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HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix WR-005-0MA02

Water resources and flood risk

MA02: Wimboldsley to Lostock Gralam

Flood risk assessment

M325

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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 Wimboldsley to Lostock Gralam area (MA02).

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 Wimboldsley to Lostock Gralam area, the Water resources assessment (Volume 5: Appendix WR-003-0MA02) 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-004-0MA02)[1]; and
- WFD compliance assessment baseline data (BID WR-002-00001)[2].

1.1.6 Maps referred to throughout this assessment are contained in the Volume 2, MA02 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-004-0MA02. 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 (2012), *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 Wimboldsley to Lostock Gralam 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. The proposed temporary borrow pits are of a significant scale compared to the permanent works. Excavation of the borrow pits will be undertaken in accordance with the measures outlined in the draft Code of Construction Practice (CoCP) (Volume 5, Appendix CT-002-00000), and will, as far as reasonably practical, not increase flood risk to vulnerable receptors. The design of the temporary works will ensure that, if a flood does occur, the borrow pits will fill with floodwater. It is also assumed that the restored borrow pit areas will cause no increase in flood risk. At this stage, it is assumed that the areas will be restored to their existing ground levels, which will in turn restore their original floodplain hydraulic functionality. However, consideration should be given to the potential use of the borrow pits for flood risk reduction during design development. The permanent drainage of the restored borrow pit areas will also maintain existing surface water runoff characteristics as far as reasonably practical. Therefore, it is assumed that these features will not increase flood risk, due to the measures set out in Section 9 of the Borrow pit report (Volume 5, Appendix CT-008-00000).

1.2.3 The risk of flooding to site 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 sites will be registered with the Environment Agency Flood Warning and Flood Alert service, 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. 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 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 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.

1.2.9 The Volume 2, Community Area report for the Wimboldsley to Lostock Gralam 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 MA02 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. 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)

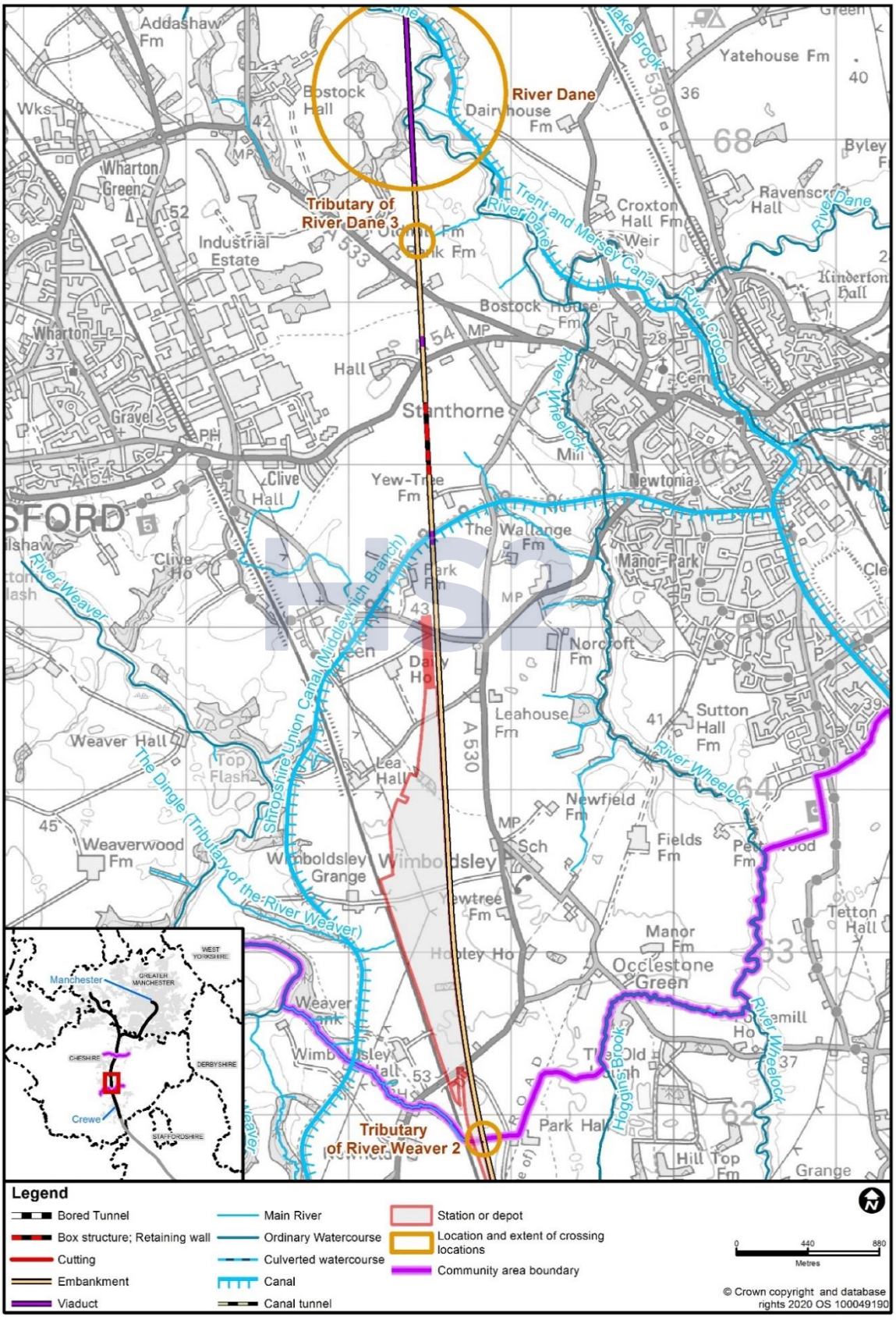
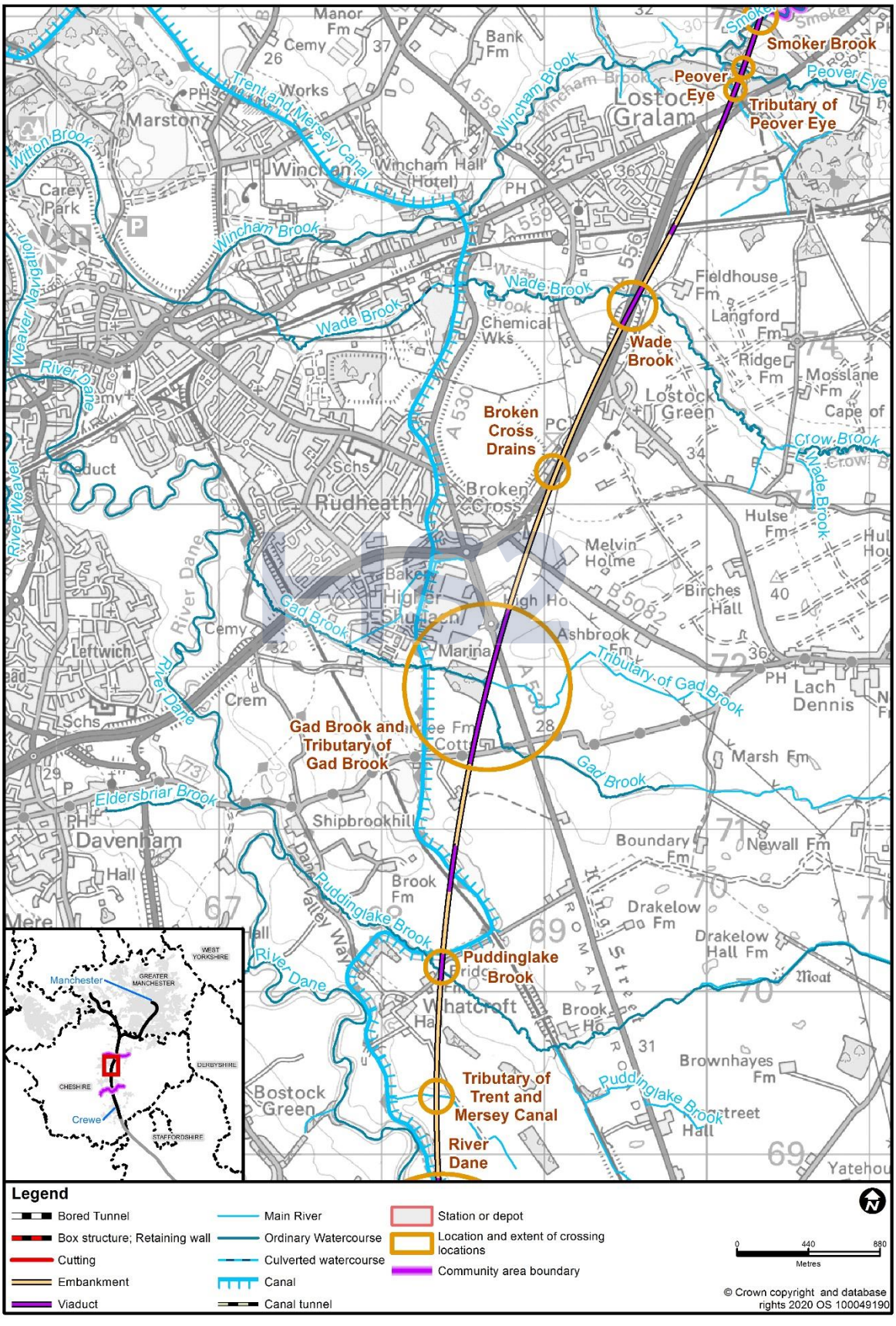


Figure 2: Location and extent of the study area (northern extent)



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 West and Cheshire Council (CWCC) and Cheshire East Council (CEC) are the LLFA in the Wimboldsley to Lostock Gralam area. No engagement has been undertaken with the LLFA. 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 CWCC Preliminary Flood Risk Assessment (PFRA)[6] was published in 2011, the CEC PFRA[7] was published in 2011, the CWCC Local Flood Risk Management Strategy (LFRMS)[8] was published in 2016, and the CEC LFRMS[9] was published in 2015. The LFRMS contains a number of policies related to sustainable development, access to, and maintenance of,

[6] Jacobs (2011), *Cheshire West and Chester Preliminary Flood Risk Assessment.* Available online at: https://consult.cheshirewestandchester.gov.uk/file/4411609.

[7] Jacobs (2011), *Cheshire East Council Preliminary Flood Risk Assessment*. Available online at: https://webarchive.nationalarchives.gov.uk/ukgwa/20140328094439mp_/http://www.environment-agency.gov.uk/research/planning/135532.aspx#5.

[8] Cheshire West and Chester County Council (2016), *Cheshire West and Chester Local Flood Risk Management Strategy.* Available online at: https://consult.cheshirewestandchester.gov.uk/file/4770530.

[9] Cheshire East Council (2017), *Cheshire East Council Local Flood Risk Management Strategy*. Available online at:https://moderngov.cheshireeast.gov.uk/ecminutes/documents/s59547/Local%20Flood%20Risk%20Management%20Strategy%20-%20app%202.pdf.

ordinary watercourses and the need to consider environmental opportunities that reinforce the objectives of the River Basin Management Plan (RBMP)[10]. The Proposed Scheme design has sought to align with these objectives where reasonably practicable.

2.2.3 CWCC have produced a Strategic Flood Risk Assessment (SFRA)[11] and CEC have produced a SFRA[12] that cover the Wimboldsley to Lostock Gralam 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.

[10] 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.

[11] JBA Consulting (2016), *Cheshire West and Chester Level 1 Strategic Flood Risk Assessment.* Available online at: https://consult.cheshirewestandchester.gov.uk/portal/cwc_ldf/cw_lp_part_two/ev_base/sfra2016.

[12] 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 CWCC and 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[13] historical flood reports in the Wimboldsley to Lostock Gralam area showed no recorded historical flooding within 10km of the Proposed Scheme. However, recent localised flood events occurred in Northwich in October 2019[14]. These flood events may be subject to a Section 19 report in the future.

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
  - River Dane;
  - Wade Brook;
  - Puddinglake Brook;
  - Gad Brook and Tributary of Gad Brook 3;
  - Peover Eye and Tributary of Peover Eye; and
  - Smoker Brook.
- ordinary watercourses
  - Tributary of River Weaver 2;
  - Tributary of River Dane 3;
  - Tributary of the Trent and Mersey Canal; and
  - Broken Cross Drains.

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

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

[14] BBC News (2019), *Rising floodwaters lead to Northwich evacuations.* Available online at: https://www.bbc.co.uk/news/av/uk-england-manchester-50209113/rising-floodwaters-lead-to-northwich-evacuations.

considered below. Receptors have been identified based on OS mapping and committed development information[15].

Risk from main rivers: River Dane, Puddinglake Brook, Gad Brook, Wade Brook, Peover Eye, and Smoker Brook

3.2.3 These main rivers have 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.

3.2.4 The receptors upstream and downstream of the Proposed Scheme that are at potential risk from these watercourses 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[16]) is the most common receptor for these watercourses:

- River Dane: agricultural land (less vulnerable) (Figure 3);
- Puddinglake Brook: agricultural land (less vulnerable) and a cottage (more vulnerable) on Whatcroft Hall Lane just downstream of the crossing (Figure 4);
- Gad Brook and Tributary of Gad Brook 3: agricultural land (less vulnerable) and Davenham Road (less vulnerable) (Figure 5);
- Wade Brook: agricultural land (less vulnerable) (Figure 6);
- Peover Eye and Tributary of Peover Eye:
  - Woodland (water compatible);
  - A559 Manchester Road (less vulnerable);
  - Mill Lane (less vulnerable) (Figure 7); and
- Smoker Brook: agricultural land (less vulnerable) and Linnards Lane (less vulnerable) (Figure 7).

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. 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.

[15] Volume 5: Appendix CT-004-00000, Planning data.

[16] 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: Hulseheath to Manchester Airport, (MA02), Section 4.

Figure 3: Extent of the Environment Agency's Flood Zones 2 and 3, River Dane

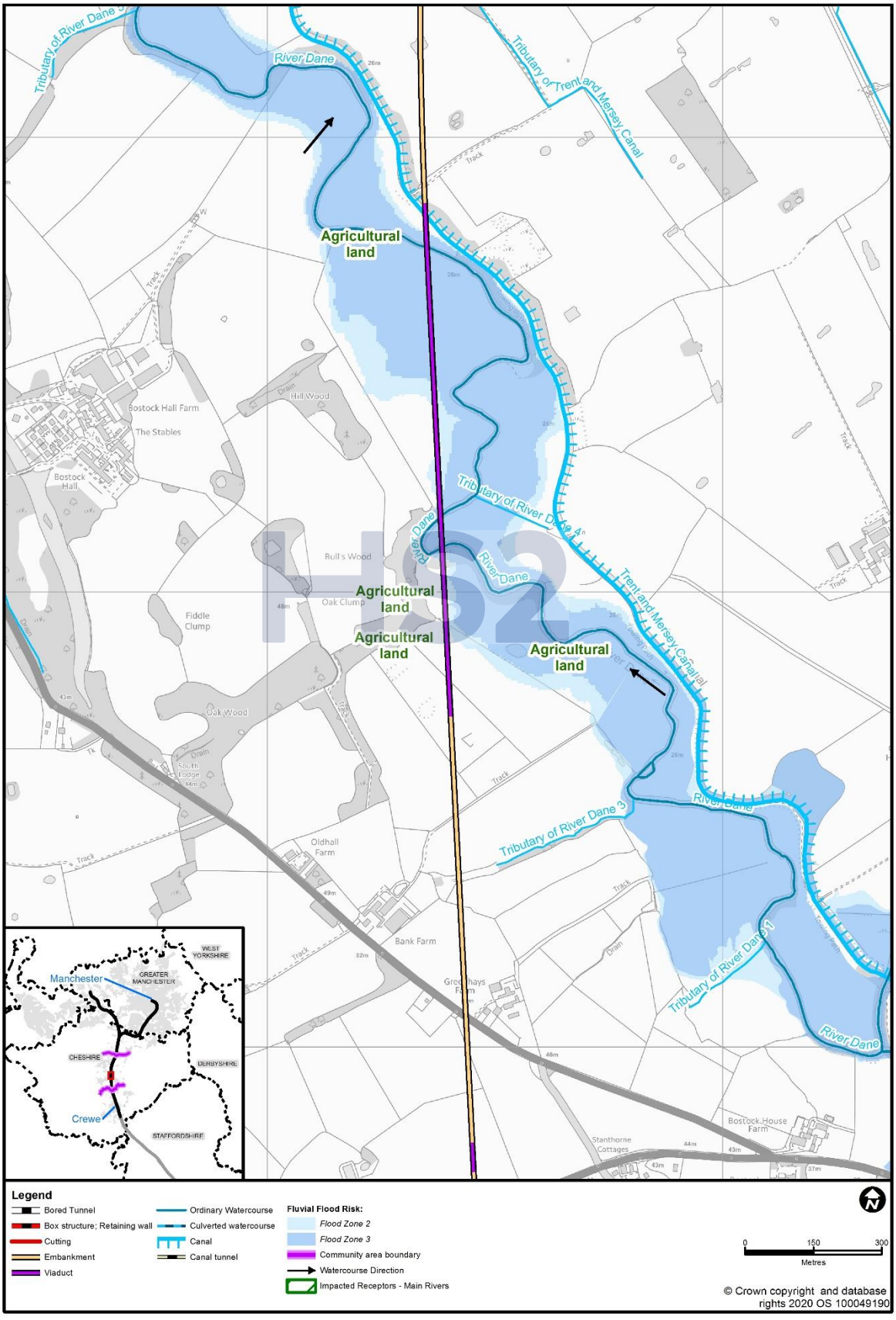


Figure 4: Extent of the Environment Agency's Flood Zones 2 and 3, Puddinglake Brook

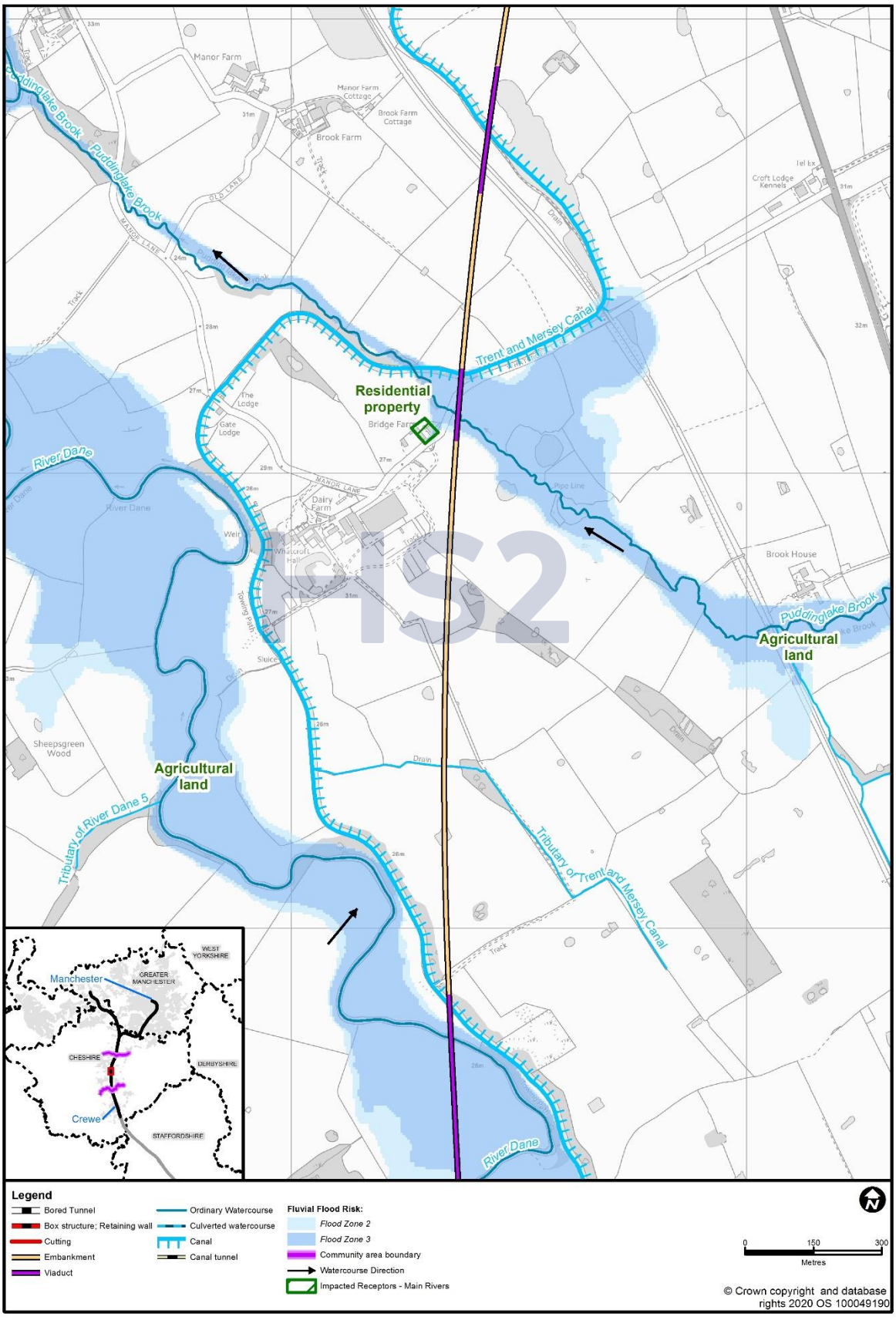


Figure 5: Extent of the Environment Agency's Flood Zones 2 and 3, Gad Brook

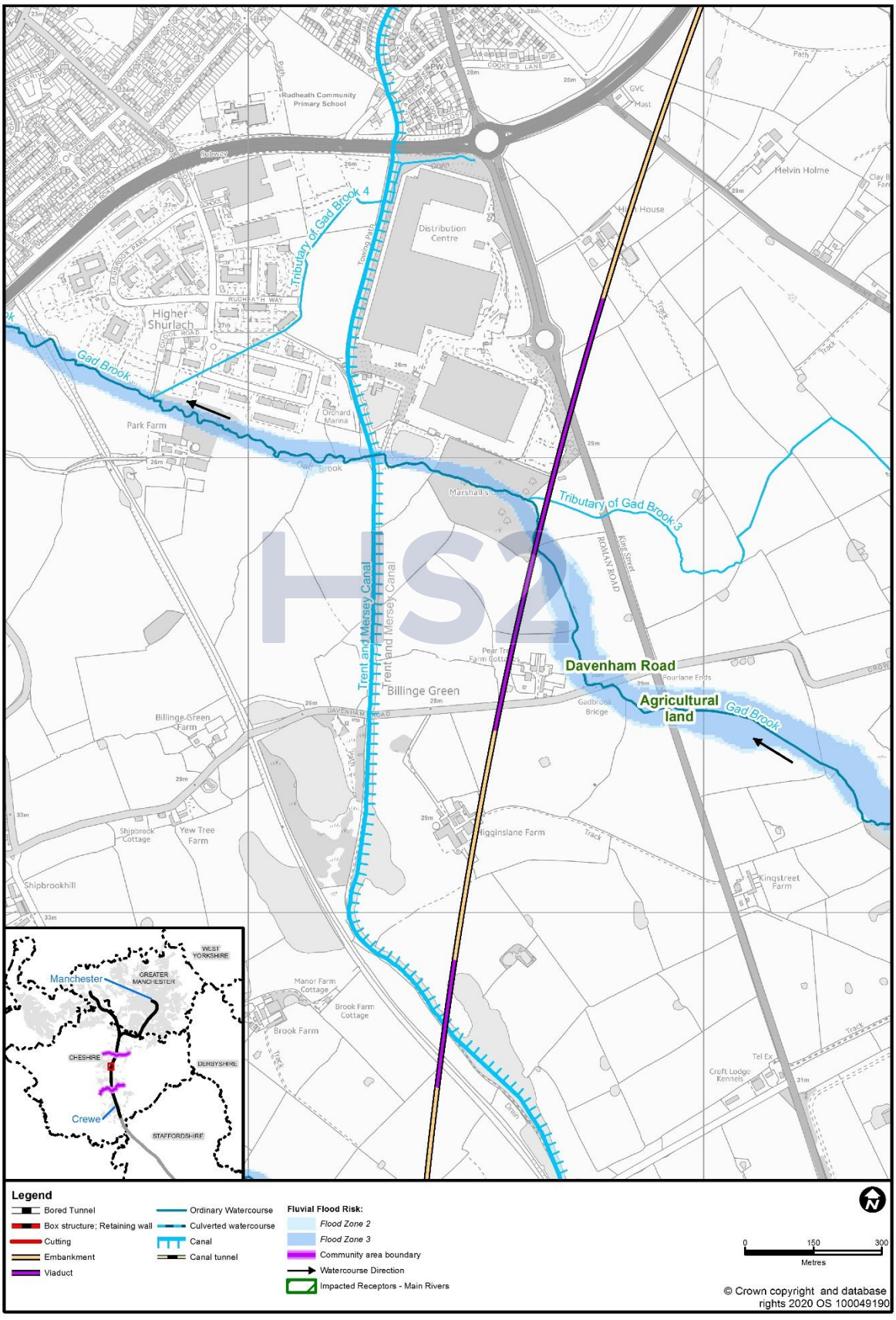


Figure 6: Extent of the Environment Agency's Flood Zones 2 and 3, Wade Brook

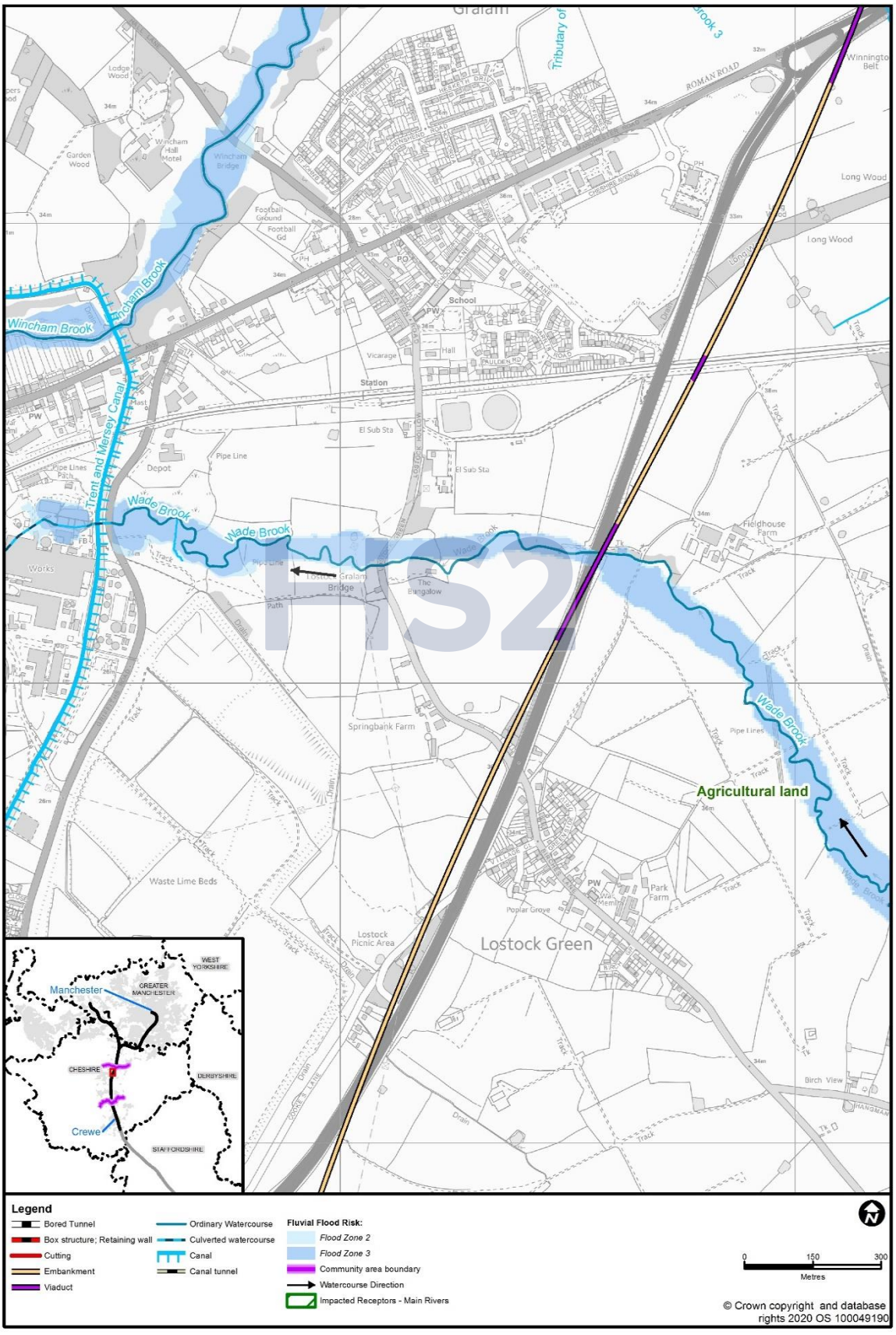
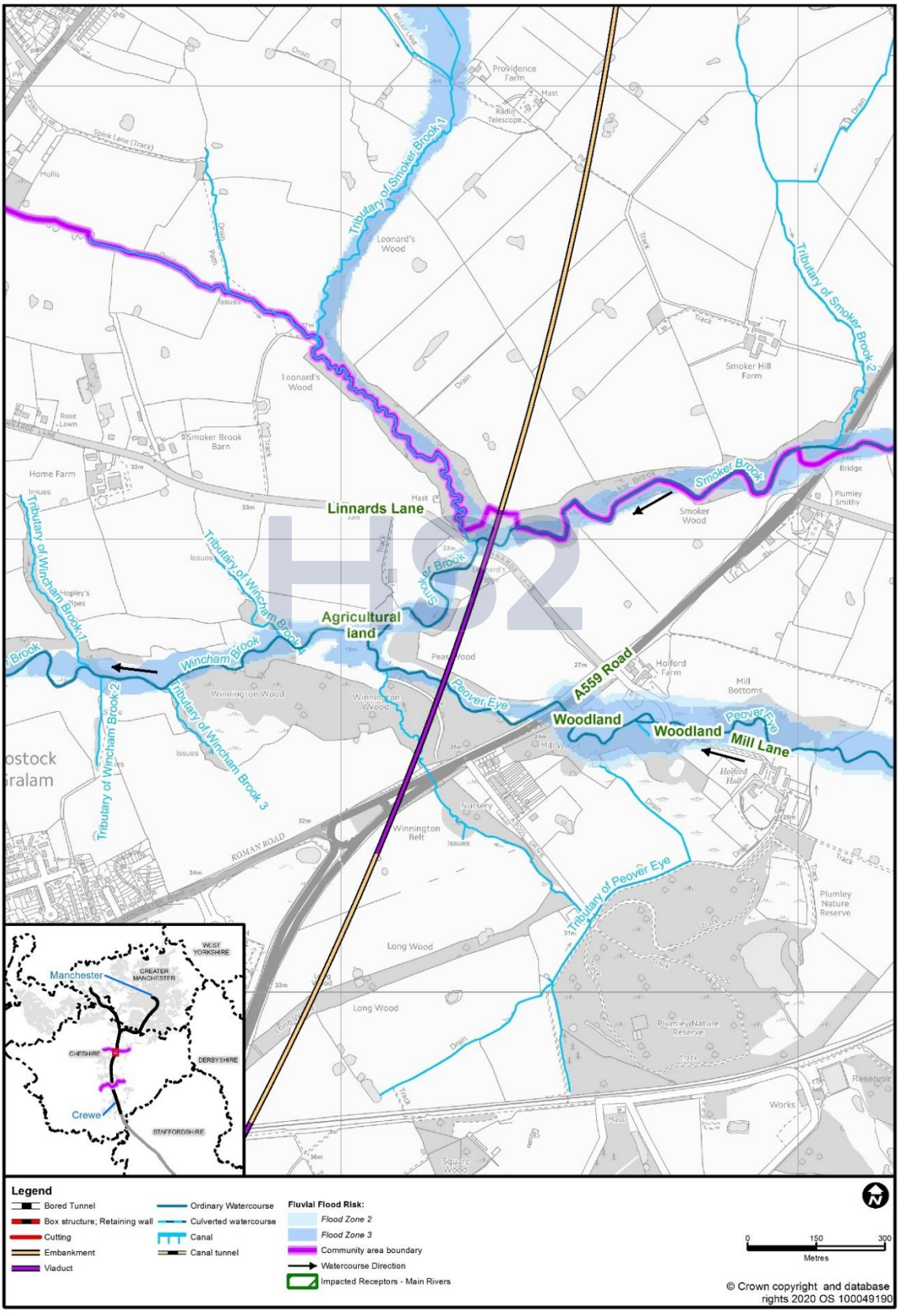


Figure 7: Extent of the Environment Agency's Flood Zones 2 and 3, Peover Eye/Smoker Brook



Other watercourses

3.2.6 Other ordinary watercourses located within the Wimboldsley to Lostock Gralam area include:

- Tributary of River Dane 3 (see Figure 8);
- Tributary of the Trent and Mersey Canal (see Figure 8);
- Tributary of River Weaver 2 (see Figure 9); and
- Broken Cross Drains (see Figure 10).

3.2.7 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. Figure 8, Figure 9 and Figure 10 indicate the receptors at risk for the surface water flow paths associated with these watercourses which is 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 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.

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%) annual exceedance probability (AEP) flood event. This dataset indicates where surface water flow paths cross the proposed scheme. Two surface water flow paths have been identified in the study area.

3.3.2 As indicated in Figure 9, agricultural land south of Green Lane Bridge and north of Stove Room Wood (less vulnerable) are the receptors at risk from a surface water flow path at Clive Green.

3.3.3 As indicated in Figure 10, agricultural land (less vulnerable), and an instrument house and telecoms mast (essential infrastructure) are at risk from surface water east of Rudheath.

3.3.4 In line with the SMR, a climate change allowance has been adopted to assess the future flood risk to receptors associated with each surface water flow path 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 8: Extent of the Environment Agency's RoFSW dataset, Bostock

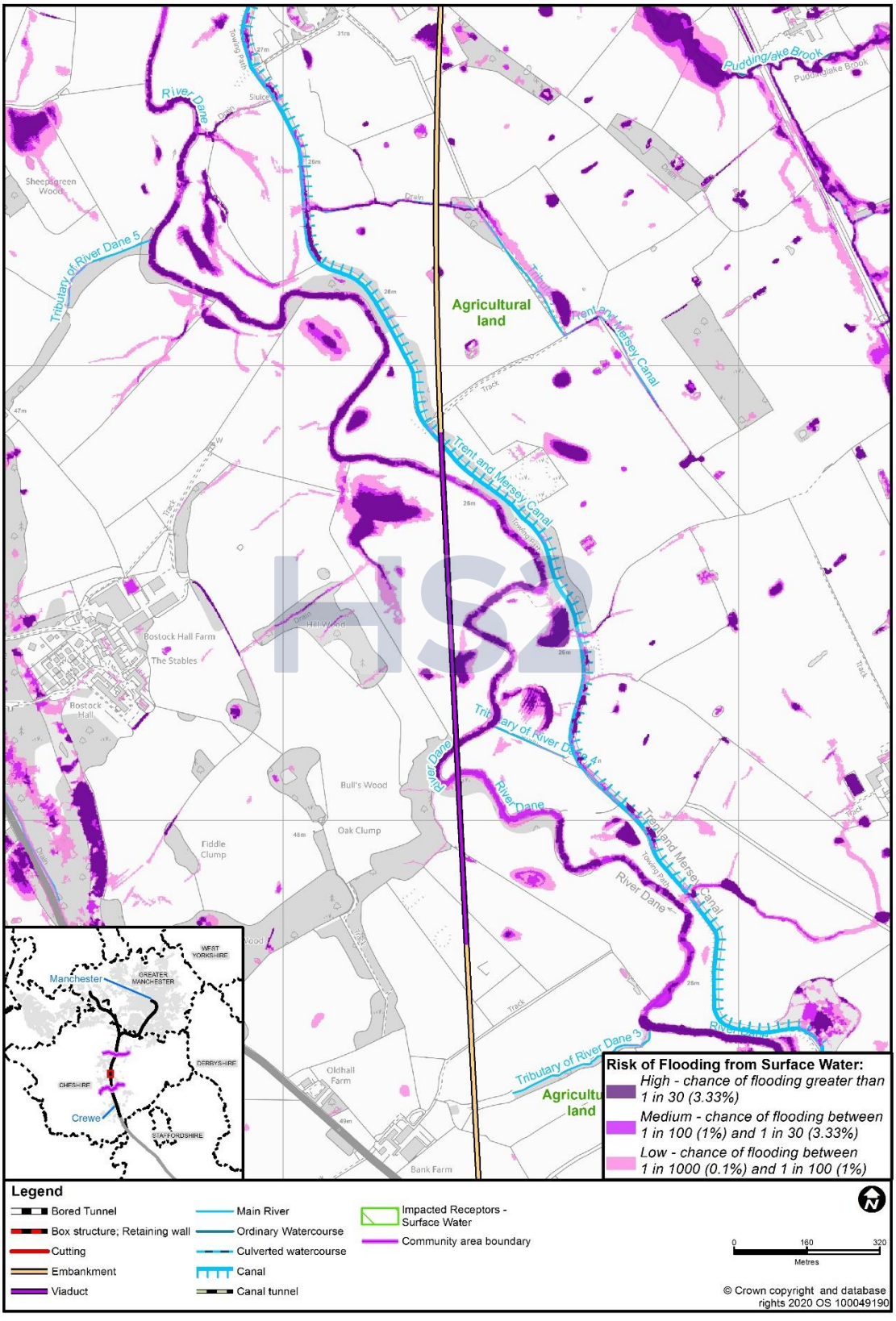


Figure 9: Extent of the Environment Agency's RoFSW dataset, surface water flow path at Clive Green

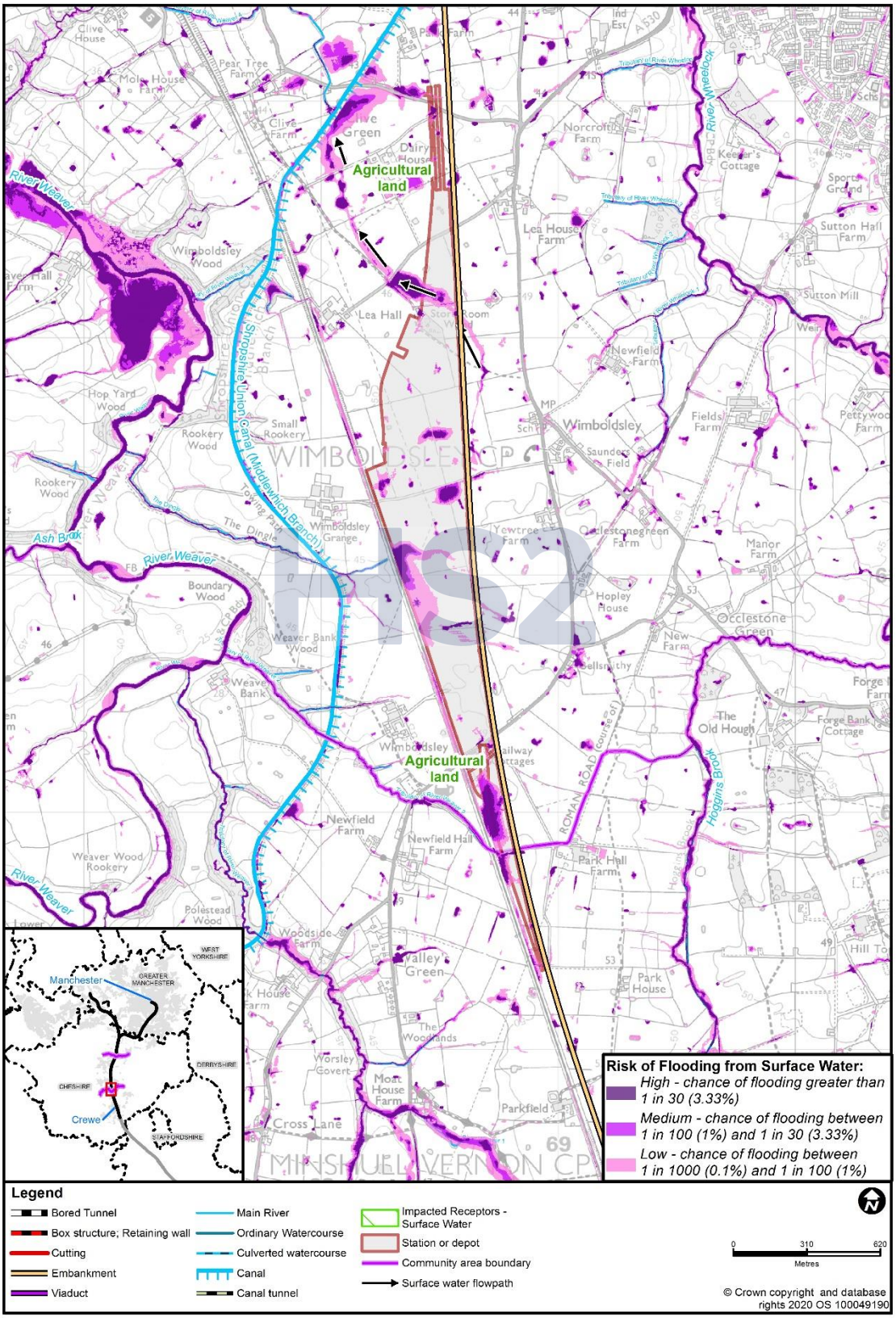
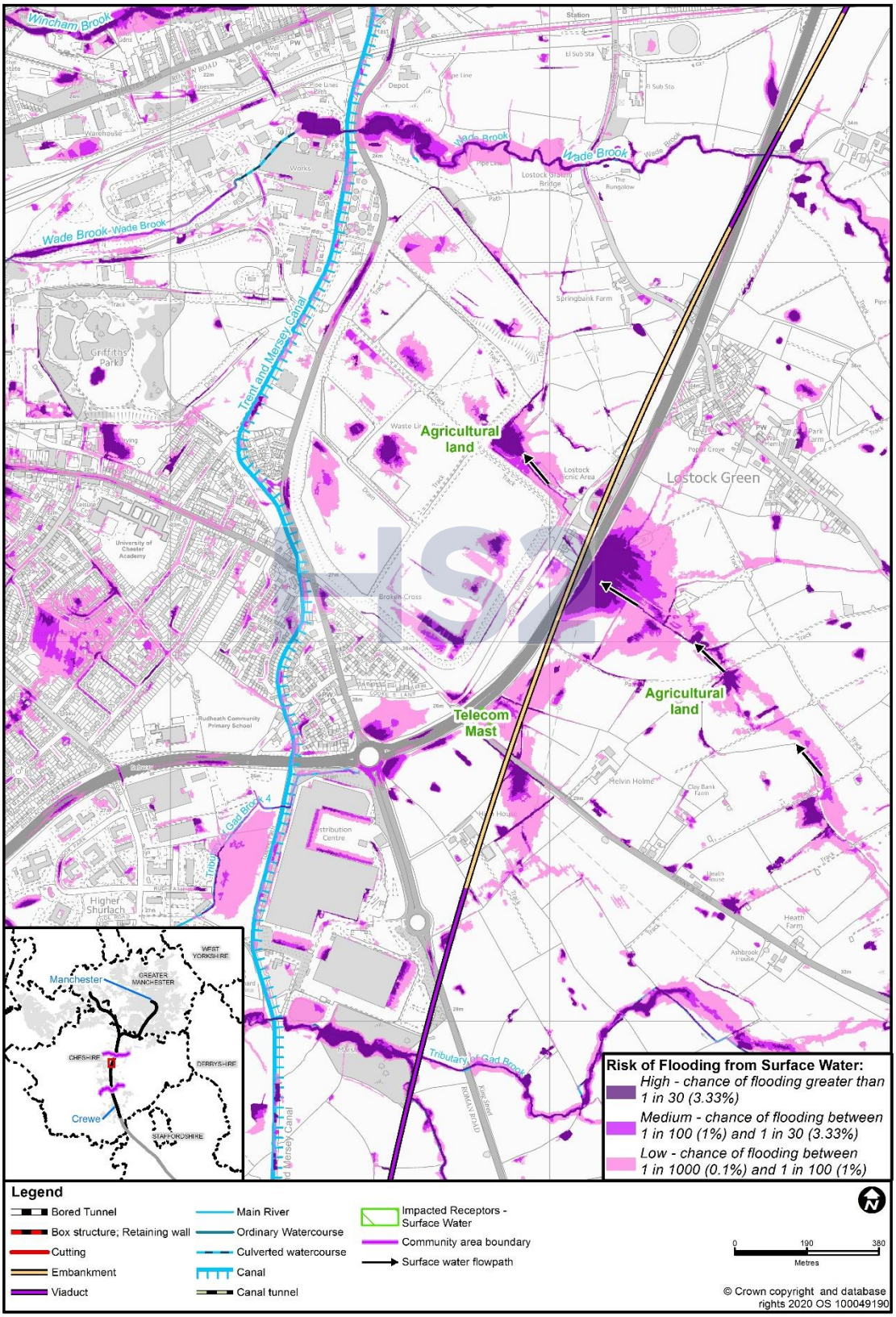


Figure 10: Extent of the Environment Agency's RoFSW dataset, surface water flow path Rudheath



3.4 Risks associated with groundwater

3.4.1 The British Geological Society (BGS) susceptibility to groundwater flooding dataset[17] 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.

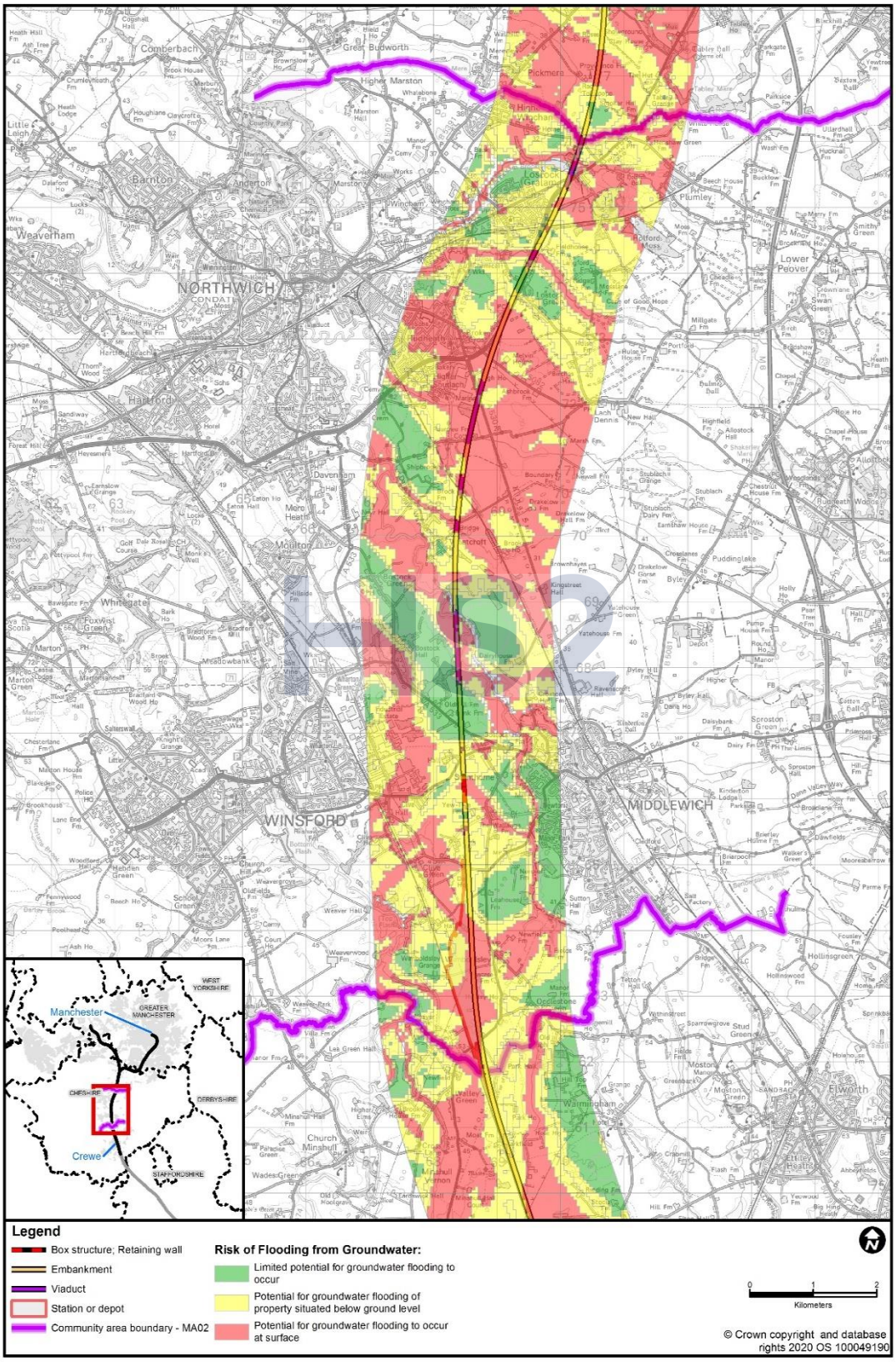
3.4.3 The BGS susceptibility to groundwater flooding dataset (presented in Figure 11) indicates that there is potential for groundwater flooding to occur at surface at the following locations:

- Wimboldsley;
- Clive Green;
- Whatcroft;
- Rudheath; and
- Wincham.

3.4.4 This is due to the nature of the superficial deposits (glacial till and alluvium). The SFRA[11,12] does not report any historic groundwater flooding incidents within the study area.

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

Figure 11: Susceptibility to groundwater flooding throughout the study area



3.5 Risks associated with artificial sources

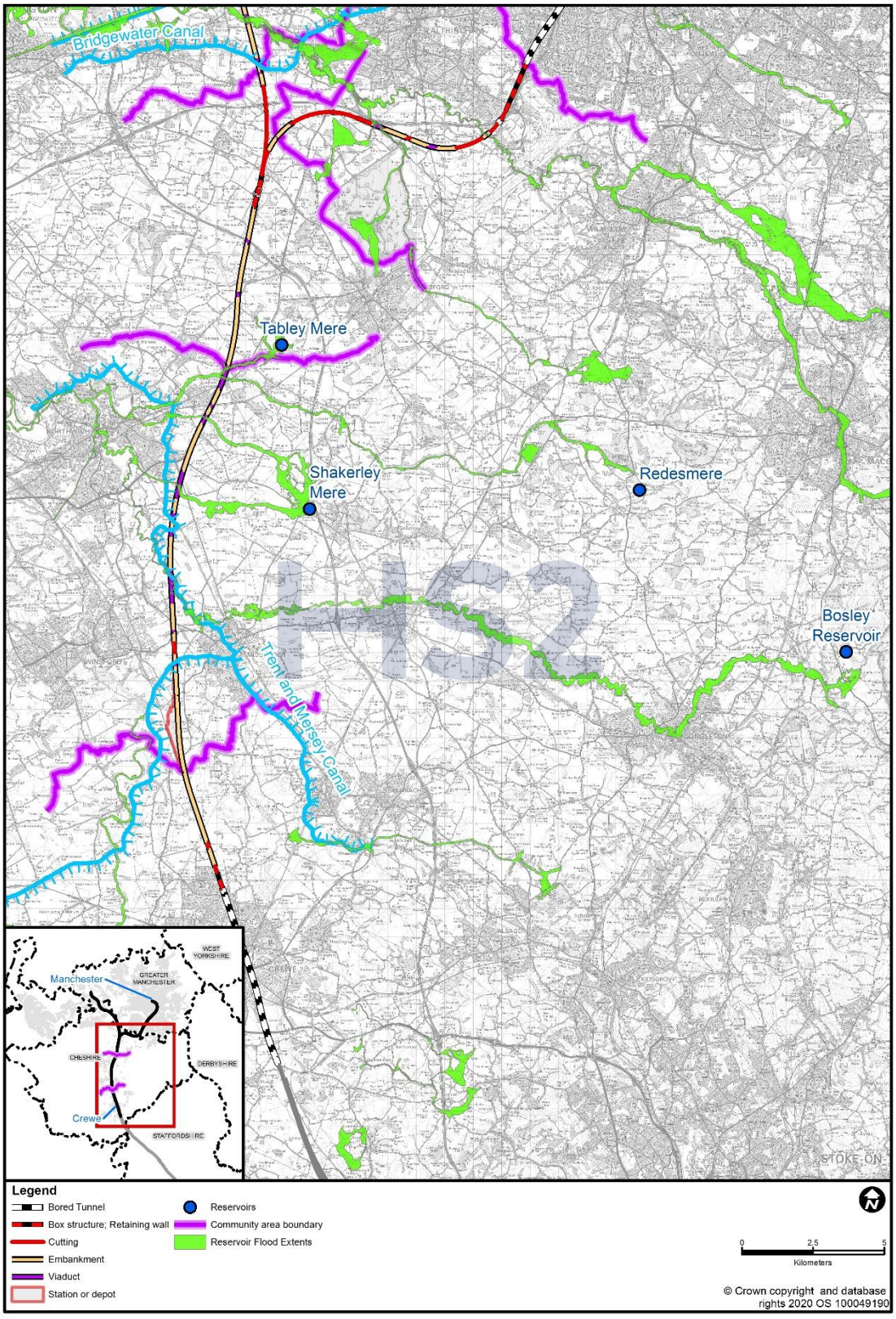
3.5.1 Flooding from artificial water bodies may occur due to failure of an impounding structure, such as a dam or canal embankment. The following features have been identified within the study area that are a potential source of flood risk:

- large raised reservoirs or impounded water bodies[18] shown on the Environment Agency's flood risk from reservoirs mapping[5];
  - Shakerley Mere is located approximately 4.5km east of the Proposed Scheme;
  - Bosley Reservoir is located approximately 27km east of the Proposed Scheme;
  - Redesmere is located approximately 17km east of the Proposed Scheme; and
  - Tabley Mere is located approximately 2km north-east of the Proposed Scheme;
- Shropshire Union Canal and the Trent and Mersey Canal, which pass through the Wimboldsley to Lostock Gralam area; and
- 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, as shown in Volume 2, MA02 Map Book: Map Series CT-05 and CT-06.

3.5.2 Figure 12 shows the location of artificial sources within the Wimboldsley to Lostock Gralam area and a summary of the baseline flood risk from artificial sources is provided in Table 1.

[18] Meres listed have been analysed for dam breach by the Environment Agency and are included in the Reservoir Flood Maps dataset.

Figure 12: Artificial flood sources in the vicinity of the study area



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 assessments and calculations where applicable.

Table 1: Summary of baseline flood risk

Source / pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
River Dane	Agricultural land (less vulnerable)	Environment Agency Flood Zones 2 and 3	Less vulnerable	70% (increase to peak river flow)
Wade Brook	Agricultural land (less vulnerable)	Environment Agency Flood Zones 2 and 3	Less vulnerable	70% (increase to peak river flow)
Puddinglake Brook	Cottage on the left bank of the Brook just downstream of the crossing (more vulnerable)	Environment Agency Flood Zones 2 and 3	More vulnerable	70% (increase to peak river flow)
	Agricultural land (less vulnerable)			
Gad Brook	Davenham Road (less vulnerable)	Environment Agency Flood Zones 2 and 3	Less vulnerable	70% (increase to peak river flow)
	Agricultural land (less vulnerable)			
Peover Eye and Tributary of Peover Eye	Woodland (water compatible)	Environment Agency Flood Zones 2 and 3	Less vulnerable	70% (increase to peak river flow)
	A559 Manchester Road (less vulnerable)			
	Mill Lane (less vulnerable)			
Smoker Brook	Linnards Lane (less vulnerable)	Environment Agency Flood Zones 2 and 3	Less vulnerable	70% (increase to peak river flow)
	Agricultural land (less vulnerable)			
Tributary of River Weaver 2	Agricultural land (less vulnerable)	RoFSW 0.1% AEP flood extent	Less vulnerable	40% (increase in peak rainfall intensity)
Tributary of River Dane 3	Agricultural land (less vulnerable)	RoFSW 0.1% AEP flood extent	Less vulnerable	40% (increase in peak rainfall intensity)
Tributary of the Trent and Mersey Canal	Agricultural land (less vulnerable)	RoFSW 0.1% AEP flood extent	Less vulnerable	40% (increase in peak

Source / pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
				rainfall intensity)
Broken Cross Drains	Agricultural land (less vulnerable)	RoFSW 0.1% AEP flood extent	Less vulnerable	40% (increase in peak rainfall intensity)
Surface water flow path at Clive Green	Agricultural land (less vulnerable)	RoFSW 0.1% AEP flood extent	Less vulnerable	40% (increase in peak rainfall intensity)
Surface water east of Rudheath	Instrument house and telecoms mast (essential infrastructure) Agricultural land (less vulnerable)	RoFSW 0.1% AEP flood extent	Essential infrastructure	40% (increase in peak rainfall intensity)
Shakerley Mere, Bosley Mere, Redesmere, Tabley Mere	Agricultural land (less vulnerable)	Environment Agency long-term flood risk information	Less vulnerable	N/A
Groundwater	Agricultural land (less vulnerable) Davenham Road (less vulnerable)	BGS Susceptibility to groundwater flooding dataset	Less vulnerable	N/A

4 Flood risk impacts and effects

4.1 Rivers and ordinary watercourses

Viaducts

4.1.1 The Proposed Scheme within the Wimboldsley to Lostock Gralam area includes viaduct crossings of the River Dane, Puddinglake Brook, Gad Brook, Tributary of Gad Brook 3, Wade Brook, Peover Eye, Tributary of Peover Eye, and Smoker Brook, as well as the realignment of the A556 Chester Road over Wade Brook. As these crossings have mapped flood zones and the Proposed Scheme at crossings does not affect the floodplains, other than at the viaduct piers, it was determined that detailed modelling was not required. Hydraulic analysis of these watercourses 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 climate change (CC) flood level.

River Dane

4.1.3 The River Dane viaduct is approximately 1.1km in length. Hydraulic analysis of head loss associated with the piers indicates that without any mitigation the viaduct piers have the potential to cause localised (generally within 10m) increases in peak flood levels of up to 130mm upstream of the piers and decreases of 85mm downstream of the piers. The increase in peak water level is classified as a minor impact as it is a highly localised impact constrained to the immediate vicinity of the piers, and will affect agricultural land (a moderate value receptor) and small areas of woodland (a low value receptor). This results in a minor adverse effect which is not significant.

4.1.4 Replacement floodplain storage (RFS) has been identified on a level for level basis as a precautionary measure to address the loss of floodplain storage at this crossing (Figure 13). This RFS has not been included in the hydraulic analysis at this stage. The RFS will be refined during design development and ensure that there is no net loss of floodplain storage and therefore no impact on flood risk elsewhere due to the proposed crossing. The volume required has been estimated using the Flood Zone 2 (1 in 1000 year) extent which is considered to be similar to the 1 in 100 year flood extent including climate change.

4.1.5 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 as far as reasonably practicable will ensure no impacts on peak flood levels.

Puddinglake Brook

4.1.6 The Puddinglake Brook viaduct is approximately 160m in length. Hydraulic analysis of head loss associated with the piers indicates that without any mitigation the viaduct piers have the potential to cause localised changes in peak flood level of up to 1mm. The increase in peak flood level is classified as a negligible impact, which is not significant, and no further mitigation is proposed.

Gad Brook and Tributary of Gad Brook 3

4.1.7 The Gad Brook viaduct is approximately 980m in length and spans Gad Brook and Tributary of Gad Brook 3. Hydraulic analysis of head loss associated with the piers indicates that without any mitigation the viaduct piers have the potential to increase the peak flood level by up to 160mm within 10m of the piers and decrease the peak flood level downstream of the piers by up to 30mm. The analysis extended 170m upstream of the viaduct crossing where the impact of the piers was shown to be less than 1mm, therefore it can be assumed that there is no impact further upstream at Pear Tree Farm cottages. This increase in peak flood level is classified as a minor impact, as it is a highly localised impact constrained to the immediate vicinity of the piers. This impact affects non-coniferous woodland (a low value receptor) and agricultural land (a moderate value receptor). This results in a minor adverse effect which is not significant.

4.1.8 RFS has been identified on a level for level basis as a precautionary measure to address the loss of floodplain storage at this crossing (Figure 14). This RFS has not been included in the hydraulic analysis at this stage. The RFS will be refined during design development to ensure that there is no net loss of floodplain storage and therefore no impact on flood risk elsewhere due to the proposed crossing. The volume required was estimated using the Flood Zone 2 (1 in 1000 year) extent which is considered to be similar to the 1 in 100 year flood extent including climate change.

4.1.9 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 ensuring no impacts on peak flood levels as far as reasonably practical.

Wade Brook

4.1.10 The Wade Brook hydraulic analysis indicated that the viaduct piers are located on higher ground assumed to be outside of the flood extent and therefore no change in peak flood

level is expected. However, this will be reassessed during design development to account for ground levels changes in this area.

4.1.11 The realigned A556 Chester Road crossing involves the construction of two piers within Flood Zone 3. Hydraulic analysis of head loss associated with these piers indicates that without mitigation the viaduct piers have the potential to cause localised increases in peak flood level of up to 100mm around the piers, up to 30mm increase upstream and up to 20mm increase downstream. This increase in flood level is classified as a minor impact, as it is highly localised constrained to the immediate vicinity of the piers, affecting agricultural land (a moderate value receptor). This results in a minor adverse impact which is not significant.

4.1.12 On a precautionary basis RFS has been identified downstream to address the loss of floodplain storage at this crossing (Figure 14). This RFS has not been included in the hydraulic analysis at this stage. The RFS will be refined during design development to ensure that there is no net loss of floodplain storage and therefore no impact on flood risk elsewhere due to the realigned A556 Chester Road crossing. The volume required was estimated using the Flood Zone 2 (1 in 1000 year) extent which is considered to be similar to the 1 in 100 year flood extent including climate change.

Smoker Brook, Peover Eye and Tributary of Peover Eye

4.1.13 The Smoker Brook viaduct is approximately 1.1km in length and crosses Smoker Brook, Peover Eye, and the Tributary of Peover Eye. Hydraulic analysis of head loss associated with the piers indicates that without any mitigation the viaduct piers at Peover Eye are likely to cause localised changes in peak flood level of up to 70mm within 10m upstream of the piers and decreases in peak flood level of up to 120mm downstream of the piers. The increase in peak flood level is classified as a minor impact, as it is highly localised impact constrained to the immediate vicinity of the piers. This minor impact will affect non-coniferous woodland, a low value receptor. This results in a negligible effect which is not significant. There is also a proposed watercourse realignment of the Peover Eye to avoid the viaduct pier currently located in the channel.

4.1.14 The viaduct piers at Smoker Brook are likely to cause localised changes in peak flood levels of less than 50mm upstream of the piers and decreases in peak flood level of up to 100mm downstream of the Smoker Brook piers. The impact is classified as a minor impact and will affect agricultural land, a moderate value receptor. This results in a minor adverse effect which is not significant.

4.1.15 RFS has been identified on a volume for volume basis, due to topographic constraints, as a precautionary measure to address the loss of floodplain storage at this crossing (Figure 14). This RFS has not been included in the hydraulic analysis at this stage. The RFS will be refined during design development to ensure that there is no net loss of floodplain storage. The volume required was estimated using the Flood Zone 2 (1 in 1000 year) extent which is considered to be similar to the 1 in 100 year flood extent including climate change.

4.1.16 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 ensuring no impacts on peak flood levels as far as reasonably practical.

Figure 13: Replacement floodplain storage areas (southern extent)

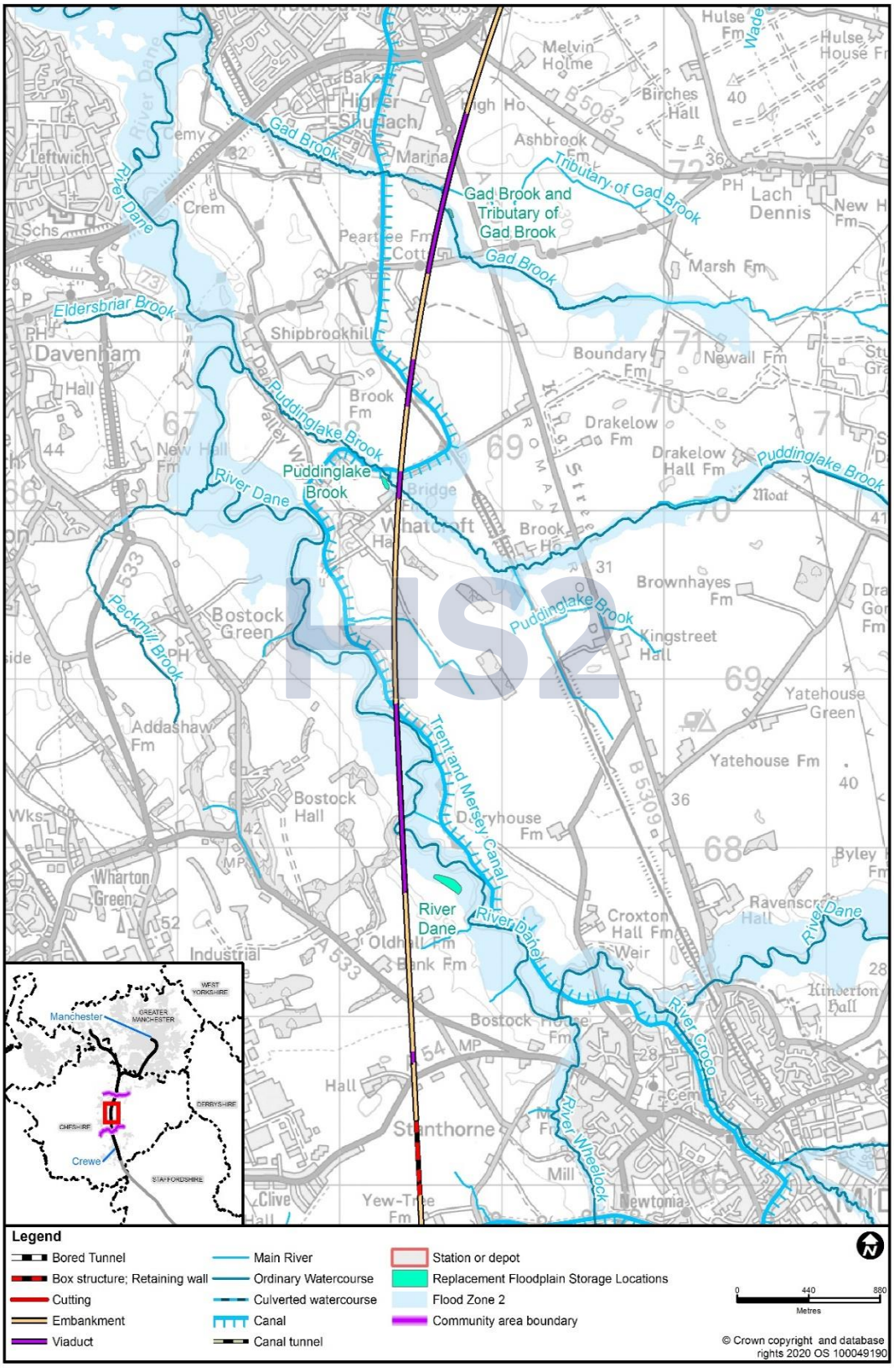
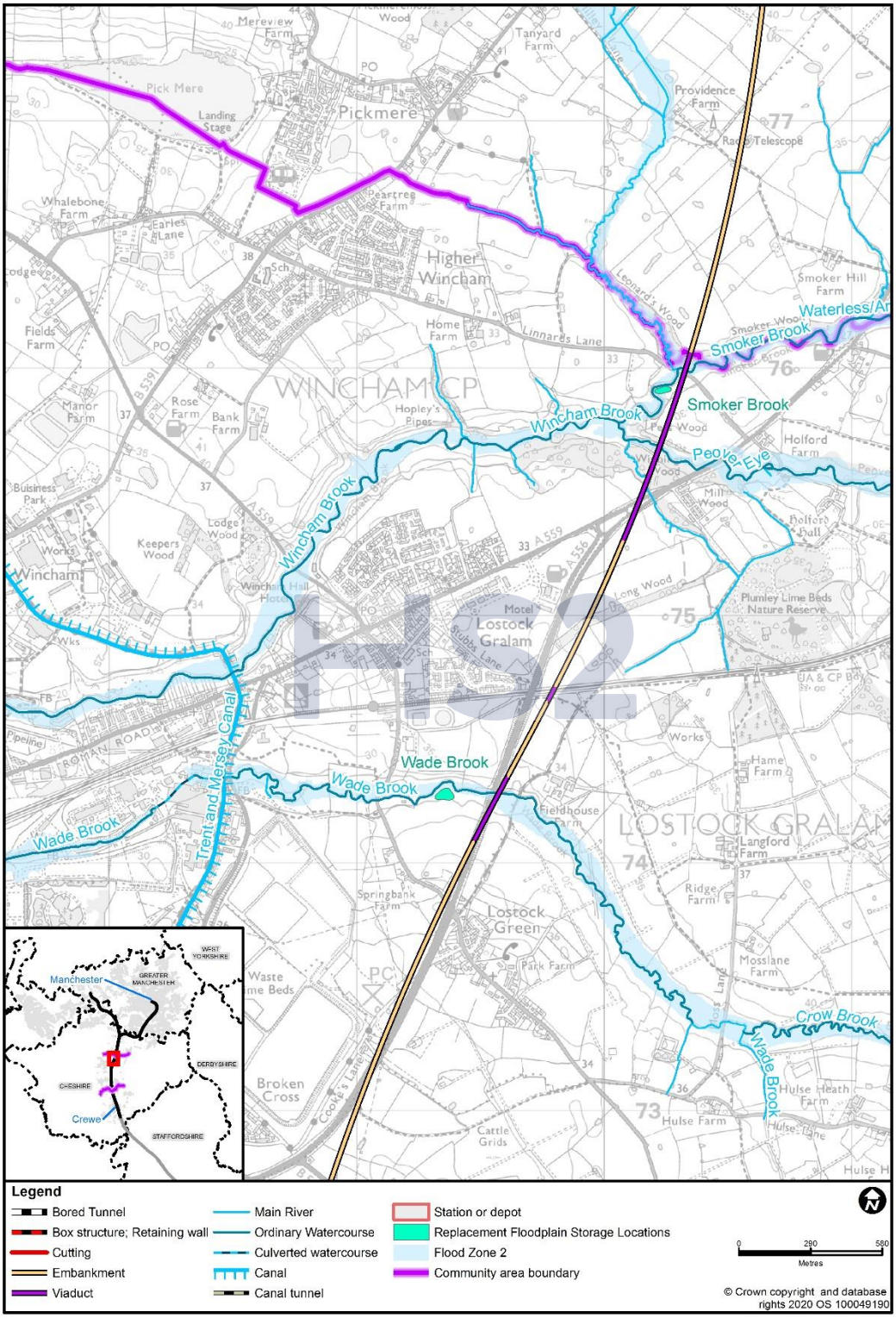


Figure 14: Replacement floodplain storage areas (northern extent)



Culverts and channel realignments

4.1.17 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[5]. The RoFSW[5] dataset has therefore been used to indicate the potential flood extent generated and the receptors affected along these ordinary watercourses.

4.1.18 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 15 and Figure 16 show the location of proposed culverts. The following calculation procedure has been undertaken to size the culverts:

- use of the Revitalised Rainfall-Runoff Model version 2.2 (ReFH2)[19] 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 SMR;
- 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 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.

4.1.19 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)[20]
Tributary of River Weaver 2	Park Hall culvert	<0.10	40%	<0.10	1.35m high x 1.35m wide	3.35
Tributary of River Weaver 2 - offline	A530 Nantwich Road offline east culvert	2.52	40%	3.78	1.65m high x 1.35m wide	10.5

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

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

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)[20]
Tributary of River Weaver 2 - offline	A530 Nantwich Road offline west culvert	2.52	40%	3.78	1.65m high x 1.35m wide	13.7
Tributary of River Dane 3	Bank culvert	0.18	40%	0.26	1.35m high x 1.35m wide	6.78
Tributary of the Trent and Mersey Canal	Whatcroft culvert	0.63	40%	0.91	1.35m high x 1.35m wide	9.70
Broken Cross Drains	A556 Chester Road culvert	1.57	40%	2.31	1.35m high x 1.35m wide	2.90
Tributary of River Weaver 4 - offline	Clive Green Lane offline culvert	0.10	40%	0.10	1.35m high x 1.35m wide	4.92

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

4.1.21 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. At the Tributary of River Weaver 2, the channel realignment is also affected by the A530 Middlewich Road realignment and permanent access requirements. In addition, channel realignments of Peover Eye and Tributary of Peover Eye may be needed to avoid viaduct piers within the watercourse. 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.

4.1.22 There are a number of additional offline unnamed culverts beneath access roads listed in Table 3 below. These will be sized during design development following the calculation procedure outlined in this section.

Table 3: Unnamed culverts

Watercourse	Location
Tributary of Trent and Mersey Canal	Unnamed culvert east of Whatcroft culvert
Broken Cross Drains	Unnamed culvert west of A556 Chester Road
Broken Cross Drains	Unnamed culvert north-west of A556 Chester Road

Figure 15: Proposed culverts (southern extent)

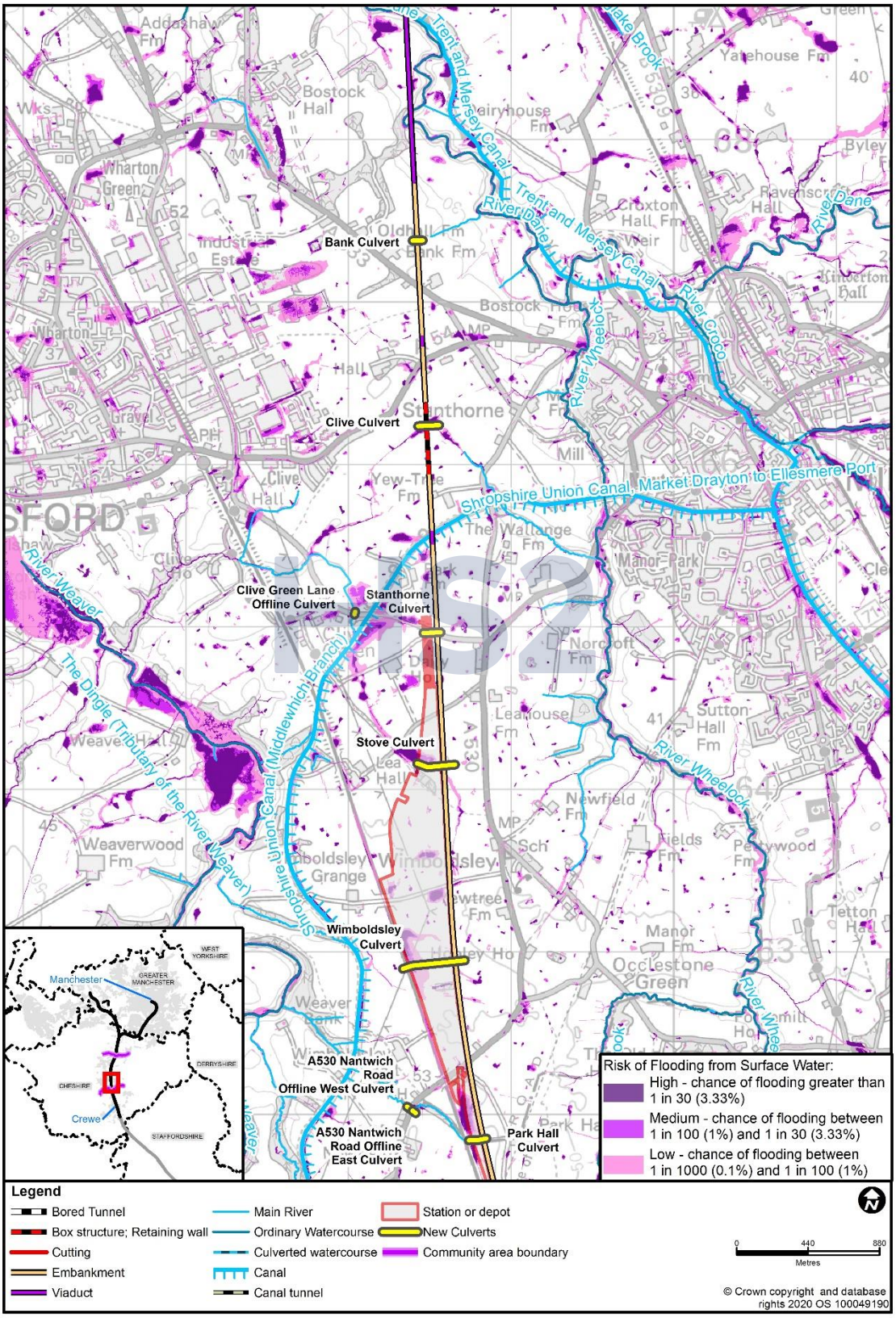
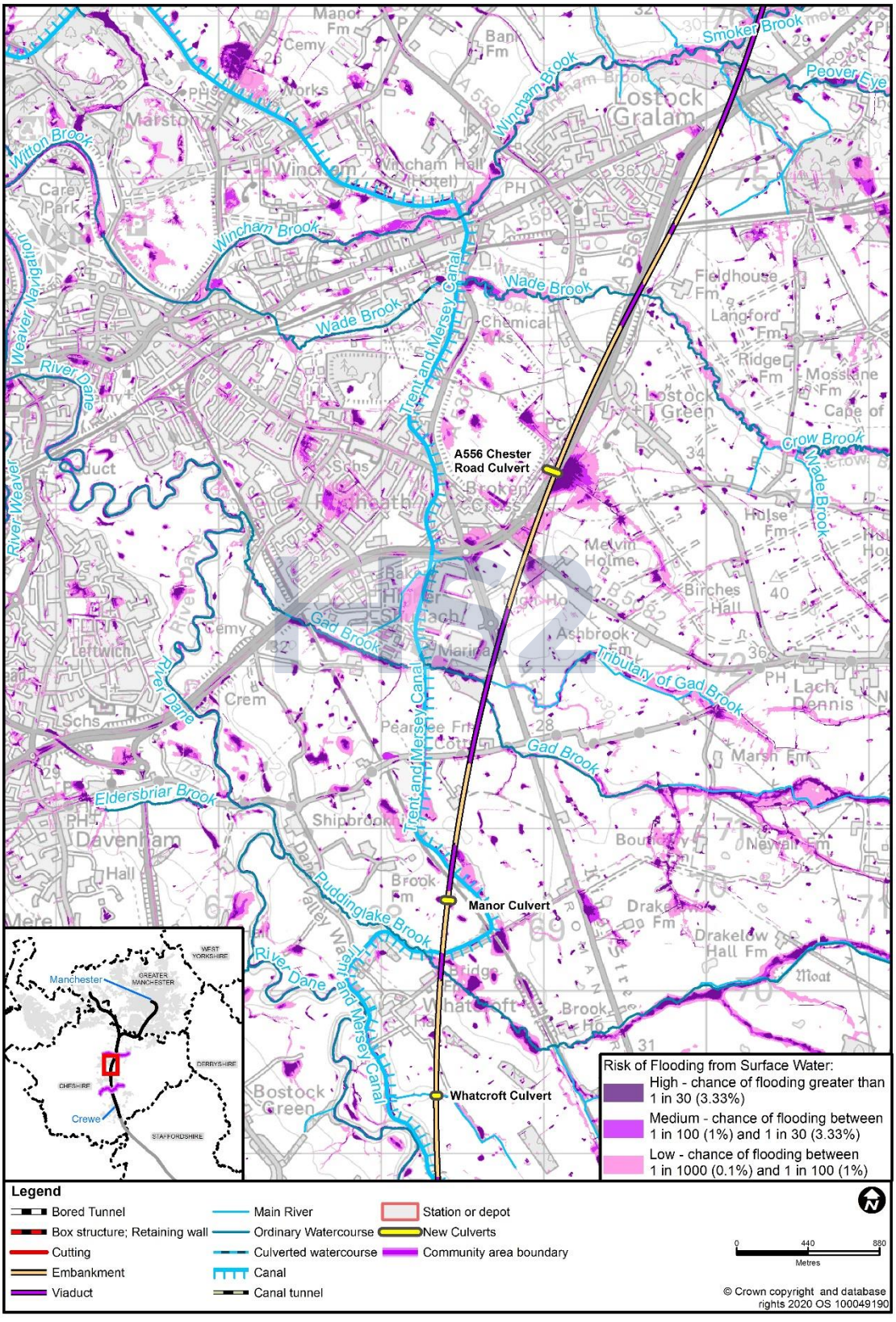


Figure 16: Proposed culverts (northern extent)



Temporary construction compounds and stockpiles

4.1.23 Table 4 highlights the temporary site compounds and stockpiles located in areas at risk of flooding. A temporary satellite compound is proposed which is fully located in Flood Zone 3 and is at risk of flooding from Puddinglake Brook. There is also a temporary compound proposed on Davenham Road, part of which is located in Flood Zone 3 and is at risk of flooding from Gad Brook, and a stockpile partially located in Flood Zone 3 located close to the confluence of Gad Brook and Tributary of Gad Brook 3 affected by surface water.

4.1.24 The risk of flooding to these compounds and stockpiles 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 sites will be registered with the Environment Agency Flood Warning and Flood Alert service, if applicable.

4.1.25 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, as far as reasonably practicable.

Table 4: Details of temporary site compounds and stockpiles at risk of flooding

Water-course/ location	Construction compound	Flood zone	Risk of flooding from surface water	Location constraints	Potential mitigation
Tributary of River Weaver 2	Satellite compound	Not defined	Majority of the site within the 1 in 100 (1%) AEP and 1 in 30 (3.33%) AEP event extents	Constrained by surrounding stockpiles, existing railway line, road diversion and scheme components	Surface water management strategy (which may include pumping water to discharge downstream) Compound drainage to take flood zones into account Keep ground raising to a minimum and allow flow beneath buildings
	Temporary earthworks stockpile	Not defined	Majority of the site within the 1 in 100 (1%) AEP and 1 in 30 (3.33%) AEP vent extents	Constrained by satellite compound to the east, utilities compound to the south	
Gad Brook	Satellite compound	Approximately 20% of the site within Flood Zones 2 and 3	Surface water flow path through the compound	Location required for proximity to scheme, constrained by watercourse, utilities compounds and scheme components	Compound layout and drainage to take flood zones into account Reinstate ditch lines along the edge of site boundaries

Water-course/ location	Construction compound	Flood zone	Risk of flooding from surface water	Location constraints	Potential mitigation
					Keep ground raising to a minimum and allow flow beneath buildings
	Stockpile	Southern end of the stockpile located in Flood Zones 2 and 3	Northern end of stockpile located in the 1 in 1000 (0.1%) AEP event extent	Constrained by utilities compounds	Stockpile will be cut back to ensure surface water flow path not severed
Puddinglake Brook	Satellite compound	Entire compound located in Flood Zones 2 and 3	Surface water flow path through the compound	Location required for proximity to scheme, constrained by watercourse, canal and existing railway line	Compound formation, surface and drainage to be designed to mitigate potential flooding Keep ground raising to a minimum and allow flow beneath buildings
Wimbold-sley	Stockpile	Not defined	Surface water flow path through the stockpile	Constrained by utilities compounds	Stockpile will be cut back to ensure surface water flow path not severed
River Dane	Stockpile	Northern end of stockpile located in Flood Zone 2	Area of surface water ponding within the stockpile	Location constrained by the extent of the Consolidated Construction boundary and the scheme components	Perimeter drainage to assist water redistribution around stockpile
Tributary of River Wheelock 5	Stockpile	Not defined	Surface water flow path through stockpile	Constrained by utilities compounds	Stockpile will be cut back to ensure surface water flow path not severed
	Stockpile	Not defined	Southern end of stockpile covers a surface water flow path	Constrained by utilities compounds	Stockpile will be shortened to ensure surface water flow path not severed
Broken Cross Drains	Stockpile	Not defined	Approximately 50% of stockpile located within surface water flood extent	Constrained by scheme and construction traffic route	Runs parallel to permanent embankment earthworks Drainage designed to ensure no additional impact from stockpile
	Stockpile	Not defined	Stockpile fully located within surface water flood extent	Constrained by scheme and construction traffic route	

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 These flow paths have been addressed in the design of the Proposed Scheme by providing culverts and/or channel features to collect and convey surface water from one side of the Proposed Scheme to the other.

4.2.3 The design process outlined in Section 4.1 has also been followed to size these culverts and the associated channels. In this way the existing flow paths are preserved, and the flooding characterises of the local area will remain unchanged.

4.2.4 Details of the culvert and channel design are provided in Table 5. The location of the culverts can be seen in Figure 15 and Figure 16.

Table 5: Details of culvert design at surface water flow paths

Watercourse/ location	Structure/ feature 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/channel dimensions (m)	Culvert/ channel capacity (m^3/s)[20]
Dry valley discharging to The Dingle	Wimboldsley culvert	0.90	40%	1.33	1.35m high x 1.35m wide	3.56
Dry valley discharging to Tributary of River Weaver 4 at Stove Room Wood	Stove culvert	0.03	40%	0.04	1.35m high x 1.35m wide	3.68
Track drain discharging to Tributary of River Weaver 4 at Clive Green Lane	Stanthorne culvert	0.10	40%	0.14	1.35m high x 1.35m wide	3.86
Track drain discharging to Puddinglake Brook	Manor culvert	0.10	40%	0.15	1.35m high x 1.35m wide	4.21
Track drain discharging to Tributary of River Wheelock 5	Clive culvert	0.46	40%	0.67	1.35m high x 1.35m wide	2.62

4.2.5 The proposed Crewe North rolling stock depot will increase the impermeable footprint at the site. An increase in impermeable surfaces will lead to an increase in peak surface water runoff rates and volume. It is proposed to implement a drainage scheme using SuDS (sustainable drainage system) which will discharge surface water runoff from the site into

the tributaries of the River Weaver at greenfield rates. This will ensure flood risk elsewhere is not increased due to the proposed scheme.

4.2.6 By following this design approach, the local flood risk characteristics are preserved and the risk to the receptors is unchanged.

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. Further details of the groundwater assessment are set out in the Water resources assessment (Volume 5: Appendix WR-003-0MA02).

4.3.3 There are four borrow pits proposed in the Wimboldsley to Lostock Gralam area. There are three cohesive borrow pits (MA02 borrow pit A to C) within glacial till adjacent to the Proposed Scheme, and one granular borrow pit (MA02 borrow pit D) within glaciofluvial sheet deposits 5km east of the Proposed Scheme. The three cohesive borrow pits will be backfilled to existing ground level as part of the restoration plan and it is assumed that the backfill material will be of a similar permeability. The granular borrow pit is likely to be backfilled with material of a lower permeability. The restoration plans will include land drainage mitigation measures. These will be designed in detail following ground investigation and monitoring to ensure no overall increase in groundwater flood risk.

4.3.4 There is potential that the Environment Agency will not grant permission for dewatering at the granular borrow pit. In this instance, wet working will be required which could lead to a localised increase in groundwater levels and groundwater flooding on the downgradient side of the borrow pit during excavation. However, given the distance to these receptors, the likely shallow hydraulic gradient across the site and the likely small open working area at any one time during the excavation process, this is assessed to be a negligible impact on receptors downgradient of the borrow pit. The receptors include commercial buildings (moderate value), agricultural land (moderate value), residential properties (high value), an

electrical substation (very high value) and a gas distribution station (very high value). Therefore, the potential impact on groundwater flooding could lead to a negligible effect, which is not significant.

4.3.5 The assessment has shown that there are no other features of the Proposed Scheme in the Wimboldsley to Lostock Gralam 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 groundwater level changes are set out in the Water resources assessment (Volume 5, Appendix WR-003-0MA02).

4.4 Artificial sources

4.4.1 Shakerley Mere, Bosley Reservoir, Redesmere, and Tabley Mere are shown on the Environment Agency's flood risk from reservoirs mapping[5] dataset. The reservoirs all lie outside of the extent of the Proposed Scheme and therefore will not be impacted by the development. The reservoir mapping dataset indicates that, in the event of a failure of Shakerley Mere, the Wade Brook and Gad Brook floodplain areas will be affected by the resulting flood. The resulting flood from a failure of Bosley Reservoir will affect the River Dane floodplain, a failure of Redes Mere will affect the Peover Eye floodplain, and failure of Tabley Mere will affect the Smoker Brook floodplain at the Proposed Scheme. These large reservoirs are subject to the requirements of the Reservoirs Act 1975[21], and as such are inspected annually. This increases the likelihood that any degradation in the operational performance of a reservoir will be identified and addressed before there is an increased risk of failure. Whilst the consequences of failure are potentially very high, this inspection and maintenance regime means that the overall risk of flooding from this source is considered low and very unlikely to change as a result of the Proposed Scheme.

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, MA02 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 Shropshire Union Canal and Trent and Mersey Canal are located in the Wimboldsley to Lostock Gralam study area. The Proposed Scheme will not encroach into the canal channels or embankments and will therefore not change the canal flood risk. In the event of embankment failure, flood risk posed to the Proposed Scheme will be unchanged as the Proposed Scheme is elevated over both the Shropshire Union Canal (overbridge) and the

[21] Department for Environment, Food and Rural Affairs and Environment Agency (2014), *Reservoirs: owner and operator requirements*. Available online at: https://www.gov.uk/guidance/reservoirs-owner-and-operator-requirements.

Trent and Mersey Canal (viaduct) (Proposed Scheme track elevations designed following HS2 Ltd technical standards).

4.4.4 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[22].

[22] 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 how they represent the existing watercourses. The areas of RFS identified will be incorporated into the models and the design of all the viaducts, bridges and culverts will be developed mitigating all impacts on peak flood levels as far as is reasonably practicable. The effect of RFS areas on the agricultural land quality classification is assessed in Section 4: Agriculture, forestry and soils of the Environmental Statement.

5.1.2 The hydraulic analysis of the viaduct crossings at the River Dane, Gad Brook and Wade Brook indicates that the Proposed Scheme, without mitigation, has the potential to lead to localised increases in peak flood level of more than 100mm. At Puddinglake Brook, Smoker Brook, Peover Eye and Tributary of Peover Eye the hydraulic analysis indicates that the Proposed Scheme, without mitigation, has the potential to lead to localised increases in water level of up to 50mm. Although these impacts are considered to be minor, RFS has been provided on a precautionary basis to address the loss of floodplain storage caused by the viaduct piers, and where appropriate embankments, and compensate for any wider cumulative impact. The provision for RFS has been made on a level for level basis where possible. Where level for level compensation was not possible due to topographic constraints, additional volumetric compensation storage is proposed. The RFS, together with other design measures, will mitigate flood risk posed by the Proposed Scheme, resulting in negligible impacts and negligible effects, which are not significant.

5.1.3 The assessment indicates that if wet working is required during excavation of the granular borrow pit, there is a potential risk of groundwater flooding on the downgradient side of the borrow pit. This assessment assumes that dewatering will take place. Mitigation measures and a contingency plan will be developed, if a license for dewatering is not permitted by the Environment Agency, to reduce the potential for groundwater flooding. Measures may include minimising the open area of excavation and inclusion of drainage channels downgradient of the site.

5.1.4 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 to ensure no potential effects on flood risk as far as reasonably practical.

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 engaged. 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 Wimboldsley to Lostock Gralam 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 the viaduct crossings. 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 hydraulic analysis at Wade Brook showed that the viaduct piers for the realigned A556 Chester Road crossing intersected with Flood Zone 3 and caused localised increases in flood level. The Wade Brook viaduct pier is not shown to be within the flood extents, however in future design phases further review will be undertaken to assess the impact of any ground level changes and ensure there is no impact on flood risk.

6.2.4 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 MA02.

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