E117

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA2: Colwich to Yarlet

Flood risk assessment (WR-003-002)

July 2017

ES 3.5.2.2.15

E117

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA2: Colwich to Yarlet

Flood risk assessment (WR-003-002)

July 2017

ES 3.5.2.2.15

Department for Transport

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

High Speed Two (HS2) Limited,
Two Snowhill
Snow Hill Queensway
Birmingham B4 6GA

Telephone: 08081 434 434

General email enquiries: HS2enquiries@hs2.org.uk

Website: www.gov.uk/hs2

A report prepared for High Speed Two (HS2) Limited:

ARUP

ERM

High Speed Two (HS2) Limited has actively considered the needs of blind and partially sighted people in accessing this document. The text will be made available in full on the HS2 website. The text may be freely downloaded and translated by individuals or organisations for conversion into other accessible formats. If you have other needs in this regard, please contact High Speed Two (HS2) Limited.

recycle

Printed in Great Britain on paper containing at least 75% recycled fibre.

Contents

List of figures

List of tables

1 Introduction

1.1 Structure of the water resources and flood risk appendices

1.1.1 The water resources and flood risk Appendices comprise both route-wide and community area specific documents. The route-wide water resources and flood risk Appendices comprise:

- a Water Framework Directive compliance assessment (Volume 5: Appendix WR-001-000); and
- a water resources operation and maintenance plan (Volume 5: Appendix WR-005-000).

1.1.2 For Colwich to Yarlet (CA2), the area specific appendices comprise:

- a water resources assessment (Volume 5: WR-002-002); and
- a flood risk assessment (this appendix).

1.1.3 Hydraulic modelling reports, which describe the approach to assessing key flood risk issues identified within the study area, are included in Background Information and Data (BID)[1]. These documents comprise:

- Hydraulic modelling report – Great Haywood (Background Information and Data: BID-WR-004-005); and
- Hydraulic modelling report - Hopton (Background Information and Data: BID-WR-004-006).

1.1.4 Maps (WR-01, WR-02, WR-05 and WR-06) referred to throughout this flood risk assessment are contained in the Volume 5, Water resources and flood risk assessment Map Book.

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

1.2 Scope, assumptions and limitations

1.2.1 The purpose of this flood risk assessment is to consider the flood risk implications of the permanent works associated with the Proposed Scheme within the Colwich to Yarlet area. Temporary works have not been assessed unless they are of a significant scale compared to the permanent works proposed and have potential to adversely affect flood risk.

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

[1] HS2 (2017) *High Speed 2 (HS2) Phase 2a (West Midlands – Crewe), Background Information and Data, Hydraulic Modelling Reports. BID-WR-004*, www.gov.uk/hs2

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

1.2.4 The assessment has involved an initial scoping study using existing available information, including information 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.

1.2.5 Hydraulic modelling has been undertaken in locations where the potential for impacts on flood risk were identified in the scoping study. This modelling has made best use of existing models provided by the Environment Agency. No new channel survey has been obtained. Floodplain geometry was however updated using Light Detection and Ranging (LiDAR) data. A number of assumptions have been made within the hydraulic models and these are described in detail in the hydraulic modelling reports in the BID[1].

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

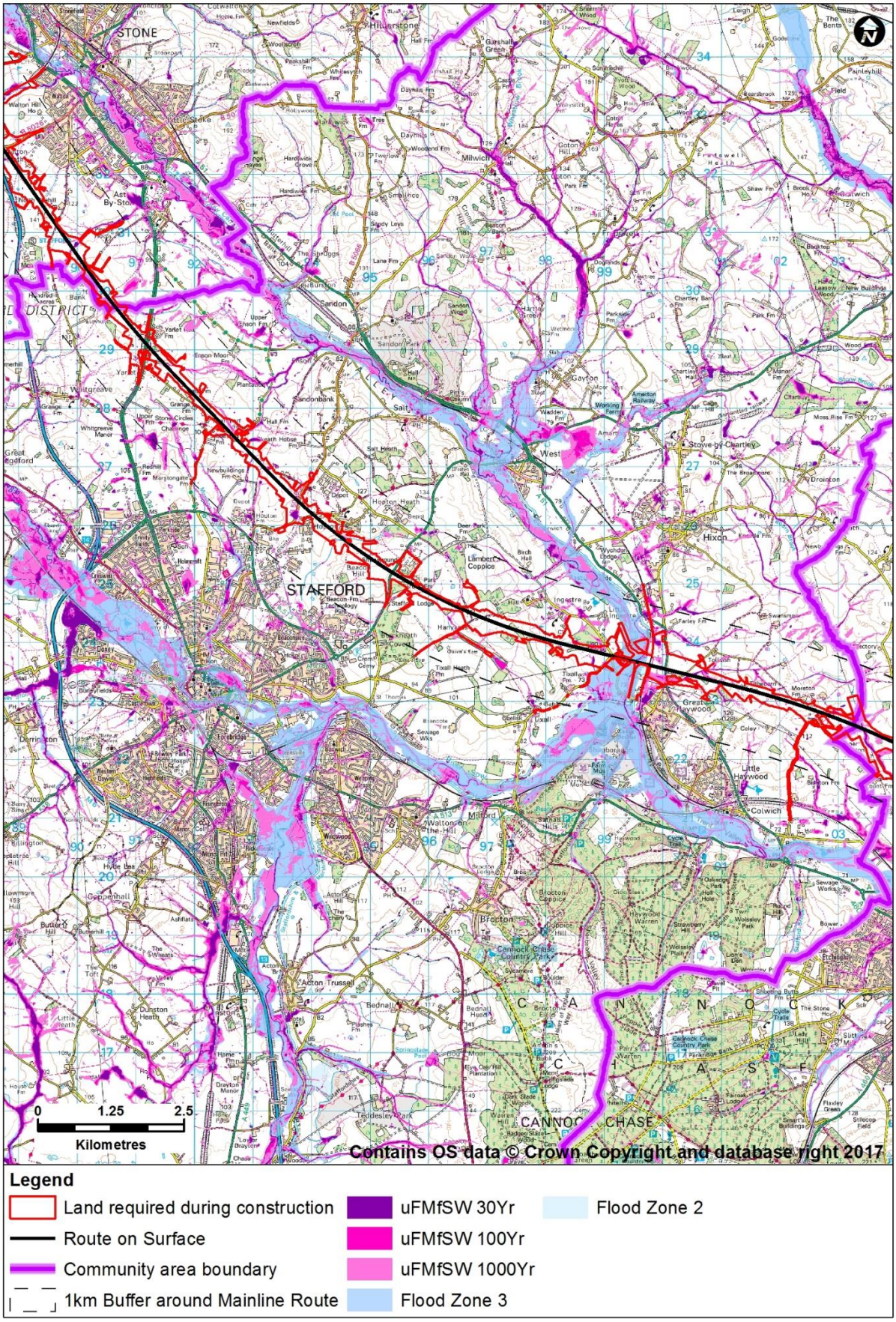
1.3 Location and extent

1.3.1 The location and extent of the study area is shown in Figure 1. The study area extends 1km from the centreline of the route of 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. Figure 1 also shows the extent of the land required during construction of the Proposed Scheme, Environment Agency Flood Zones 2 and 3[2], as well as the areas at risk from surface water flooding. The flood zone information is based on the Environment Agency's flood map for planning (rivers and sea) and the updated flood map for surface water (uFMfSW)[3].

[2] Flood Zone 2 comprises land assessed as having between a 1 in 100 (1%) 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%) or greater annual probability of river flooding

[3] Gov.uk, *Long term flood risk information*, https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=402498&northing=282043&address=100070518535

Figure 1: Location and extent of study area



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 National Planning Policy Framework (NPPF)[4]. 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 without increasing flood risk elsewhere. The Sequential Test and Exception Test in NPPF aim to achieve these policy objectives.

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). Staffordshire County Council (SCC) is the LLFA in the Colwich to Yarlet area. A series of meetings has been held with SCC LLFA technical specialists to gather information, develop the approach adopted in this assessment and agree principles related to the hydraulic design of the Proposed Scheme.

2.2.2 The SCC Preliminary Flood Risk Assessment (PFRA)[5] was published in 2011 and the Local Flood Risk Management Strategy (LFRMS) [6] was published in 2015. SCC 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). The Proposed Scheme design has sought to align with these policies where reasonably practicable.

2.2.3 The Local Planning Authorities (LPA) Stafford Borough, Lichfield District, South Staffordshire and Cannock Chase have produced a Strategic Flood Risk Assessment (SFRA)[7] that covers the Colwich to Yarlet area. The key flood risk objectives outlined in the SFRA are to: reduce surface water runoff, support Water Framework Directive delivery and to prevent new development within sensitive development locations. The Proposed Scheme design has sought to align with these objectives where reasonably practicable.

[4] Department for communities and local government (2012), *National Planning Policy Framework*
[5] Royal Haskoning (2011), *Staffordshire County Council Preliminary Flood risk Assessment*
[6] Shropshire and Staffordshire County Council (2015), *Shropshire and Staffordshire Local Flood Risk Management Strategy*
[7] Capita (2014), *South Staffordshire, Cannock Chase, Lichfield and Stafford Strategic Flood Risk Assessment (SFRA)*

3 Approach to flood resilience

3.1 Overall aims

3.1.1 The Proposed Scheme aims to avoid an increase in the risk of flooding from all sources, taking into account the projected impact of climate change.

3.2 Route selection

3.2.1 The route of the Proposed Scheme has been selected based on application of the sequential approach advocated in NPPF. This approach aims to steer new development to areas with the lowest probability of flooding. Avoidance of areas with a high probability of flooding was a key consideration in the original Appraisal of Sustainability[8] and consequently the route of the Proposed Scheme avoids flood zones wherever reasonably practicable. It is recognised within NPPF that essential transport infrastructure has to cross areas at risk of flooding, for example at river crossings. In such circumstances, the Exception Test requires that it be demonstrated that the infrastructure would be safe from flooding over its lifetime, would not increase flood risk elsewhere and that the wider benefits to society outweigh flood risk. The manner in which the scheme aligns with the Sequential Test and Exception Test in NPPF is outlined in Volume 3, Water resources and flood risk.

3.3 Design standard

3.3.1 The Proposed Scheme will be protected against flooding from any source during the current 1 in 1,000 (0.1%) annual probability flood with water levels not rising closer than 1m to the top of rail level.

3.4 Hydraulic capacity

3.4.1 In locations where the route of the Proposed Scheme will cross watercourses or surface water flow paths, the design aim is for structures to accommodate flood flows up to and including the 1 in 100 (1%) annual probability storm with an allowance for climate change.

3.4.2 A minimum of 600mm freeboard above the 1 in 100 (1%) annual probability plus climate change flood event has been allowed to the soffit of all bridges and viaducts.

3.4.3 A minimum of 300mm freeboard above the 1 in 100 (1%) annual probability plus climate change flood event has been allowed to the soffit of all culverts.

3.5 Floodplain storage

3.5.1 Watercourse crossings have been designed to reduce losses of floodplain storage. Wherever such losses are anticipated, provision has been made to replace this storage at the affected location on a 'level for level' and 'volume for volume' basis.

[8] HS2, *Appraisal of Sustainability*, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/68981/options-for-phase-two-of-the-high-speed-rail-network-appraisal-of-sustainability.pdf

3.6 Maintenance access

3.6.1 Four metres vertical clearance above floodplain ground level has been provided to the underside of viaducts to ensure access to riverbanks. Piers have been set eight metres back from the bank top.

3.7 Off-site effects

3.7.1 The design of the Proposed Scheme's drainage systems aims to ensure that there will be no significant increases in flood risk downstream, during storms up to and including the 1 in 100 (1%) annual probability design event, with an allowance for climate change.

3.8 Climate change allowances

3.8.1 In general the design of the Proposed Scheme has adopted a precautionary approach to potential future increase in peak river flows and rainfall intensities, using the recommended post 2080s allowances within the latest guidance provided by the Environment Agency[9]. The details of how this guidance should be applied in practice to the Proposed Scheme have been agreed with Environment Agency.

Increases in peak river flow

3.8.2 The risk based approach within the guidance recommends selection of a suitable allowance, from a range of possibilities, for use in the assessment and design of flood risk management for new buildings or infrastructure, based on the consequences should that value be exceeded.

3.8.3 Table 1 shows the range of potential allowance categories for use in the Humber river basin district in which the Colwich to Yarlet area lies.

Table 1: Allowance percentages (post 2080) for each allowance category in the Humber river basin

River basin	Allowance category	Allowance
Humber	H++	65%
	Upper end	50%
	Higher central	30%
	Central	20%

3.8.4 The allowance category used depends on both the vulnerability to flooding of the receptor potentially affected and the flood zone within which it is located. Table 2 shows the basis on which the allowance categories have been selected for use in the preliminary hydraulic design of viaducts, bridges and culverts. The vulnerability of

[9] Environment Agency, *Flood risk assessments: climate change allowances,* https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

each receptor has then been classified using Table 2 of the planning practice guidance on flood risk and coastal change[10], which is aligned with the receptor value tables in the Scope and Methodology Report (SMR)[11] and its Addendum[12].

Table 2: Allowance categories for each existing property or land use in different flood zones

Flood Zone	Receptor Vulnerability	Allowance Category
Flood Zone 2	Essential infrastructure	Upper end
	Highly vulnerable	
	More vulnerable	Higher central
	Less vulnerable	Central
	Water compatible	Central
Flood Zone 3a	Essential infrastructure	Upper end
	Highly vulnerable	
	More vulnerable	
	Less vulnerable	Higher central
	Water compatible	Central
Flood Zone 3b	Essential infrastructure	Upper end
	Highly vulnerable	
	More vulnerable	
	Less vulnerable	
	Water compatible	Central

3.8.5 Railways, motorways and 'A' roads with one or two number identifiers (e.g. A1 or A34) are considered essential infrastructure, while all other roads are considered less vulnerable.

3.8.6 The vulnerability level used for each assessment corresponds with the existing property or land use with the highest vulnerability within the area considered.

[10] Department for Communities and Local Government (2016), *Planning practice guidance*, https://www.gov.uk/government/collections/planning-practice-guidance
[11] Environmental Impact Assessment Scope and Methodology Report, Volume 5: Appendix CT-001-001
[12] Environmental Impact Assessment Scope and Methodology Report, Volume 5: Appendix CT-001-002

For example, if the consequence of a culvert being under-capacity would be to cause flooding of a major road, or of flood-vulnerable components of the Proposed Scheme itself, the culvert is designed to accommodate an 'upper end' allowance for climate change. The probability of this allowance being exceeded post 2080 is considered to be 1 in 10 (10%).

Increases in peak rainfall intensity

3.8.7 A peak rainfall intensity allowance of 40% has been used as the basis for the preliminary design of track drainage, runoff attenuation elements and surface water catchments less than 5km^2.

Use of the H++ scenarios

3.8.8 This extreme scenario represents a credible upper limit to the changes that could potentially occur beyond the end of this century. Sensitivity analyses undertaken to provide a high level assessment of the performance of the Proposed Scheme under 'design exceedance' conditions has used allowances that equal or exceed the H++ value provided in the guidance for peak river flows, which for the Humber catchment is 65%, as indicated in Table 1.

4 Flood risk assessment methodology

4.1 Overview

4.1.1 The approach to flood risk assessment is based on the government's planning practice guidance on flood risk and coastal change,[13] CIRIA Publication C624 'Development and flood risk: guidance to the construction industry[14]' and the Design Manual for Roads and Bridges (DMRB)[15]. The assessment process has proceeded as follows:

- all existing potential sources of flooding have first been identified, together with the pathways or mechanisms by which they have potential to cause risk to life, economic or environmental damage, disruption or nuisance;
- all existing property and assets (receptors) at risk from these sources, and their relative vulnerability to flooding impacts, have then been determined;
- an assessment of the magnitude of the impacts at each of these receptors, taking into consideration the mitigation measures incorporated into the design, has then been completed; and
- the significance of the flood risk issues at affected receptors has been identified, together with suggestions for additional mitigation, where this is necessary to address any significant effects identified.

4.2 Identification of relevant flood sources and pathways

4.2.1 The Environment Agency's Flood Map for Planning (Rivers and Sea)[16] has been used to scope the baseline flood hazard associated with rivers and ordinary watercourses. These plans define Flood Zone 2 (land assessed as having between a 1 in 100 (1%) and 1 in 1,000 (0.1%) annual probability of river flooding) and Flood Zone 3 (land assessed as having a 1 in 100 (1%) or greater annual probability of river flooding).

4.2.2 The updated Flood Map for Surface Water (uFMfSW) has been used to scope surface water flood hazards. Infrastructure failure flood hazards have been scoped using the Environment Agency Risks of flooding from reservoirs national dataset. The British Geological Survey (BGS) national dataset, areas susceptible to groundwater flooding (AStGWF)[17], has been used to scope the future risk of groundwater flooding.

4.2.3 At locations where there is potential for the Proposed Scheme to increase flood risk, hydraulic models have been used to assess the impacts of identified receptors in more detail.

[13] DCLG, *Planning practice guidance and planning system*, https://www.gov.uk/guidance/flood-risk-and-coastal-change
[14] CIRIA (2004), *'Development and flood risk: guidance to the construction industry*
[15] Highways Agency, *Design for Roads and Bridges*, http://www.standardsforhighways.co.uk/ha/standards/dmrb/
[16] Gov.uk, *Flood map for planning*, https://flood-map-for-planning.service.gov.uk
[17] British Geological Survey, *Susceptibility to groundwater flooding*, http://www.bgs.ac.uk/products/hydrogeology/groundwaterFlooding.html

4.3 Identification of receptors

4.3.1 Existing receptors with potential to be affected by the Proposed Scheme have been identified using Ordnance Survey mapping information and address point data. Receptor vulnerability is based on the definitions in Table 52 of the SMR[11], which is aligned with Table 2 of the planning practice guidance on flood risk and coastal change[10].

4.4 Assessing impacts and effects

4.4.1 Impact magnitude has been considered in terms of increases in peak flood levels associated with floods with a range of annual probabilities. The significance of the resulting effects on flood risk reflect the vulnerability of the receptor and the magnitude of the predicted impact, as defined by the matrix in Table 3, which is based on Table 50 and Table 52 of the SMR[11].

Table 3: Significance of flood effects

Flood vulnerability of receptor	**Magnitude of impact on peak flood levels**			
	Negligible (< +/- 10mm)	Minor > 10mm ≤ 50mm	Moderate > 50mm ≤ 100mm	Major > 100mm
Very high	Negligible - not significant	Moderate adverse – significant	Major adverse - significant	Major adverse – significant
High	Negligible - not significant	Moderate adverse – significant	Moderate adverse - significant	Major adverse – significant
Moderate	Negligible - not significant	Minor adverse - not significant	Moderate adverse - significant	Moderate adverse - significant
Low	Negligible - not significant	Negligible - not significant	Minor adverse - not significant	Minor adverse - not significant

4.4.2 Regardless of the significance of the flood risk effects, the design aim will be to mitigate all impacts on flood risk during the detailed design phase.

5 Flood risk baseline

5.1 Historical flooding incidents

5.1.1 There are no records of flooding in the vicinity of the Proposed Scheme in either the PFRA or the SFRA reports published by SCC and Stafford Borough Council (SBC). The accounts of flooding adjacent to the study area are focused on Stafford, where the River Trent poses a significant flood risk to property and there have also been incidents of surface water flooding.

5.2 Risks associated with rivers and ordinary watercourses

5.2.1 The key flood risk from rivers and ordinary watercourses is that associated with the River Trent at Great Haywood. The River Trent is the only main river within the study area.

5.2.2 The River Sow flows into the River Trent in the approximately 1km downstream of the Proposed Scheme, as such the flood risk characteristics of this main river are not affected.

5.2.3 An existing hydraulic model of the River Trent provided by the Environment Agency has been reviewed and updated in order to improve its accuracy. This model has then been used to determine the flood extent resulting from the 1 in 100 (1%) annual probability plus climate change flood event and to identify existing receptors that are at potential risk from this source. These areas are shown in Figure 2.

5.2.4 The receptors located upstream of the Proposed Scheme together with their vulnerability are listed below:

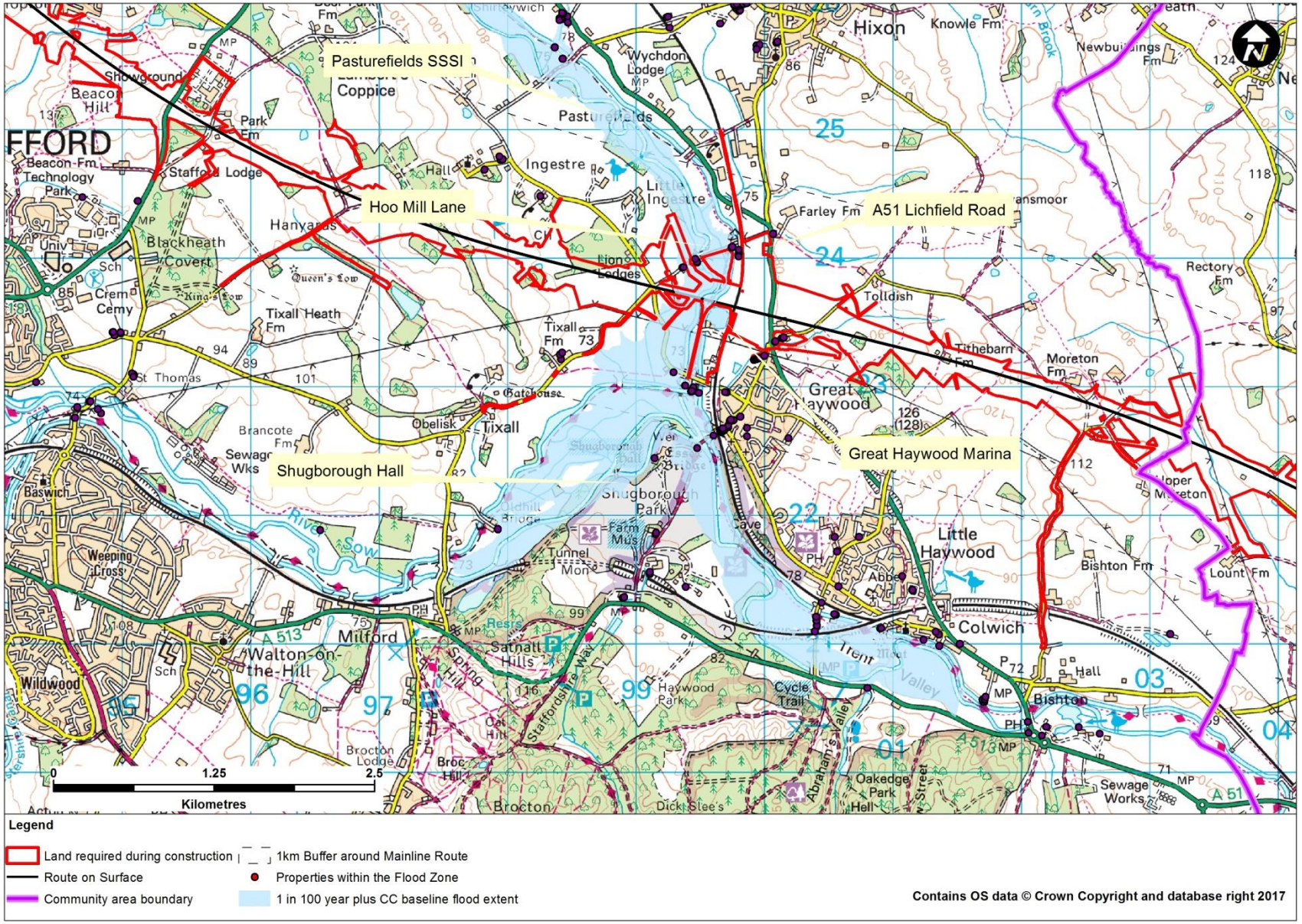
- Hoo Mill (more vulnerable);
- Hoo Mill Lane (less vulnerable);
- Hoo Mill cottages (located approximately 1km from the route centreline) (more vulnerable); and
- sections of the Trent and Mersey Canal (water compatible).

5.2.5 Figure 2 indicates that Pasturefields Salt Marsh Site of Special Scientific Interest (SSSI) and Special Area of Conservation would be inundated by the River Trent in the event of a flood of this magnitude.

5.2.6 The receptors located downstream of the Proposed Scheme, together with their vulnerability to flooding are listed below:

- Mill Lane (less vulnerable);
- six properties located along Mill Lane (more vulnerable);
- the Mill (more vulnerable);
- Great Haywood Marina (water compatible); and
- the Staffordshire and Worcestershire Canal (water compatible).

Figure 2: Flood risk associated with the River Trent at Great Haywood



5.2.7 The National Trust (NT) has provided consultation responses which expressed concerns related flood risk impacts on the Shugborough Estate and Shugborough Hall specifically. The updated modelling of the 1 in 100 (1%) annual probability plus climate change flood extent indicates that, in the baseline condition, Shugborough Estate is partially inundated. This may include some of the buildings. Shugborough Hall is not affected by the 1 in 100 (1%) annual probability plus climate change flood extent under baseline conditions.

5.2.8 A climate change allowance comprising a 50% increase in peak river flows has been adopted at this crossing.

Other watercourses

5.2.9 Other ordinary watercourses located within the Colwich to Yarlet study area include:

- a tributary of the Moreton Brook at Moreton Grange;
- a tributary of the River Trent at Tolldish Lane;
- a tributary of the River Trent at Lionslodge covert;
- a tributary of the Kingston Brook at Berryhill;
- tributaries of the Kingston Brook at Hopton; and
- tributaries of the River Trent at Marston Lane and Yarlet Wood.

5.2.10 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 uFMfSW outputs were used to determine possible flood extents generated by these watercourses.

5.2.11 Figure 3 and 4 indicate the receptors at risk for the surface water flow paths associated with these watercourses. Undeveloped agricultural land is the most common receptor with the specific receptors listed below:

- building at Moreton Grange Farm (more vulnerable);
- Bishton Lane (less vulnerable);
- Tolldish Lane (less vulnerable);
- the A51 Lichfield Road (essential infrastructure);
- two residential properties located on Tolldish Lane (more vulnerable);
- land associated with residential properties within Mill Court, Hunters Close and Nursery Way within Pipe Ridware (less vulnerable); and
- Hopton Lane (less vulnerable).

5.2.12 Climate change allowances of 40% increase in peak river flows have been adopted at these crossings, as the watercourses concerned have catchment areas of less than 5km^2.

5.3 Risks associated with surface water

5.3.1 This section describes the risk associated with the surface water as shown by the Environment Agency's uFMfSW data set for the 1 in 100 (1%) annual probability flood event. As presented in Figure 3 and Figure 4 areas of undeveloped agricultural land are at risk from surface water flooding as well as the following receptors:

- building at Moreton Grange Farm (more vulnerable);
- Bishton Lane (less vulnerable);
- Tolldish Lane (less vulnerable);
- the A51 Lichfield Road (essential infrastructure);
- two residential properties located on Tolldish Lane (more vulnerable);
- land associated with residential properties within Mill Court, Hunters Close and Nursery Way within Pipe Ridware (less vulnerable);
- Sandon Road (less vulnerable);
- Hopton Lane (less vulnerable);
- access road to Newbuildings cottages (less vulnerable);
- Marston Lane (less vulnerable); and
- A34 Stone Road (essential infrastructure).

5.3.2 A climate change allowance of 40% increase in peak flows has been adopted at these surface water flow path crossings, because the catchment areas are all less than 5km^2.

Figure 3: Surface water flood risk (southern extent of the study area)

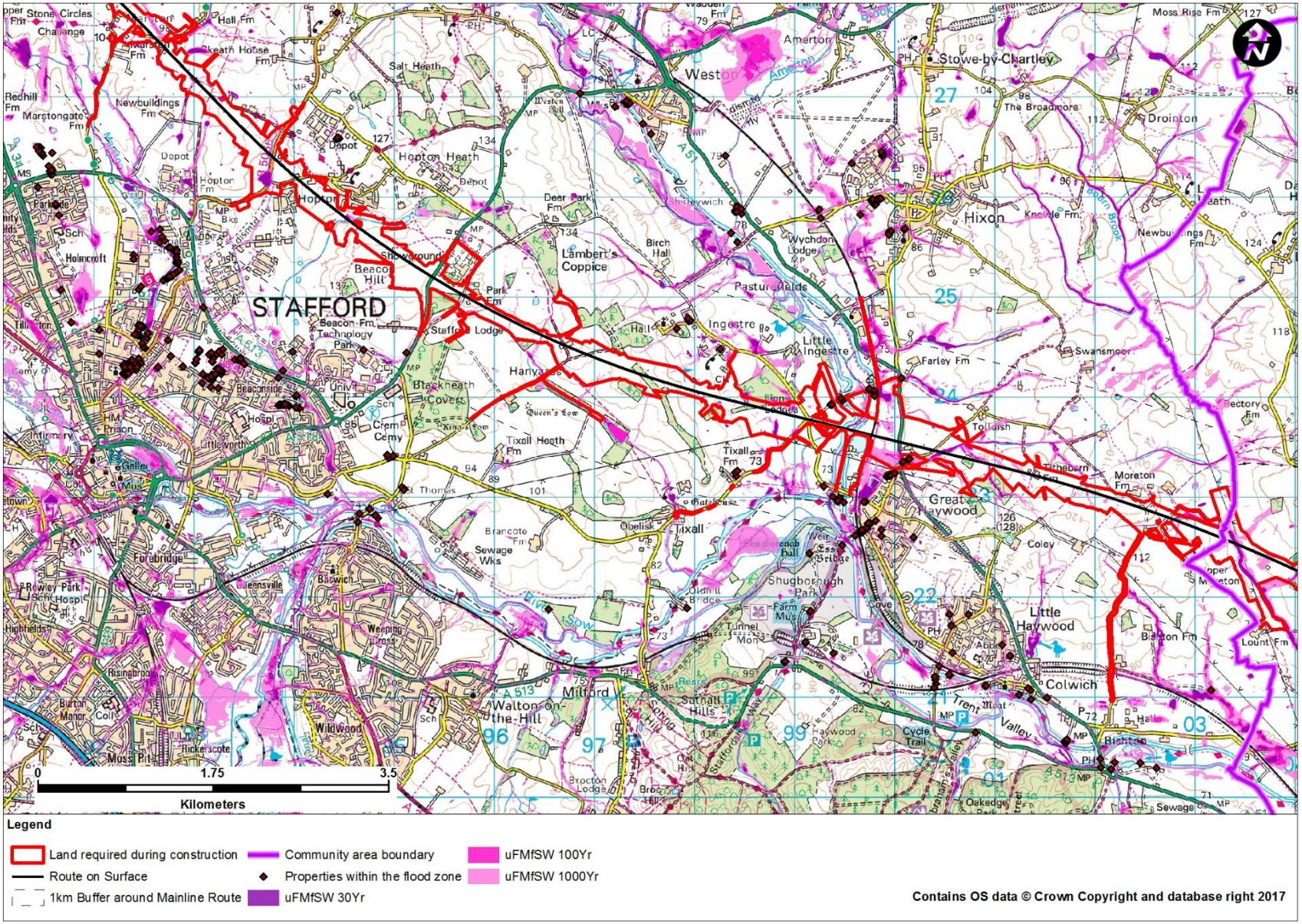
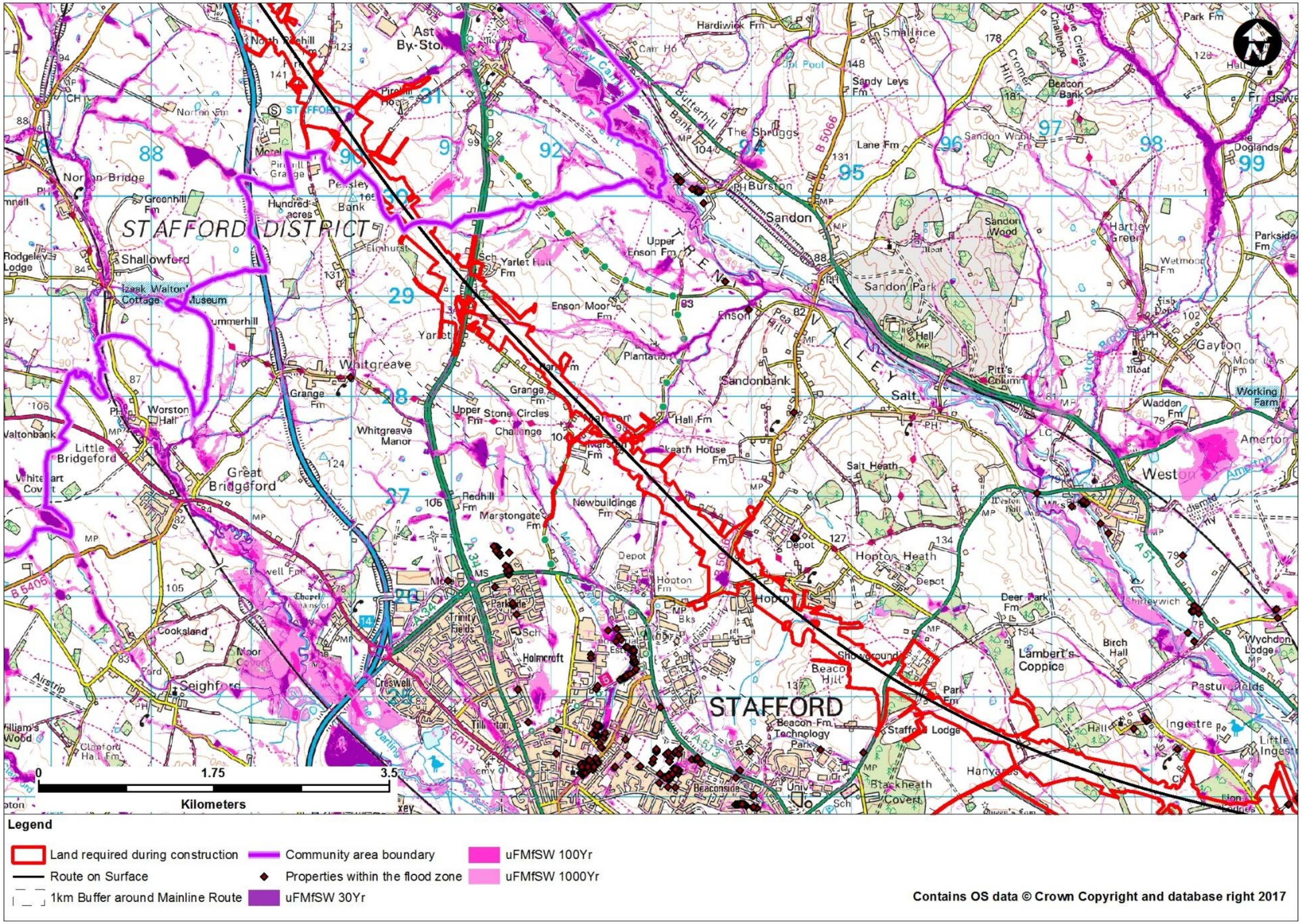


Figure 4: Surface water flood risk (northern extent of the study area)



5.4 Risks associated with groundwater

5.4.1 The AStGWF provides the main dataset used to assess 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 AStGWF map uses four susceptibility categories to show the proportion of each 1km grid square where geological and hydrogeological conditions combine to indicate a potential risk that groundwater flooding might occur. It does not show the likelihood of groundwater flooding actually occurring.

5.4.2 Along the River Trent Valley and other areas where Alluvium, River Terrace Deposits and Glaciofluvial Sheet Deposits are present, land is classified as having the potential for groundwater flooding to occur at the surface. Around Hopton, where superficial deposits are absent but the near surface bedrock is Sherwood Sandstone, the area is classified as having limited potential for groundwater flooding to occur.

5.4.3 The SFRA does not report any historic groundwater flooding incidents within the study area.

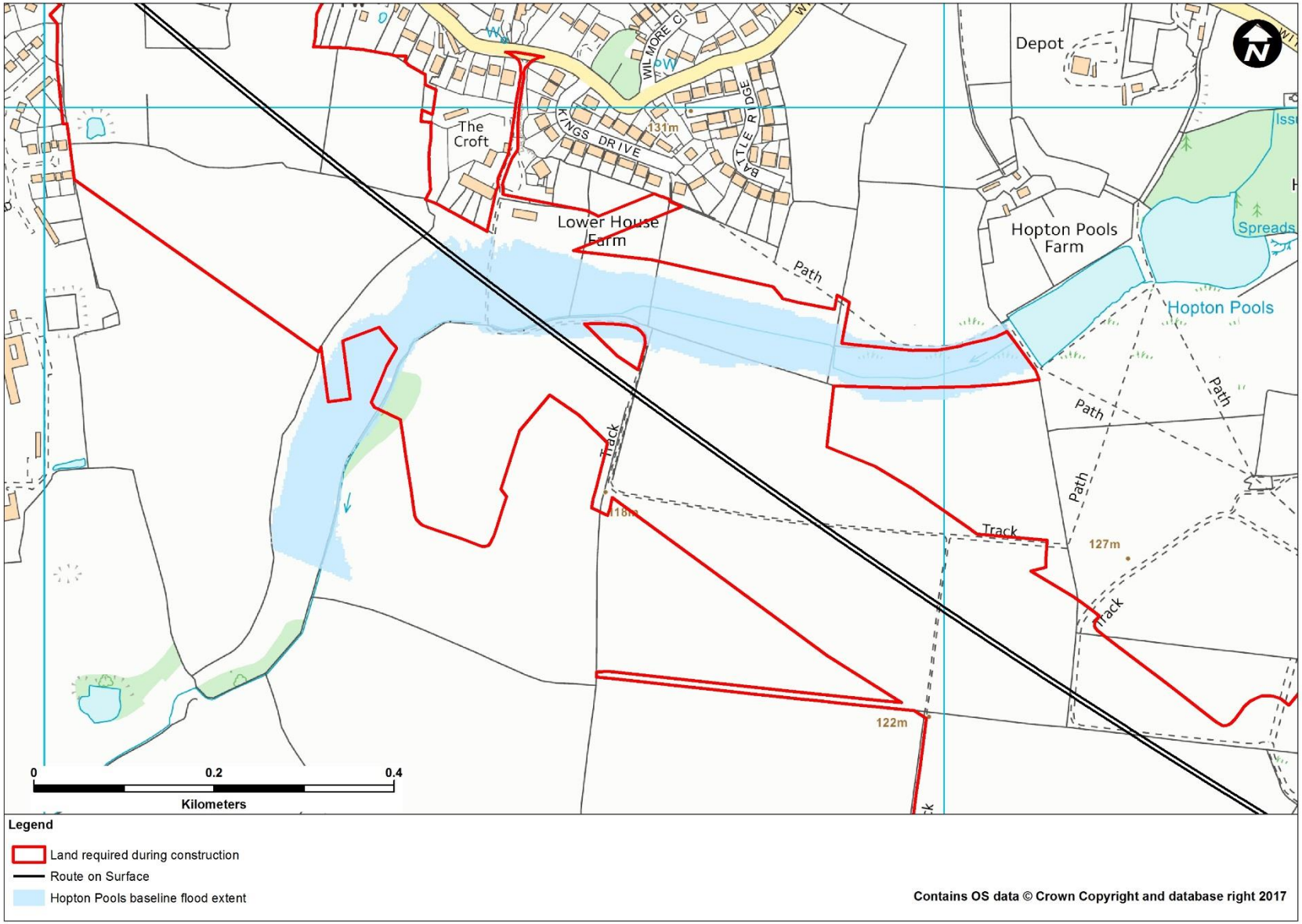
5.5 Risks associated with artificial sources

5.5.1 Flooding from artificial water bodies may occur from failure of a retaining structure which impounds water. The following man-made features have been identified within the study area as being a potential source of flood risk:

- The Environment Agency's Flood risk from reservoirs mapping indicates that in the event of a failure of a reservoir with a volume in excess of 25,000m^3, the River Trent floodplain area in the vicinity of Great Haywood will be affected;
- the Trent and Mersey Canal is spanned by the route and the Staffordshire and Worcestershire Canal is located within 800m of the Proposed Scheme. The key location where a failure of the canal system would cause significant flooding is in the vicinity of Great Haywood where both canals are embanked so that they sit above the local ground level. The Staffordshire and Worcestershire Canal is an embanked feature that crosses the River Trent's main channel on an aqueduct; and
- major water supply pipelines and sewerage (foul and surface water) infrastructure have been identified and are accounted for in the Proposed Scheme Maps CT-05 and CT-06, available in the Volume 2 Map Book.

5.5.2 There are two fishing ponds located on a tributary of Kingston Brook in the vicinity of Hopton, known locally as Hopton Pools. These features would pose a potential risk to downstream receptors, including the Proposed Scheme, in the event of a breach occurring in the embankments that impound water in the ponds. For this reason, a preliminary breach analysis has been undertaken to determine the extent of flooding that would occur in the event of a breach under current conditions. The extent of the predicted flooding within the area modelled is shown in Figure 5.

Figure 5: Flood risk under breach conditions at Hopton



5.6 Summary of baseline flood risk

Table 4 below provides a summary of the all 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 4: Summary of baseline flood risk

Source / Pathway	Receptors	Data Source	Highest Receptor Vulnerability Level	Climate Change Allowance used for assessment
River Trent	Hoo Mill (more vunerable)	1 in 100 (1%) annual probability flood extent with allowance for climate change[18]	More vulnerable	50%
	Hoo Mill Lane (less vulnerable)			
	Hoo Mill cottages (more vulnerable)			
	Trent and Mersey Canal (water compatible)			
	Properties located along Mill Lane (more vulnerable)			
	The Mill (more vulnerable)			
	Great Haywood Marina (water compatible)			
	The Staffordshire and Worcestershire Canal (water compatible)			

[18] Derived from new hydraulic modelling undertaken for the purpose of the Proposed Scheme. Details are provided in the hydraulic modelling reports presented in HS2 (2017) *High Speed 2 (HS2) Phase 2a (West Midlands – Crewe), Background Information and Data, Hydraulic Modelling Report, BID-WR-004*, Available online at: www.gov.uk/hs2

Source / Pathway	Receptors	Data Source	Highest Receptor Vulnerability Level	Climate Change Allowance used for assessment
	Shugborough Estate (more vulnerable)			
tributary of Moreton Brook	Moreton Grange Farm (more vulnerable)	uFMfSW 1% Annual Exceedance Probability (AEP)	More vulnerable	40%
	Agricultural land and woodland (less vulnerable)			
tributary of River Trent at Tolldish Lane	Properties along Tolldish Lane (more vulnerable)	uFMfSW 1% AEP	More vulnerable	40%
	A51 Lichfield Road (Essential infrastructure)			
	Land associated with residential properties within Mill Court, Hunters Close and Nursery Way (less vulnerable)			
tributary of River Trent at Lionslode covert	Agricultural land and woodland (less vulnerable)	uFMfSW 1% AEP	Less vulnerable	40%
tributary of the Kingston Brook at Berryhill	Agricultural land and woodland (less vulnerable)	uFMfSW 1% AEP	Less vulnerable	40%
tributary of the Kingston Brook at Hopton	Agricultural land and woodland (less vulnerable)	uFMfSW 1% AEP	Less vulnerable	40%
tributary of the River Trent at Marston Lane	Marston Lane (less vulnerable)	uFMfSW 1% AEP	Less vulnerable	40%

Source / Pathway	Receptors	Data Source	Highest Receptor Vulnerability Level	Climate Change Allowance used for assessment
	Agricultural land and woodland (less vulnerable)			
tributary of the River Trent at Yarlet Wood	Agricultural land and woodland (less vulnerable)	uFMfSW 1% AEP	Less vulnerable	40%
Surface water	Agricultural land and woodland near Tithebarn covert (less vulnerable)	uFMfSW 1% AEP	Essential infrastructure	40%
	Agricultural land and woodland near Tixall (less vulnerable)			
	Agricultural land and woodland near Weetmans plantation (less vulnerable)			
	Agricultural land and woodland at Trent Walk (less vulnerable)			
	Agricultural land and woodland at A518 Weston Road (less vulnerable)			
	Agricultural land and woodland south of Hopton (less vulnerable)			
	B5066 Sandon Road (less vulnerable)			
	Agricultural land and woodland near Marston (less vulnerable)			

Source / Pathway	Receptors	Data Source	Highest Receptor Vulnerability Level	Climate Change Allowance used for assessment
	A34 Stone Road (essential infrastructure)			
	Agricultural land and woodland at Yarlet (less vulnerable)			
	Yarlet Bank Farm (more vulnerable)			
	Agricultural land and woodland near Peasley Bank (less vulnerable)			
Breach of Hopton	Agricultural land near Hopton (less vulnerable)	1 in 1000 annual probability flood extent	Less vulnerable	n/a
Trent and Mersey Canal and Staffordshire and Worcestershire Canal	Great Haywood	OS mapping	More vulnerable	n/a
Water utilities	All land along the Proposed scheme where assets exist	Utility plans as shown on CT-05 and CT-06	More vulnerable	n/a

6 Post-development flood risk assessment

6.1 Rivers and ordinary watercourses

Viaducts

6.1.1 The Proposed Scheme in the vicinity of Great Haywood includes a crossing of the main channel of the River Trent by a viaduct (Great Haywood viaduct). The hydraulic models of these watercourses have been used in the design and assessment of the Proposed Scheme in the following ways:

- to define the 1 in 100 (1%) annual probability flood extent including an allowance for climate change;
- to confirm supporting abutments and embankments of the viaducts are located outside the 1 in 100 (1%) annual probability flood extent including an allowance for climate change, where reasonably practical; and
- to determine the impact of flood levels of intermediate piers or any other permanent features associated with the Proposed Scheme.

6.1.2 Details of all the hydraulic modelling assessments undertaken of these watercourses can be found in the supporting hydraulic modelling reports contained in the BID[1]. The results of these assessments are reported below for each watercourse in turn.

River Trent

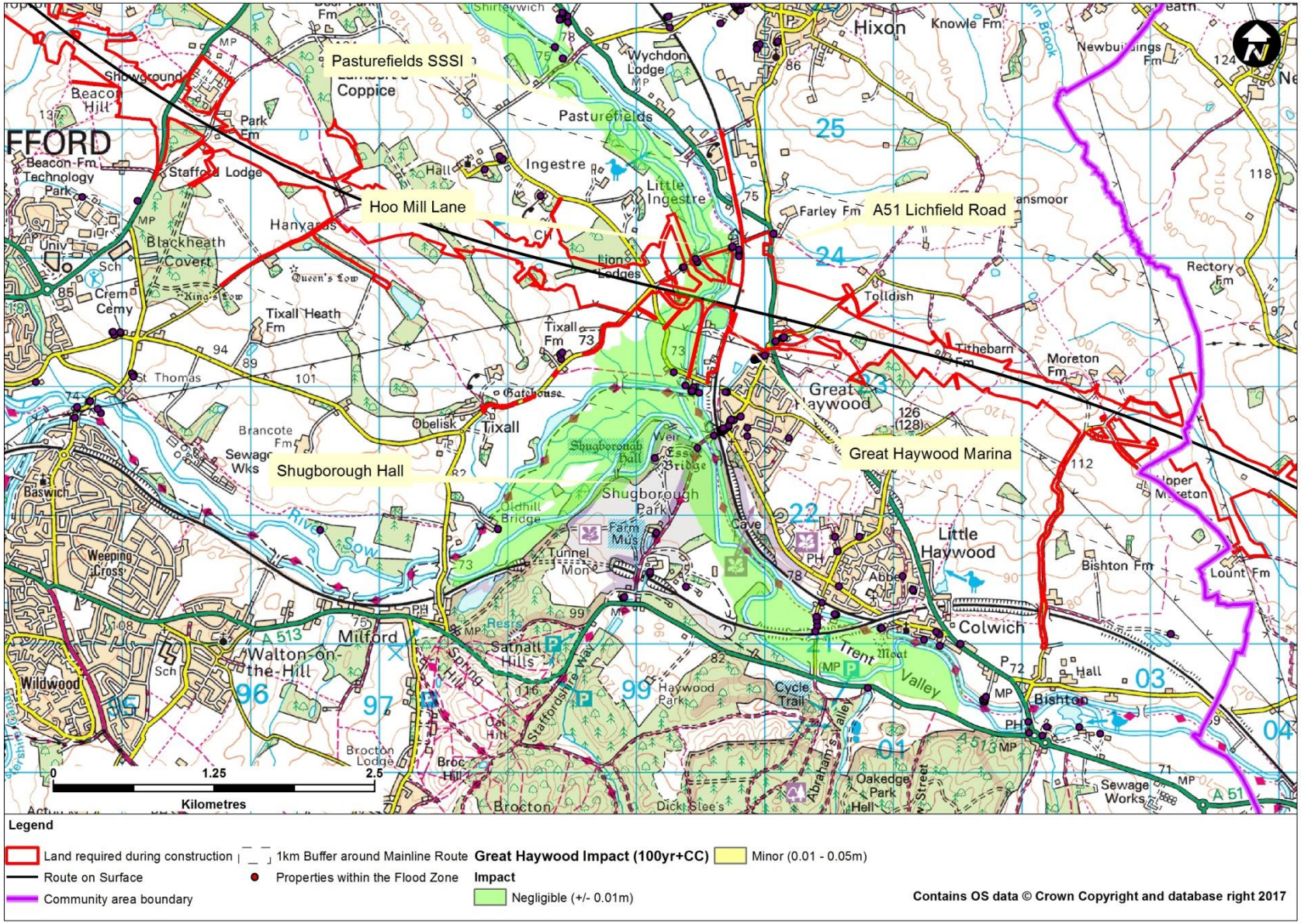
6.1.3 The effect of the viaduct piers on flood water levels in the vicinity of Great Haywood is shown in Figure 6.

6.1.4 The results of the hydraulic model study of the River Trent indicate that the piers of the proposed Great Haywood viaduct will cause a negligible change in peak flood level.

6.1.5 Figure 6: confirms there are no changes in flood risk at Shugborough Hall, the Shugborough Estate or at Pasturefields SSSI.

6.1.6 A small realignment of one of the drainage features located within the River Trent floodplain is required due to a proposed pier location. By providing a channel that matches the dimensions and capacity of the existing channel, the flood risk characteristics of the local area will remain unchanged.

Figure 6: Post development flood risk at Great Haywood



Culverts and channel diversions

6.1.7 In addition to the main watercourse crossings where the design and assessment has involved more detailed fluvial hydraulic modelling, the Proposed Scheme crosses a number of smaller ordinary watercourses that have not been modelled nor have they been mapped as part of the Environment Agency's Flood map for planning (rivers and sea) data set. Therefore, the uFMfSW data set has been used to indicate the potential flood extent generated and the receptors affected along these watercourses.

6.1.8 At the locations where these ordinary watercourses cross the Proposed Scheme culvert structures are required to convey the water under the route. It may also be necessary to realign the existing channel at the approach and downstream of the culvert. This is to make sure that the watercourse crossing is as short as reasonably practicable to reduce ecological and hydromorphological impacts.

6.1.9 At other locations channel diversions have been implemented to remove the need for a culvert crossing.

6.1.10 The diverted and realigned channels will have the same dimensions and hydraulic capacity as the existing channel unless a change in size would be beneficial to flood risk, as identified at detailed design stage.

6.1.11 The following calculation procedure has been undertaken to size the culverts:

1. use of the Revitalised Rainfall-Runoff Model version 2.2 (ReFH2) to determine the peak flow generated during the 1 in 100 (1%) annual probability storm event;
2. determination of the appropriate climate change allowance to be applied following the procedure outlined in Section 3;
3. determination of the existing gradient of the watercourse using Ordnance Survey Mapping and LiDAR data;
4. determination of the roughness characteristics of the existing culvert; and
5. selection of a structure with the capacity to convey the 1 in 100 (1%) annual probability peak flow, incorporating the appropriate allowance for climate change, whilst ensuring a minimum of 300mm freeboard to the culvert soffit above this design flood level.

6.1.12 The details of the culvert design applied to the ordinary watercourses are provided in Table 5.

Table 5: Details of culvert design at ordinary watercourse crossings

Watercourse/Location	Structure name	Estimated 1 in 100 (1%) annual probability peak flow (m^3/s)	Climate change allowance	Culvert dimensions (m)	Culvert capacity (m^3/s)
Tributary of the River Trent at Tolldish culvert	Tolldish culvert	3.49	40%	3x1.35	5.93
Tributary of the River Trent at Lionlodge Covert	Lionlodge culvert	0.16	40%	1.35x1.35	1.41
Tributary of the Kingston Brook at Berryhill	Berryhill (South) culvert	0.46	40%	1.35x1.35	1.41
Tributary of the River Trent at Yarlet Wood	Yarlet Wood drop inlet culvert	0.72	20%	1.35x1.35	1.41

6.1.13 By following this design approach the flood risk to the receptors identified will be unchanged. The sizing of the culvert required for the Kingston Brook at Hopton is discussed in Section 6.4.

6.1.14 The tributary of the River Trent at Marston Lane will pass through an underbridge that also accommodates the Marston Bridleway 8. The channel capacity will match existing conditions.

6.1.15 Each of the ordinary watercourse crossings in Table 5 are associated with a channel realignment to reduce the length of culvert as far reasonably practicable. The tributary of Moreton Brook at Moreton Grange is also to be diverted. The realigned and diverted channels will match the existing channels' capacities unless it is identified at detailed design stage that a change in size would be beneficial to flood risk.

6.1.16 The ordinary watercourses identified are also affected by highway diversions and permanent access requirements at the following locations:

- A518 Weston Road realignment affecting the tributary of Kingston Brook at Berryhill;
- balancing pond access located downstream of Hopton culvert crossing tributary of Kingston Brook;
- changes to B5066 Sandon Road and Hopton Lane includes crossing of a tributary of Kingston Brook; and
- balancing pond access located in the vicinity of Marston Lane crossing of the tributary of River Trent.

6.1.17 The design of the channels and culverts required to convey water under highways and permanent access roads will follow the procedures for culverts outlined above, with the aim of ensuring that there are no significant effects on flood risk.

6.2 Surface water

6.2.1 As outlined in Section 4.2, the uFMfSW data set and inspection of topographical survey information has identified surface water flow paths that are not represented by any formal channel feature and so are watercourses.

6.2.2 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 to and from the culverts or to a receiving watercourse to allow drainage of surface water from one side of the Proposed Scheme to the other.

6.2.3 The design process outlined in Section 6.1 has also been followed to size these culverts and the associated channels. In this way the existing flow paths are preserved and the flooding characteristics of the local area remain unchanged.

6.2.4 Details of the culvert and channel design are provided in Table 6.

Table 6: Details of culvert design at surface water flow paths

Watercourse/Location	Structure/feature name	Estimated 1 in 100 (1%) annual probability peak flow (m^3/s)	Climate change allowance	Culvert/channel dimensions (m)	Culvert/channel capacity (m^3/s)
Surface water flow path at the upstream of the River Trent tributary at Tixall	Hanyard's culvert	0.12	40%	1.35 x 1.35	1.41
Surface water flow path feeding tributary of Kingston Brook	Trent Walk green underbridge (shared accommodation)	0.03	40%	Assume open culvert 1.35 x 1.35	1.41
Surface water flow path at A518 Weston Road	Berryhill (North) drop inlet culvert	0.10	40%	1.35 x 1.35	1.41
Surface water flow at Sandon Road	B5066 Sandon Road culvert	0.68	40%	1.35 x 1.35	1.41
Surface water flow path at Yarlet Bank	Yarlet Bank drop inlet culvert	0.72	40%	1.35 x 1.35	1.41
Surface water flow path at Peasley Bank	Peasley Bank drop inlet culvert	1.69	40%	2.4 x 1.35	6.62

6.2.5 In addition to the above, channels are required to accept surface water flow path from Tithebarn Covert and at Tolldish Lane.

6.2.6 By following this design approach the local flood risk characteristics are preserved and the risk to the receptors outlined in Section 5.6 is unchanged including the residential properties at Tolldish Lane and the land adjacent to residential properties at Mill Court, Hunters Close and Nursery Way. As such the magnitude of the flood risk impact to these receptors is negligible.

6.2.7 This sizing convention will be carried through the design stages unless a change in size is found to be beneficial to flood risk at the more detailed design stages.

6.3 Groundwater

6.3.1 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 and have the potential to cause a rise in groundwater level in the vicinity of these structures. Other below ground features which could cause changes to the local groundwater levels, such as drained cuttings, are not assumed to increase groundwater flood risk as the drainage design will take account of groundwater flows entering the cutting.

6.3.2 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 (see Volume 5: WR-003-002).

6.3.3 Moreton retaining wall will span a 200m section of the northern side of Moreton cutting whilst Hopton retaining wall will span a short section of Hopton North and Hopton South cuttings. There is limited information about groundwater levels in these areas, and there is the potential for the retaining walls to create a barrier to groundwater flow. However following ground investigation and monitoring, drainage systems will be designed to reduce any risks identified in paragraph 6.3.1.

6.3.4 The assessment has shown that there are no other features of the Proposed Scheme in the Colwich to Yarlet area that would act as a significant barrier to groundwater flow. Therefore there will be no significant increases in groundwater levels across the aquifers which could lead to increased risks of groundwater flooding as a result of the Proposed Scheme.

6.4 Artificial sources

Blithfield reservoir

6.4.1 The Environment Agency's Flood risk from reservoirs mapping indicates that in the event of a failure of Blithfield Reservoir, the River Trent floodplain area in the vicinity of Great Haywood would be affected. However, as this is a large raised reservoir, subject to the requirements of reservoir safety legislation[19], the inundation risk posed by this reservoir is considered negligible. Nor will the Proposed Scheme affect the local flood risk characteristics in the event that a dam failure did occur.

6.4.2 Major water supply pipelines and sewerage (foul and surface water) infrastructure have been identified and are accounted for on the Proposed Scheme Maps CT-05 and CT-06 available in the Volume 2 Map Book. This infrastructure has been identified and diverted where appropriate. Measures will be taken to safeguard the local receptors during this diversion process.

[19] Department for Communities and Local Government (2014), *Reservoirs: owner and operator requirements*, https://www.gov.uk/guidance/reservoirs-owner-and-operator-requirements

The Trent and Mersey Canal

6.4.3 The Trent and Mersey Canal is crossed by the Proposed Scheme and the Staffordshire and Worcestershire Canal is located within 800m of the Proposed Scheme. The key location where a failure of the canal system would cause significant flooding is in the vicinity of Great Haywood where both canals are impounded by embankments above the local ground level. The Proposed scheme will not affect the integrity of the existing canal and so will not increase the risk of failure. If the canal embankments were to fail, the Proposed Scheme would be unaffected and would not increase flood risk elsewhere.

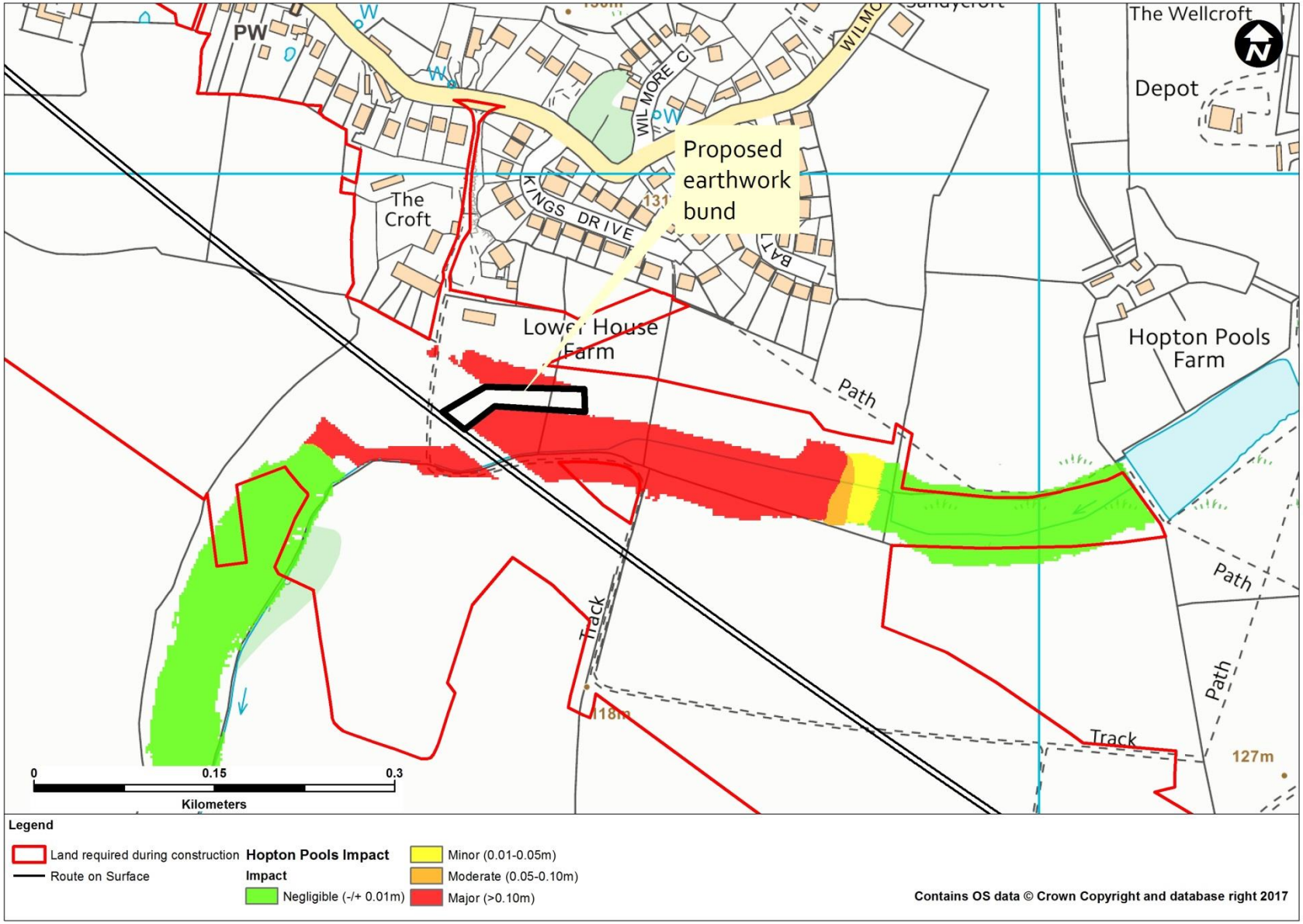
Hopton Pools

6.4.4 The culverts proposed on the Kingston Brook tributary at Hopton have adequate capacity for the 1 in 100 (1%) annual probability peak flow with an allowance for climate change (1.37 m^3/s) to ensure no impact on flood risk. However, in the event of a breach of Hopton Pools the flood waters will reach a level close to the operational level of the Proposed Scheme and cause partial inundation of existing properties located to the north of the false cutting earthworks. As a safeguard against this scenario, additional culverts have been incorporated into the design and their performance tested in the fluvial hydraulic model.

6.4.5 The rate at which water would be released during a failure of the impounding structures has been estimated to be in the range of 80 m^3/s to 140 m^3/s. The proposed culvert configuration at Hopton culvert, which comprises three culverts, each with a span of 4.2 m and a height of 1.35 m, would prevent any change in flood risk to vulnerable receptors such as local residential properties. However, there will still be potential changes to the flood extent and depth associated with a breach of these dams, which could affect the gardens of some of the properties and agricultural land and buildings, as shown on Figure 7. The Proposed Scheme incorporates an earth flood embankment to protect these receptors. More detailed analysis will be undertaken of this issue at the detailed design stage, including consultation with the owner of the Hopton Pools.

6.4.6 The overall impact of the Proposed Scheme on flood risk would be beneficial for downstream receptors at potential risk from a breach of the Hopton Pool dams. This is because the Proposed Scheme would attenuate the flows, temporarily holding a portion of the floodwater back behind the rail embankments.

Figure 7: Post development flood risk in the event of a breach occurring in the dams impounding Hopton Pools



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

6.5.1 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.

6.5.2 The design of drainage systems aims to ensure that there will be no significant increases in flood risk downstream, during storms up to and including the 1 in 100 (1%) annual probability design event, with an allowance for climate change based on the latest guidance issued by the Environment Agency.

6.5.3 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.

7 Additional flood risk management measures

7.1.1 The next stage of the design process will involve incorporation of topographical survey information into all of the existing hydraulic models to improve how they represent the existing watercourses. The areas of replacement flood storage identified will be incorporated into the models and the detailed design of all the viaducts, bridges and culverts will be developed with the aim of impacts on peak flood level being mitigated as far as is reasonably practicable.

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

8 Summary of significant flood risk effects

8.1.1 No potentially significant effects related to flood risk have been identified in the Colwich to Yarlet area.

9 Conclusions

9.1.1 Hydraulic analysis has identified that the Proposed Scheme will not have a significant effect related to flood risk on the River Trent upstream and downstream of the proposed viaduct at Great Haywood. Further hydraulic modelling and design refinement will be undertaken at the detailed design stage with the aim of reducing the minor localised impacts on peak flood level as far as is reasonably practicable.

9.1.2 The Proposed Scheme has been designed to take account of the potential for a breach to occur in the dams impounding Hopton Pools. The design will reduce the impacts of such an occurrence such that the overall impact on flood risk will be either neutral or beneficial for receptors downstream of these ponds.

10 References

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

Capita (2014), *South Staffordshire, Cannock Chase, Lichfield and Stafford Strategic Flood Risk Assessment (SFRA).*

CIRIA (2004). *Report C624: Development and Flood Risk*.

Department for Communities and Local Government (2016), *Planning practice guidance and planning system.* Available online at: https://www.gov.uk/guidance/flood-risk-and-coastal-change.

Environment Agency, *Flood risk assessments: climate change allowances*. Available online at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

Gov.uk, *Flood map for planning*. Available online at: https://flood-map-for-planning.service.gov.uk.

Gov.uk, *Long term flood risk information.* Available online at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map.

Highways Agency, *Design for Roads and Bridges*. Available online at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/.

HS2 Ltd (2017), High Speed Two Phase 2a: West Midlands to Crewe, Background Information and Data, *CA2: Colwich to Yarlet, Hydraulic modelling report - Great Haywood Viaduct,* (BID-WR-004-005). Available online at: www.gov.uk/HS2.

HS2 Ltd (2017), High Speed Two Phase 2a: West Midlands to Crewe, Background Information and Data, *CA2: Colwich to Yarlet, Hydraulic modelling report – Hopton*, (BID-WR-004-006). Available online at: www.gov.uk/HS2.

HS2 Ltd (2012), High Speed Two (HS2) Appraisal of Sustainability Options Report: Final, Available on line at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/68981/options-for-phase-two-of-the-high-speed-rail-network-appraisal-of-sustainability.pdf.

Royal Haskoning (2011), *Staffordshire County Council Preliminary Flood risk Assessment.*

Shropshire and Staffordshire County Council (2015), *Shropshire and Staffordshire Local Flood Risk Management Strategy.*

High Speed Two (HS2) Limited
Two Snowhill
Snow Hill Queensway
Birmingham B4 6GA

08081 434 434
HS2Enquiries@hs2.org.uk

E117