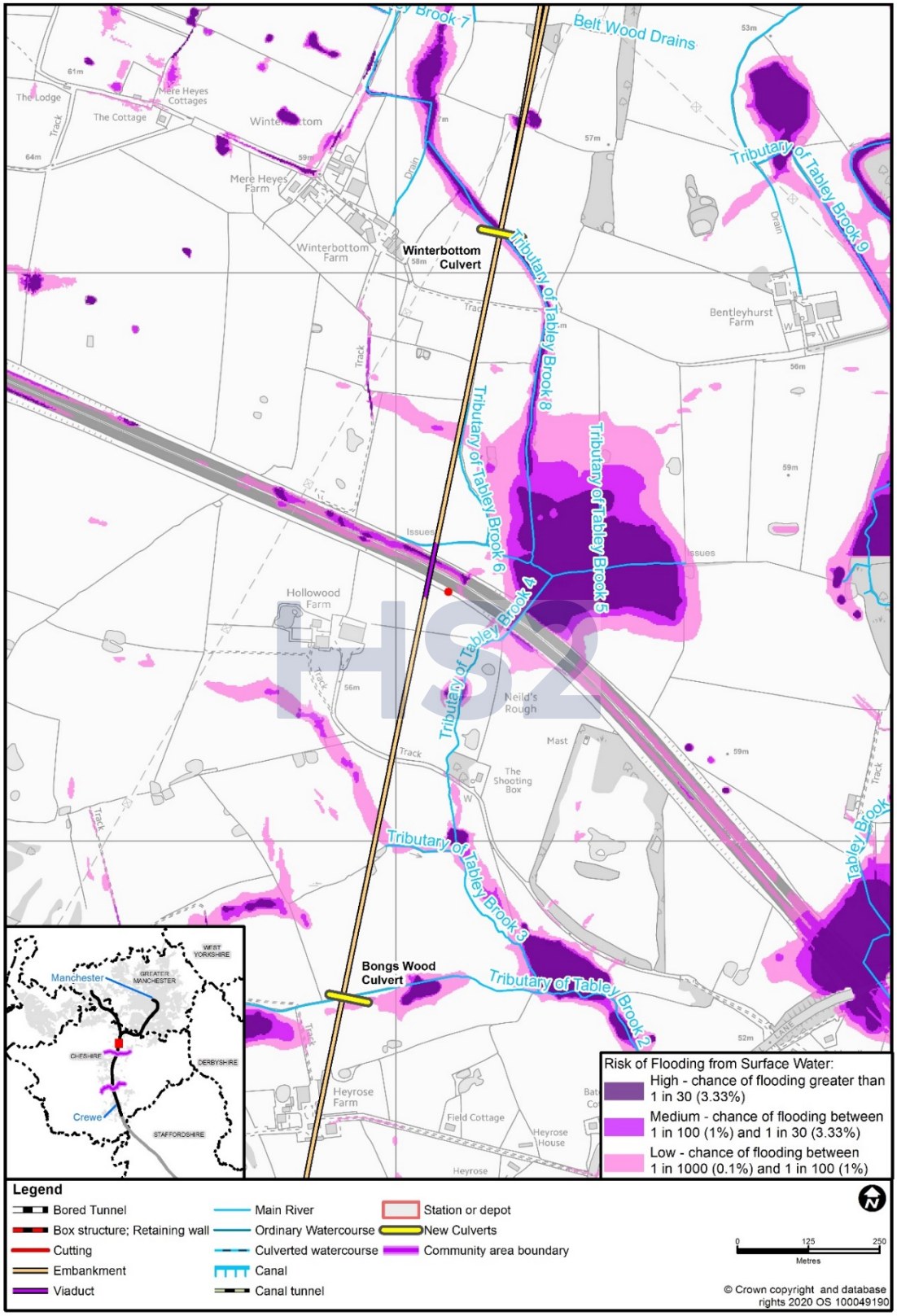
Table 5: Unnamed culverts

Watercourse/ location	Structure name
Tributary of Tabley Brook 4	Unnamed culvert north of M6 realignment
Tributary of Millington Clough 3	Unnamed culvert south of attenuation pond
Tributary of Tabley Brook 4	Unnamed culvert within Tributary of Tabley Brook 4 potential floodplain

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

4.1.26 Each of the ordinary watercourse crossings in Table 4 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 during design development that a change in size is required to ensure no adverse impacts on flood risk.

Figure 10: Proposed culverts (Southern)



Construction compounds

4.1.27 Table 6 highlights the temporary site compounds and stockpiles located in areas at risk of flooding. A temporary satellite compound is proposed which is partially located in Flood Zone 3 and is at risk of flooding from Tabley Brook.

4.1.28 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 applicable.

4.1.29 There is also a risk of flooding from these compounds to other receptors if the proposals within the compound include ground raising or stockpiles of materials which could displace flood water. Where possible buildings will be designed to allow flow beneath to prevent obstructions to flow. Stockpiles of materials will be phased and stored in lower risk areas.

Table 6: Details of temporary site compounds and stockpiles at risk of flooding

Watercourse /location	Construction compound	Flood zone	Risk of flooding from surface water	Location constraints	Potential mitigation
Tabley Brook	Satellite compound	Approximately 20% of the compound within Flood Zone 2 and 3	Compound partially in the 1 in 1000 (0.1%) AEP event flood extent	Location is required due to proximity to Budworth Road. Utilities compounds constraints in the north	Compound layout and drainage to take flood zones into account and locate lower risk items closer to the watercourse
Tributary of Tabley Brook 4 and 6	Satellite compound	Not defined	Approximately 50% of the compound within the surface water flood extents	Location required for construction of viaduct. Road constraints in the south	Compound formation and drainage to be designed to mitigate potential flooding Minor watercourses would need to be diverted
Tributary of Tabley Brook 1	Stockpile	Not defined	Stockpile covers a surface water flow path	Utilities compounds constraints in the north and south	Stockpile can be stopped either side of the flow path
Tributary of Tabley Brook 5	Temporary earthworks stockpile	Not defined	Entire stockpile within the 1 in 30 (3.33%) AEP, 1 in 100 (1%) AEP and 1 in 1000 (0.1%) AEP flood extents	River constraints in the north and south. Satellite compound constraints in the west	This is a transfer node for excavated material, the hard standing will incorporate both internal and

Watercourse /location	Construction compound	Flood zone	Risk of flooding from surface water	Location constraints	Potential mitigation
					perimeter drainage Minor watercourses would need to be diverted
Tributary of Millington Clough 4	Stockpile	Not defined	Approximately 50% of the stockpile within the surface water flood extents	Utilities compounds constraints in the east	Reduce stockpile extent
	Stockpile	Not defined	Northern part of the stockpile covers a surface water flow path	River constraints in the east. Utilities compounds constraints	Stockpile can be stopped either side of the flow path

4.2 Surface water

4.2.1 As outlined previously the RoFSW[5] 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 The surface water flow paths associated with Tributary of Tabley Brook 1, Tributary of Tabley Brook 3 and Tributary of Tabley Brook 6 have been addressed in the design of the Proposed Scheme by providing embankment toe drains to collect and convey the surface water along with any track drainage from one side of the Proposed Scheme to the other. This water is then discharged back into the watercourse via the attenuation ponds.

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 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 The Water resources assessment (Volume 5: Appendix WR-003-0MA03) has shown that there are no features of the Proposed Scheme in the Pickmere to Agden and Hulseheath area that will increase groundwater levels. Therefore, there will be no significant increase in risk of groundwater flooding as a result of the Proposed Scheme.

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 on the Volume 2, MA03 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 of drainage systems will, as far as reasonably practical, 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[16].

[16] 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 the existing hydraulic models to improve the representation of existing watercourses. Designs for the viaducts, bridges and culverts will be incorporated into the hydraulic models along with the identified areas of RFS, the mitigation measures will be refined during design development to remove potential effects on flood risk as far as is reasonably practicable. The effect of RFS areas on the agricultural land quality classification is assessed in Volume 2, Community Area report: Wimboldsley to Lostock Gralam, (MA02), Section 4.

5.1.2 The hydraulic analysis of the viaduct crossing at Waterless Brook/Arley Brook indicates that the Proposed Scheme, without mitigation, has the potential to lead to localised increases in water level. The impacts of increased water levels are considered minor, and therefore not significant. RFS has been proposed on a precautionary basis to address the loss of floodplain storage caused by the viaduct piers and compensate for any wider cumulative impacts. The provision for RFS has been made using a 1m excavation depth and doubling the calculated compensation volume required.

5.1.3 The hydraulic modelling of Millington Clough and its tributaries indicates that the Proposed Scheme could potentially cause moderate adverse effects on flood risk on the north side of the Manchester spur, which is significant. Drains embedded in the design have been provided as a mitigation measure at the foot of the embankment. The drains have been designed to address this surface runoff, following HS2 Ltd technical standards. The drainage provided will mitigate flood risk posed by the Proposed Scheme, resulting in a negligible impact and a negligible effect, which is not significant.

5.1.4 Further topographical survey, other surveys as required, hydraulic modelling, including incorporation of the RFS and embankment drains, design development, and refinement of the mitigation measures will be undertaken during design development and will, as far as reasonably practical, ensure no potential effects on flood risk.

5.1.5 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. As far as reasonably practical no parties will be 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 Pickmere to Agden and Hulseheath 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 RFS mitigation has been identified on a precautionary basis, to address the loss of floodplain storage caused by the intermediate piers at all the viaduct crossings. Drains embedded in the design have been provided as a mitigation measure to address the interruption, by the Proposed Scheme, of surface runoff flow paths in the Millington Clough area. Further assessment and refinement of the models and mitigation measures during design development will ensure any localised impacts on peak flood levels are mitigated and flood risk is unchanged as a result of the Proposed Scheme.

6.2.3 The assessment indicates that, subject to the implementation of the avoidance and mitigation measures identified, and the measures included in the Draft water resources operation and maintenance plan (Volume 5: Appendix WR-007-00000), the Proposed Scheme will not result in any significant adverse effects on flood risk in MA03.

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