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High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA1: Fradley to Colton

Flood risk assessment (WR-003-001)

July 2017

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Department for Transport

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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 Fradley to Colton (CA1), the area specific appendices comprise:

- a water resources assessment (Volume 5: WR-002-001); 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 - Pyford Brook (Background Information and Data: BID-WR-004-001);
- Hydraulic modelling report - River Trent and Bourne Brook (Background Information and Data: BID-WR-004-002);
- Hydraulic modelling report - Moreton Brook (Background Information and Data: BID-WR-004-003); and
- Hydraulic modelling report – Stockwell Heath (Background Information and Data: BID-WR-004-004).

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 Fradley to Colton area.

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

1.2.2 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. The proposed temporary borrow pits are of a significant scale compared to the permanent works. However, it is assumed that these features would not increase flood risk. Excavation of the borrow pits would be undertaken in accordance with the measures outlined in the draft CoCP, with the specific aim of not increasing flood risk to vulnerable receptors. The design of the temporary works would ensure that, if a flood does occur, the borrow pits would fill with floodwater. It is also assumed that the restored borrow pit areas would cause no increase in flood risk. The areas will be restored to their existing ground levels, which will in turn restore their original floodplain hydraulic functionality. The permanent drainage of the restored borrow pit areas will also aim to maintain existing surface water runoff characteristics.

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

1.2.4 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.

1.2.5 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.

1.2.6 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].

1.2.7 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

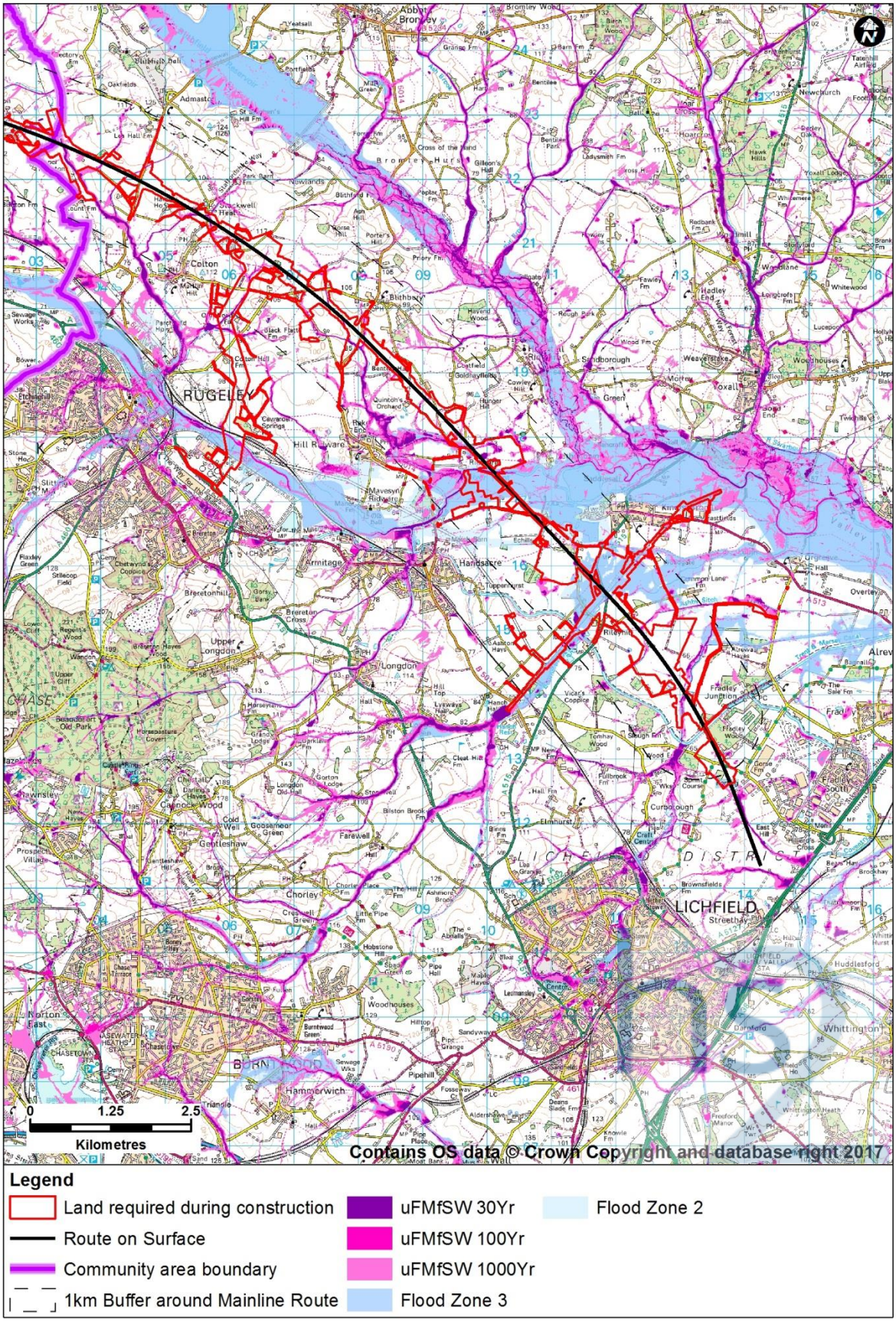
1.3.1 The location and extent of the study area is shown in Figure 1. The study area extends 1km from the centreline of the route of the Proposed Scheme. All flood risk receptors have been identified within these limits. If modelling assessments identified potential impacts beyond these limits, the study 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

[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

Agency's flood map for planning (rivers and sea) and the updated flood map for surface water (uFMfSW)[3].

[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 the 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.

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). Staffordshire County Council (SCC) is the LLFA in the Fradley to Colton 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 Fradley to Colton 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[4]. 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[4] 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 year (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 for inspection and maintenance purposes. 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 to vulnerable receptors 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, as outlined below, have been agreed with the Environment Agency.

Increases in peak river flow

3.8.2 The risk based approach within the guidance recommends selection of a suitable uplift 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 Fradley to Colton area lies.

Table 1: Allowance percentages 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

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

preliminary hydraulic design of viaducts, bridges and culverts. The vulnerability of 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.

[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

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. 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 to assess the future performance of track drainage, runoff attenuation elements and for surface water catchments of less than 5km^2.

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[10], CIRIA Publication C624 'Development and flood risk: guidance to the construction industry'[13] and the Design Manual for Roads and Bridges (DMRB)[14]. 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 potentially 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)[15] has been used to scope the baseline flood hazard associated with rivers and ordinary watercourses.

4.2.2 The updated flood map for surface water (uFMfSW)[3] has been used to scope surface water flood hazards. Infrastructure failure flood hazards have been scoped using the Environment Agency Risk of flooding from reservoirs national dataset. The British Geological Survey national dataset, areas susceptible to groundwater flooding (AStGWF)[16], 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 potential impacts in more detail.

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].

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

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 The PFRA and SFRA reports published by SCC and Lichfield District Council (LDC) describe incidents of historic flooding in the vicinity of Kings Bromley caused by the River Trent and surface water sources.

5.2 Risks associated with rivers and ordinary watercourses

5.2.1 The key flood risk from main rivers and ordinary watercourses is that associated with the following:

- Pyford Brook, near Fradley;
- River Trent, Bourne Brook, Crawley Brook and Luth Burn at Kings Bromley;
- a tributary of Moreton Brook at Stockwell Heath; and
- Moreton Brook.

5.2.2 The areas at risk of flooding from these watercourses, the receptors potentially affected and the climate change allowances used in the design and assessment of impacts and effects are considered below.

Pyford Brook, near Fradley

5.2.3 A 2D hydraulic model of Pyford Brook has been developed to define the 1 in 100 (1%) annual probability flood extent with an allowance for climate change. The results of this hydraulic modelling study are shown in Figure 2.

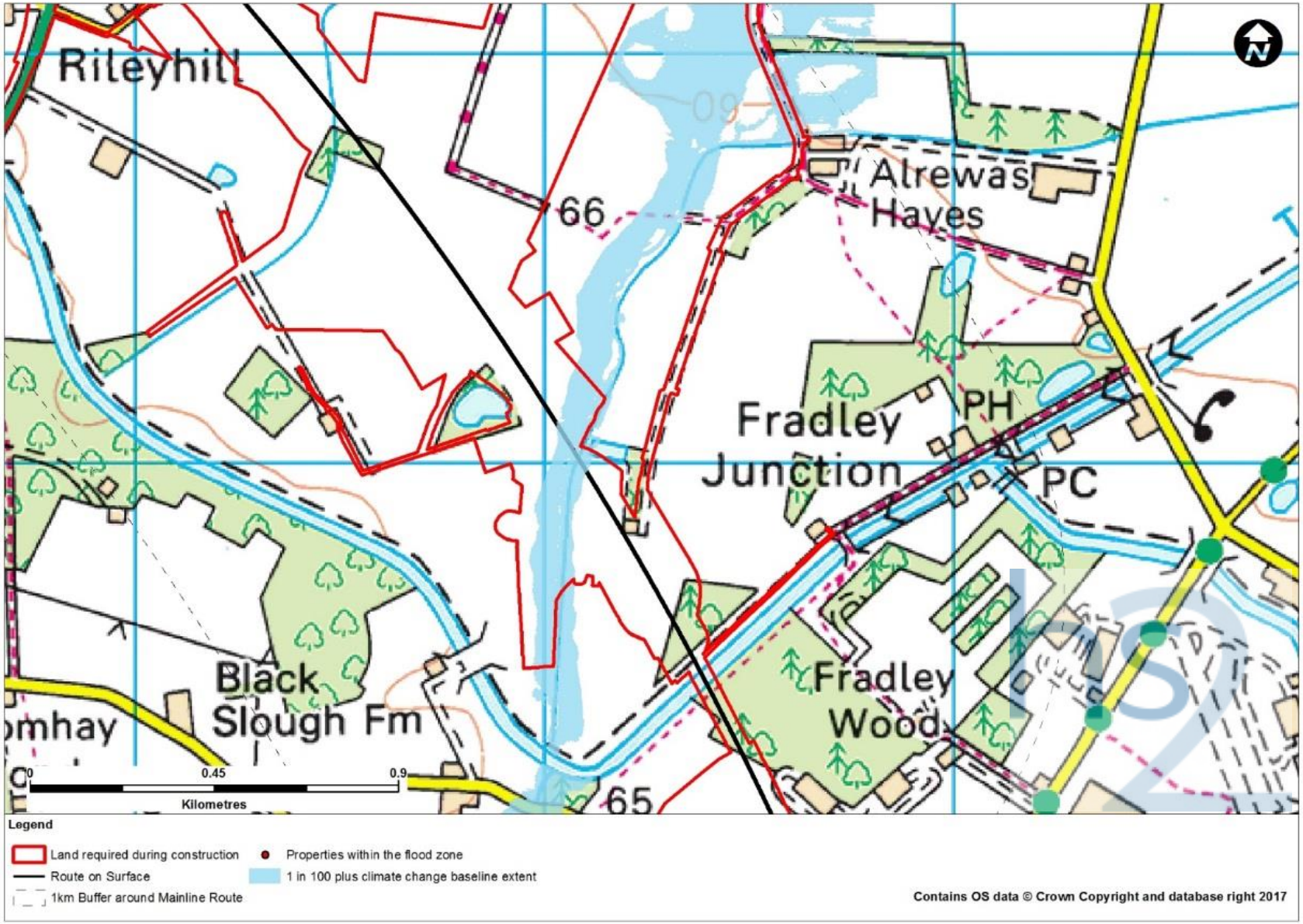
5.2.4 The receptors upstream of the Proposed Scheme that are at potential risk from this watercourse are listed below. The relative vulnerability to flooding of each receptor (as defined in NPPF and Table 52 of the SMR[11]) is also indicated:

- Curborough sewage treatment works (water compatible);
- Wood Lane (less vulnerable);
- Trent and Mersey Canal (water compatible); and
- two existing surface water abstractions, located in the vicinity of the Trent and Mersey Canal crossing (water compatible).

5.2.5 The receptors downstream of the Proposed Scheme are either agricultural land or woodland. These are less vulnerable flood receptors.

5.2.6 A climate change allowance comprising a 30% increase in peak river flows has been adopted at this crossing.

Figure 2: Extent of the modelled 1 in 100 (1%) plus climate change floodplain, Pyford Brook



River Trent at Kings Bromley

5.2.7 An existing 1D fluvial hydraulic model of the River Trent at Kings Bromley has been obtained from the Environment Agency which includes the River Trent only in the vicinity of Kings Bromley. This has been reviewed and converted to a 1D/2D model to improve its accuracy. It has then been used to define the 1 in 100 (1%) annual probability flood extent with an allowance for climate change taking account of Bourne Brook, Crawley Brook and Luth Burn as well as the main channel of the River Trent itself. The modelled flood extent is shown in Figure 3.

5.2.8 The receptors, located within the extent generated by the 1 in 100 (1%) annual probability flood event with an allowance for climate change associated with Bourne Brook, Crawley Brook, River Trent and Luth Burn, within 1km of the proposed route, are listed below with an appropriate vulnerability classification:

- Shaw Lane (less vulnerable);
- A515 Lichfield Road (less vulnerable);
- A513 Kings Bromley Lane (less vulnerable);
- Shaw Lane Farm (more vulnerable);
- Far End cottage (more vulnerable);
- Crawley Lane (less vulnerable);
- Woodgate Farm Cottage (more vulnerable);
- The Smithy (more vulnerable);
- The Old Farmhouse (more vulnerable);
- three properties on the south-western side of Kings Bromley accessed from Lichfield Road (more vulnerable);
- properties located within Manor Park, a residential area on the western edge of Kings Bromley (more vulnerable);
- golf course located adjacent to Manor Park (water compatible);
- gravel pit excavations located to the west and north of Kings Bromley (water compatible);
- existing residential property also used as a cattery and boarding kennel located adjacent to gravel pitch excavation, accessed from A53 Rugeley Road (more vulnerable);
- Glebe Farm (more vulnerable);
- buildings associated with a small nature reserve (Spencers Plantation) (less vulnerable);
- properties along Osier Bed Lane (more vulnerable);
- Mavesyn nurseries (less vulnerable);

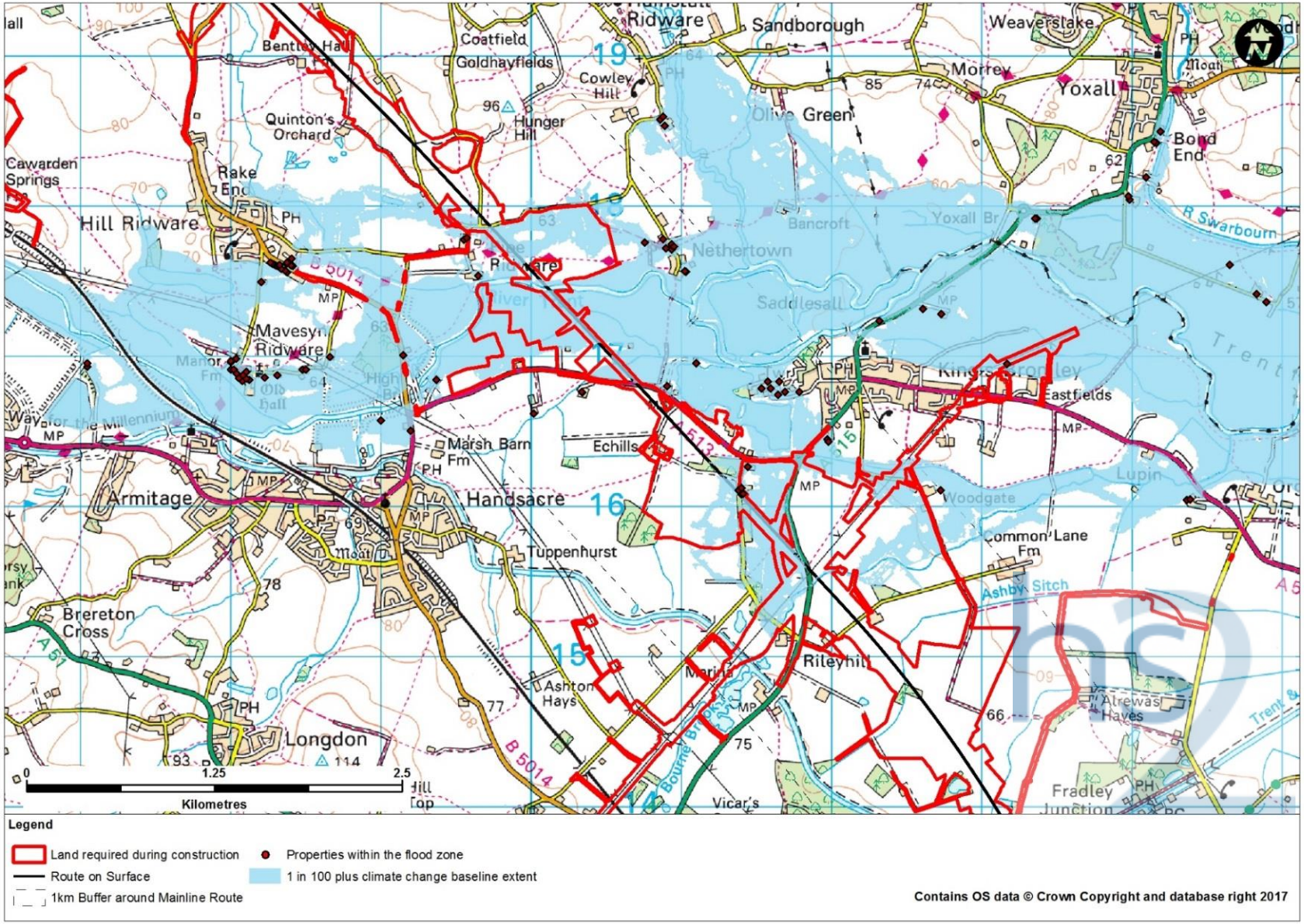
- Toll House (more vulnerable);
- Oak Farm (more vulnerable);
- B5014 Ridware Road (less vulnerable);
- Hall Farm at Pipe Ridware (more vulnerable);
- Littleton House Farm (more vulnerable);
- Pipe Lane (less vulnerable);
- a compound area owned by Severn Trent Water accessed off of Pipe Lane to the east of Hill Ridware (less vulnerable);
- Pipe Wood Lane (less vulnerable);
- property located off Pipe Wood Lane adjacent to the Luth Burn (more vulnerable);
- Brookhouse Farm (more vulnerable); and
- properties located at Nethertown (more vulnerable).

5.2.9 Buildings associated with 'The Smithy' and 'the Old Farmhouse' (more vulnerable receptors) are located within the modelled flood extent but are just outside the 1km buffer.

5.2.10 There are three licensed surface water abstractions and two licensed groundwater abstractions within the floodplain. The infrastructure associated with these abstractions is considered to be water compatible.

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

Figure 3: Extent of the modelled 1 in 100 (1%) plus climate change floodplain, River Trent at Kings Bromley

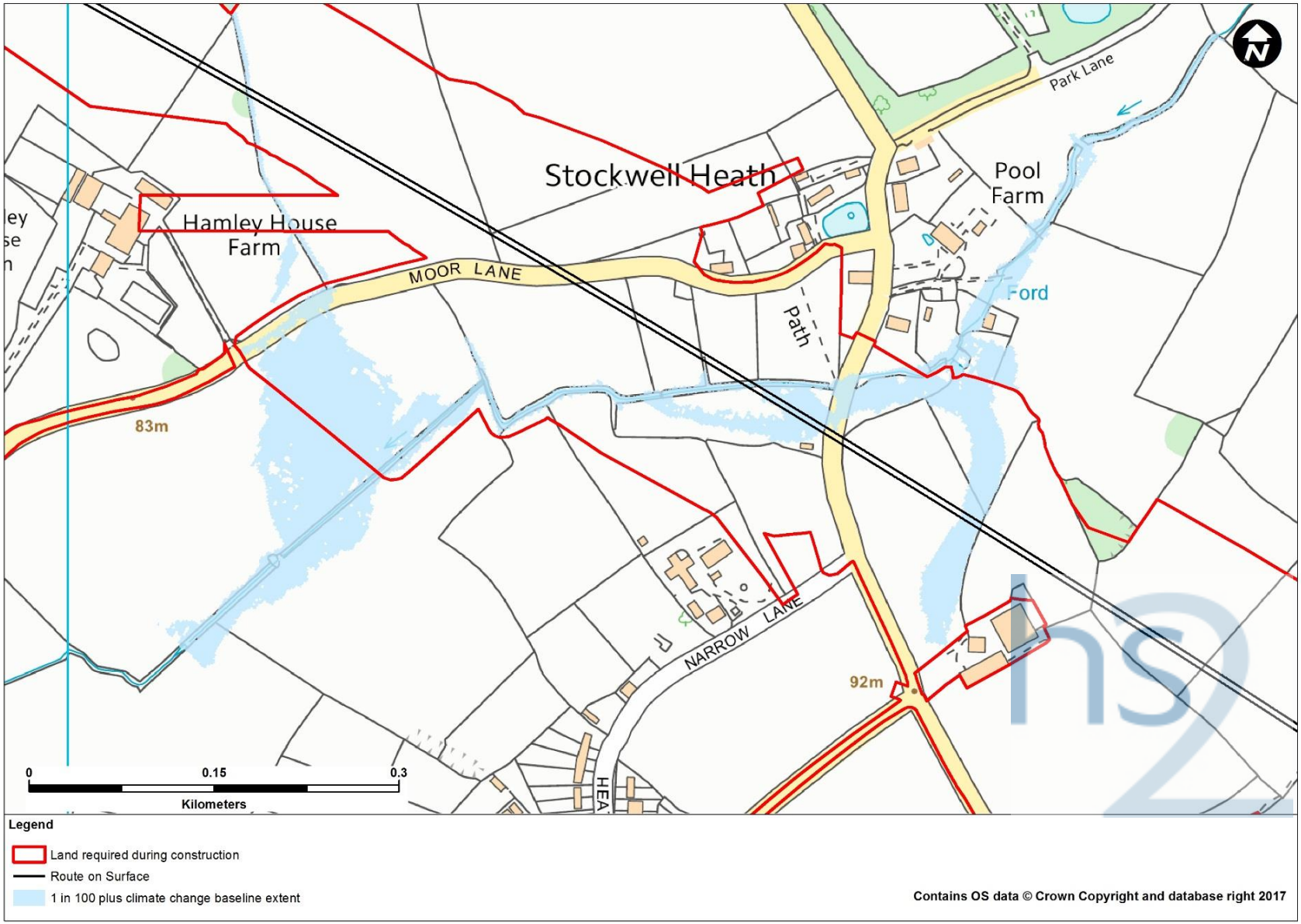


Moreton Brook tributary, Stockwell Heath

5.2.12 A 2D fluvial hydraulic model of a tributary of Moreton Brook, which flows through Stockwell Heath, has been developed to define the 1 in 100 (1%) annual probability flood extent including an allowance for climate change, as part of this study. This model was developed due to the complexity of the flood risk issues at this location and the proximity of a more vulnerable receptor. The results of this analysis are shown in Figure 4.and highlight that a property at Pool Farm, accessed off Newlands Lane (more vulnerable) and Newlands Lane itself (less vulnerable) are currently located within the flood zone, as defined in this study.

5.2.13 A climate change allowance of 50% increase in peak river flows has been adopted at this crossing.

Figure 4: Extent of the modelled 1 in 100 (1%) plus climate change floodplain, Moreton Brook tributary, Stockwell Heath



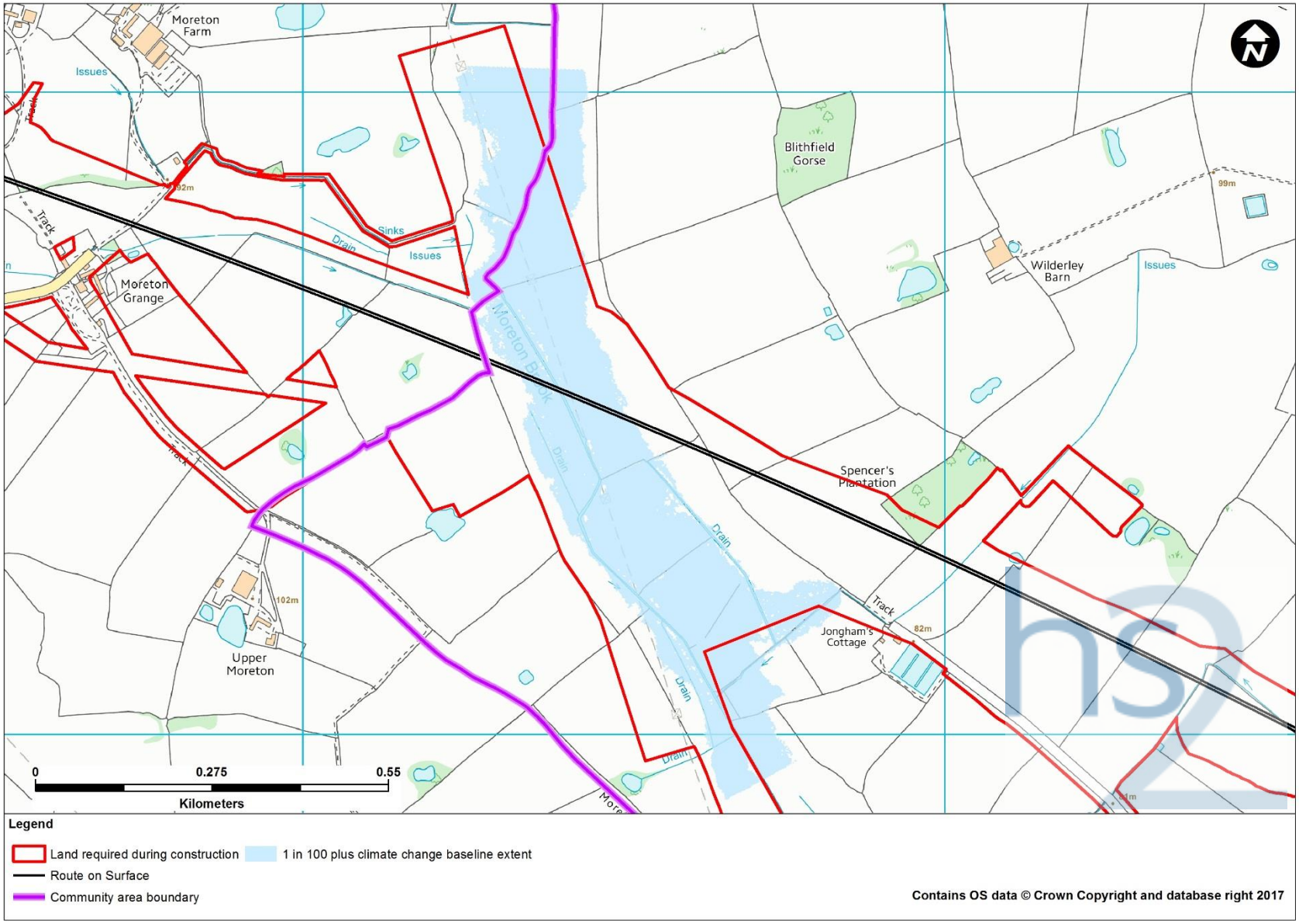
Moreton Brook

5.2.14 A 2D fluvial hydraulic model of the main channel of Moreton Brook has also been developed to define the 1 in 100 (1%) annual probability plus climate change flood extent. The results of this analysis are shown in Figure 5, which also indicates the receptors located within 1km of the Proposed Scheme.

5.2.15 All of the receptors located upstream and downstream of the Proposed Scheme within the 1 in 100 (1%) annual probability plus climate change flood extent associated with Moreton Brook can be characterised as undeveloped agricultural land and are therefore classified as less vulnerable.

5.2.16 A climate change allowance of 30% increase in peak river flows has been adopted at this crossing.

Figure 5: Flood risk associated with Moreton Brook



Other watercourses

5.2.17 Other ordinary watercourses located within the Fradley to Colton study area include:

- Ashby Sitch, located approximately 1km to the north-west of Pyford Brook, itself a tributary of Pyford Brook;
- three tributary watercourses of Bentley Brook (a tributary of the River Trent) in the vicinity of Blithbury. These channels flow in a south-easterly direction;
- a tributary of Moreton Brook which flows along and across the B5013 Uttoxeter Road in a south-westerly direction; and
- a tributary of Moreton Brook which flows in a south-westerly direction from an area in the vicinity of Wilderly Barn 500m to the north-west of the B5013 Uttoxeter Road.

5.2.18 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.

5.2.19 Figures 6 and 7 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:

- the B5014 Uttoxeter Road (less vulnerable) is affected by the tributary watercourse of Bentley Brook (a tributary of the River Trent) in the vicinity of Blithbury;
- the B5013 Uttoxeter Road, Jonghams Lane and an access road to Lount Farm (all less vulnerable) are all affected by the tributary of the Moreton Brook that passes under the B5013 Uttoxeter Road; and
- Jonghams Cottages (more vulnerable) and Jonghams Lane area affected by the tributary of Moreton Brook which flows in a south-westerly direction from an area in the vicinity of Wilderly Barn 500m to the north-west of the B5013 Uttoxeter Road.

5.2.20 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 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 6 and Figure 7 areas of undeveloped agricultural land are at risk from surface water flooding as well as the following receptors:

- the B5014 Uttoxeter Road (less vulnerable);
- Stonyford Lane (less vulnerable);

- Blithbury Road (less vulnerable);
- Hadley Gate (less vulnerable);
- Hadley Gate Field Farm (more vulnerable);
- Newlands Lane (less vulnerable);
- residential property at Pool Farm in Stockwell Heath (more vulnerable);
- Sherracop Lane (less vulnerable);
- the B5013 Uttoxeter Road (less vulnerable);
- the access road to Lount Farm from the B5013 Uttoxeter Road (less vulnerable);
- Jonghams Cottages (more vulnerable); and
- a building associated with properties located along the B5013 Uttoxeter Road near the Hamlet of Bellamour (more vulnerable) associated with a surface water flow path approximately 1km downstream of Moreton Brook.

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.

5.3.3 A summary of the baseline flood risk from surface water is provided in Table 4.

Figure 6: Surface water flood risk (southern extent of the study area)

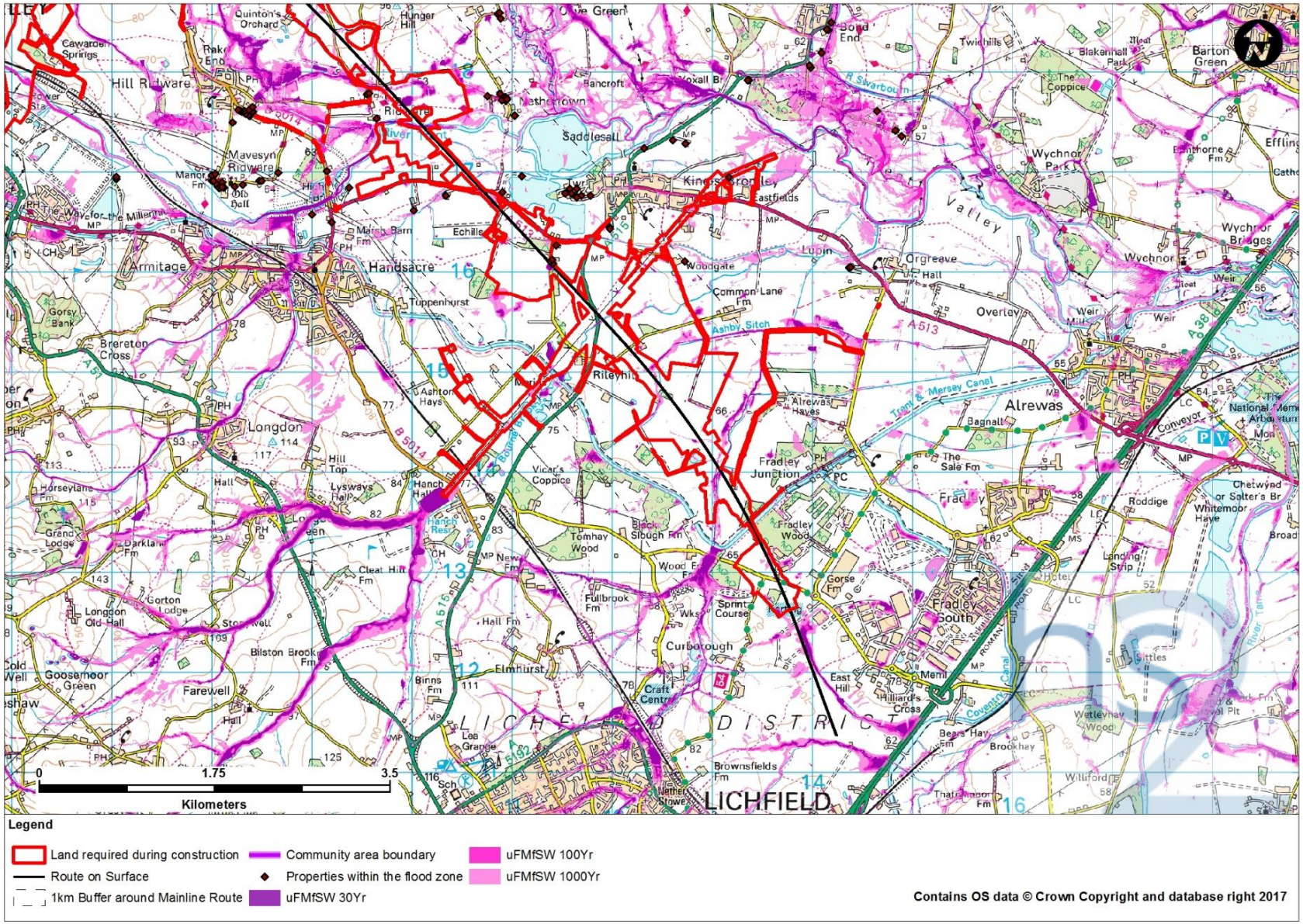
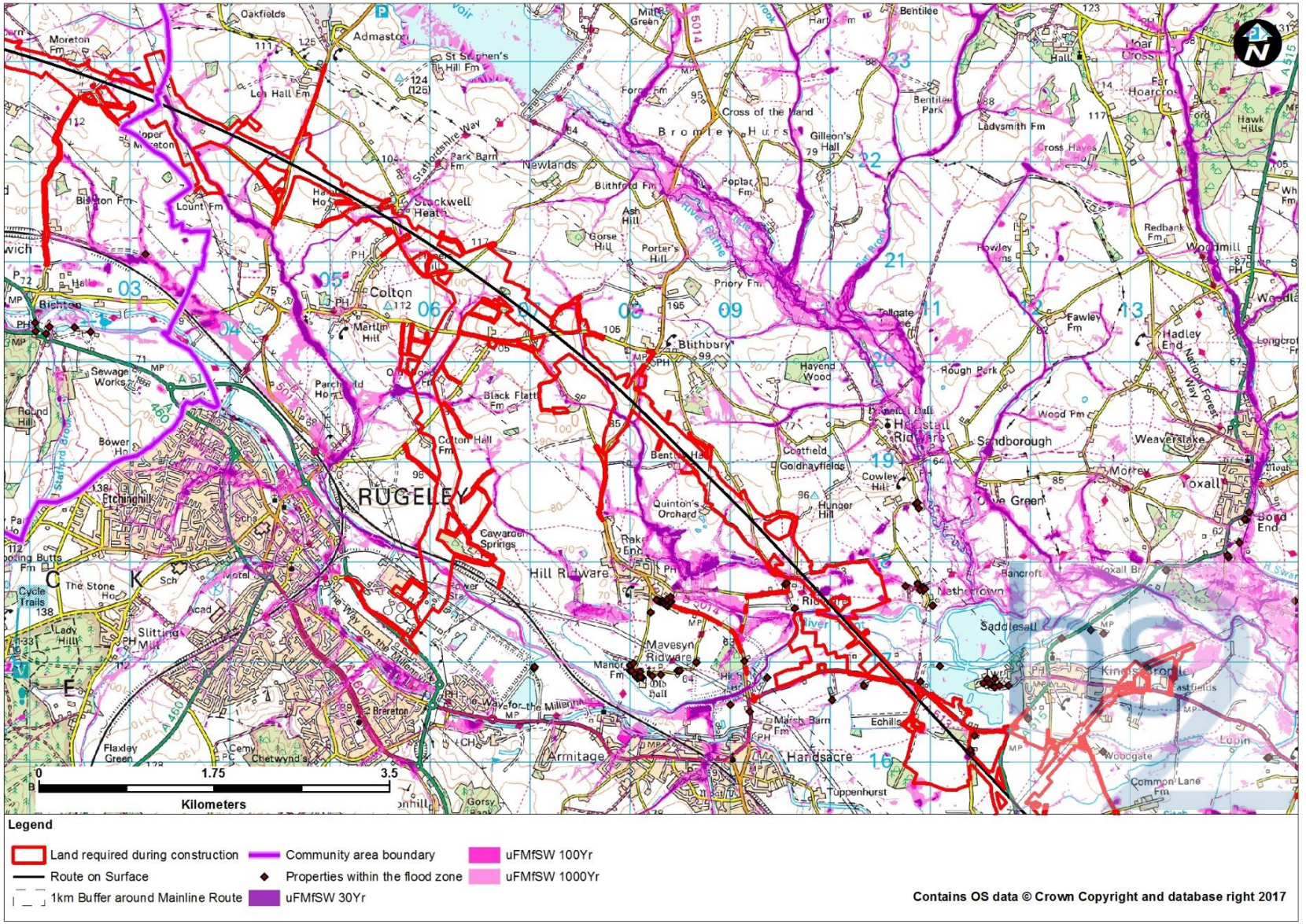


Figure 7: Surface water flood risk (northern extent of the study area)



5.4 Risks associated with groundwater

5.4.1 The AStGWF[16,] 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[16] map uses four susceptible 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 The AStGWF[16] at the southern end of the Proposed Scheme, up to Pipe Ridware, is classified as having the potential for groundwater flooding to occur at surface, associated with the River Trent floodplain. Between Pipe Ridware and Stockwell Heath, the route of the Proposed Scheme passes through smaller areas with limited potential for groundwater flooding to occur, potential for groundwater flooding of property situated below ground level, or potential for groundwater flooding to occur at surface, associated with areas of till or alluvium. Where superficial deposits are absent, the area is generally not considered to be prone to groundwater flooding.

5.4.3 The SFRA[7] 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 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:

- Blithfield Reservoir. This reservoir has a volume in excess of 25,000m^3 and as such it is shown on the Environment Agency's Flood risk from reservoirs mapping. This data set indicates that, in the event of a failure of the dam impounding Blithfield Reservoir, the River Trent floodplain in the vicinity of Kings Bromley would be affected by the resulting flood;
- the Trent and Mersey Canal, which passes through the Fradley to Colton study area; and
- major water supply pipelines and sewerage (foul and surface water) infrastructure has potential to cause flooding should it fail. However, this infrastructure is accounted for in the design of the Proposed Scheme, as shown in drawings, CT-05 and CT-06 available in the Volume 2 Map Book.

5.5.2 A summary of the baseline flood risk from artificial sources is provided in Table 4.

5.6 Summary of baseline flood risk

5.6.1 Table 4 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
Pyford Brook	Curborough Sewage treatment works (water compatible)	1 in 100 (1%) annual probability flood extent with allowance for climate change	Less vulnerable	30%
	Wood Lane (less vulnerable)			
	Trent and Mersey Canal (water compatible)			
River Trent and associated tributaries (Bourne Brook, Crawley Brook, Crawley Brook and Luth Burn)	Shaw Lane (less vulnerable)	1 in 100 (1%) annual probability flood extent with allowance for climate change	More vulnerable	50%
	A515 Lichfield Road (less vulnerable)			
	A513 Kings Bromley Lane (less vulnerable)			
	Far End cottage (more vulnerable)			
	Crawley Lane (less vulnerable)			
	Woodgate Farm Cottage (more vulnerable)			
	The Smithy (more vulnerable)			
River Trent and associated tributaries (Bourne Brook, Crawley Brook, Crawley Brook and Luth Burn)	The Old Farmhouse (more vulnerable)	1 in 100 (1%) annual probability flood extent with allowance for climate change	More vulnerable	50%
	Three properties on the south-western side of Kings Bromley accessed from Lichfield Road (more vulnerable)			

Source / Pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
	Properties located within Manor Park, a residential area on the western edge of Kings Bromley (more vulnerable)			
	Golf course located adjacent to Manor Park (water compatible)			
	Gravel pit excavations located to the west and north of Kings Bromley (water compatible)			
	Existing residential property also used as a cattery and boarding kennel located adjacent to gravel pitch excavation, accessed from A513 Rugeley Road (more vulnerable)			
	Glebe Farm (more vulnerable)			
	Buildings associated with a small nature reserve (less vulnerable)			
	Properties along Osier Bed Lane (more vulnerable)			
	Mavesyn nurseries (less vulnerable)			
River Trent and associated tributaries (Bourne Brook, Crawley Brook, Crawley Brook and Luth Burn)	Toll House (more vulnerable)	1 in 100 (1%) annual probability flood extent with allowance for climate change	More vulnerable	50%
	Oak Farm (more vulnerable)			
	B5014 Uttoxeter Road (less vulnerable)			

Source / Pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
	Hall Farm at Pipe Ridware (more vulnerable)			
	Littleton House Farm (more vulnerable)			
	Pipe Lane (less vulnerable)			
	A compound area owned by Severn Trent Water accessed off of Pipe Lane to the east of Hill Ridware (less vulnerable)			
	Pipe Wood Lane (less vulnerable)			
	Property located off Pipe Wood Lane adjacent to the Luth Burn (more vulnerable)			
	Brookhouse Farm (more vulnerable)			
	Properties located at Nethertown (more vulnerable			
Moreton Brook	Agricultural land (less vulnerable)	1 in 100 (1%) annual probability flood extent with allowance for climate change	Less vulnerable	30%
Ashby sitch	Trent and Mersey Canal (water compatible)	uFMfSW 1 in 100 (1%) annual probability flood	Less vulnerable	40%

Source / Pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
Tributaries of the Bentley Brook	B5014 Uttoxeter Road (less vulnerable)	uFMfSW 1 in 100 (1%) annual probability flood	Less vulnerable	40%
Tributary of Moreton Brook at B5013 Uttoxeter Road	B5013 Uttoxeter Road (less vulnerable)	uFMfSW 1 in 100 (1%) annual probability flood	Less vulnerable	40%
	Jonghams Lane (less vulnerable)			
	Access road to Lount Farm from the B5013 Uttoxeter Road (less vulnerable) (less vulnerable)			
Tributary of Moreton Brook from Wilderley Barn	Jonghams Cottages (more vulnerable)	uFMfSW 1 in 100 (1%) annual probability flood	More vulnerable	40%
Surface water	B5014 Uttoxeter Road (less vulnerable	uFMfSW 1 in 100 (1%) annual probability flood	More vulnerable	40%
	Stonyford Lane (less vulnerable)			
	B5013 Uttoxeter Road (less vulnerable)			
	Blithbury Road (less vulnerable)			
	Hadley Gate (less vulnerable)			

Source / Pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
	Hadley Gate Field Farm (more vulnerable)			
	Residential property at Pool Farm in Stockwell Heath (more vulnerable)			
	Sherracop Lane (less vulnerable)			
	Newlands Lane (less vulnerable)			
	B5013 Uttoxeter Road (less vulnerable)			
	Jonghams Cottages (more vulnerable)			
	Jonghams Lane (less vulnerable)			
	Access road to Lount Farm from the B5013 Uttoxeter Road (less vulnerable) (less vulnerable)			
	A building associated with properties located along the B5013 Uttoxeter Road near the Hamlet of Bellamour (more vulnerable)			
	Agricultural land and woodland (less vulnerable			
Blithfield reservoir, water utilities	Kings Bromley (from Blithfield reservoir)	EA flood risk from reservoirs data set	More vulnerable	n/a
Trent and Mersey Canal,	Agricultural land near Fradley	Ordnance survey mapping	More vulnerable	n/a

Source / Pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
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 Flood risk impacts and effects

6.1 Rivers and ordinary watercourses

Viaducts

6.1.1 The Proposed Scheme within the Fradley to Colton area includes crossings of four watercourses on viaducts; Pyford Brook, Bourne Brook, River Trent and Moreton Brook. 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.

Pyford Brook

6.1.3 As shown in Figure 8 the impact of Pyford Brook viaduct is likely to cause localised changes in peak flood level of less than 50mm. This impact would affect undeveloped farmland within the floodplain. As such it would be a minor impact affecting a moderate value receptor and so is a minor adverse effect, which is not significant.

6.1.4 An area of compensatory storage has been identified at this location to address the loss of floodplain caused by the intermediate piers in the floodplain. This will ensure that there is no net loss of floodplain storage at this location. Further topographical survey, hydraulic modelling, including incorporation of the floodplain compensatory storage, and design development will be undertaken at the detailed design stage with the aim of mitigating these localised impacts on peak flood level.

Bourne Brook and Crawley Brook

6.1.5 The Bourne Brook viaduct also spans Crawley Brook. As indicated on Figure 9, the viaduct piers will cause a local change in peak flood level of up to 50mm. This is considered a minor impact affecting a moderate value receptor and so is a minor adverse effect, which is not significant.

6.1.6 The Proposed Scheme also includes realignments of the A515 Lichfield Road and Shaw Lane at this location, together with associated culverts within Bourne Brook floodplain. Figure 9 indicates that the A515 Lichfield Road realignment may cause an increase in peak flood level in excess of 100mm at and directly adjacent to the realigned highway. This is considered a major impact affecting a moderate value receptor and so is considered a moderate adverse effect, which is significant.

6.1.7 An area of compensatory storage has been identified to address the loss of floodplain caused by the intermediate piers in the floodplain and the topographical changes caused by the A515 Lichfield Road realignment. This will ensure that there is no net loss of floodplain storage at this location. Further topographical survey, hydraulic modelling, including incorporation of the floodplain compensatory storage, and design development will be undertaken at the detailed design stage with the aim of mitigating these localised impacts on peak flood level.

Figure 8: Post development flood risk at Pyford Brook

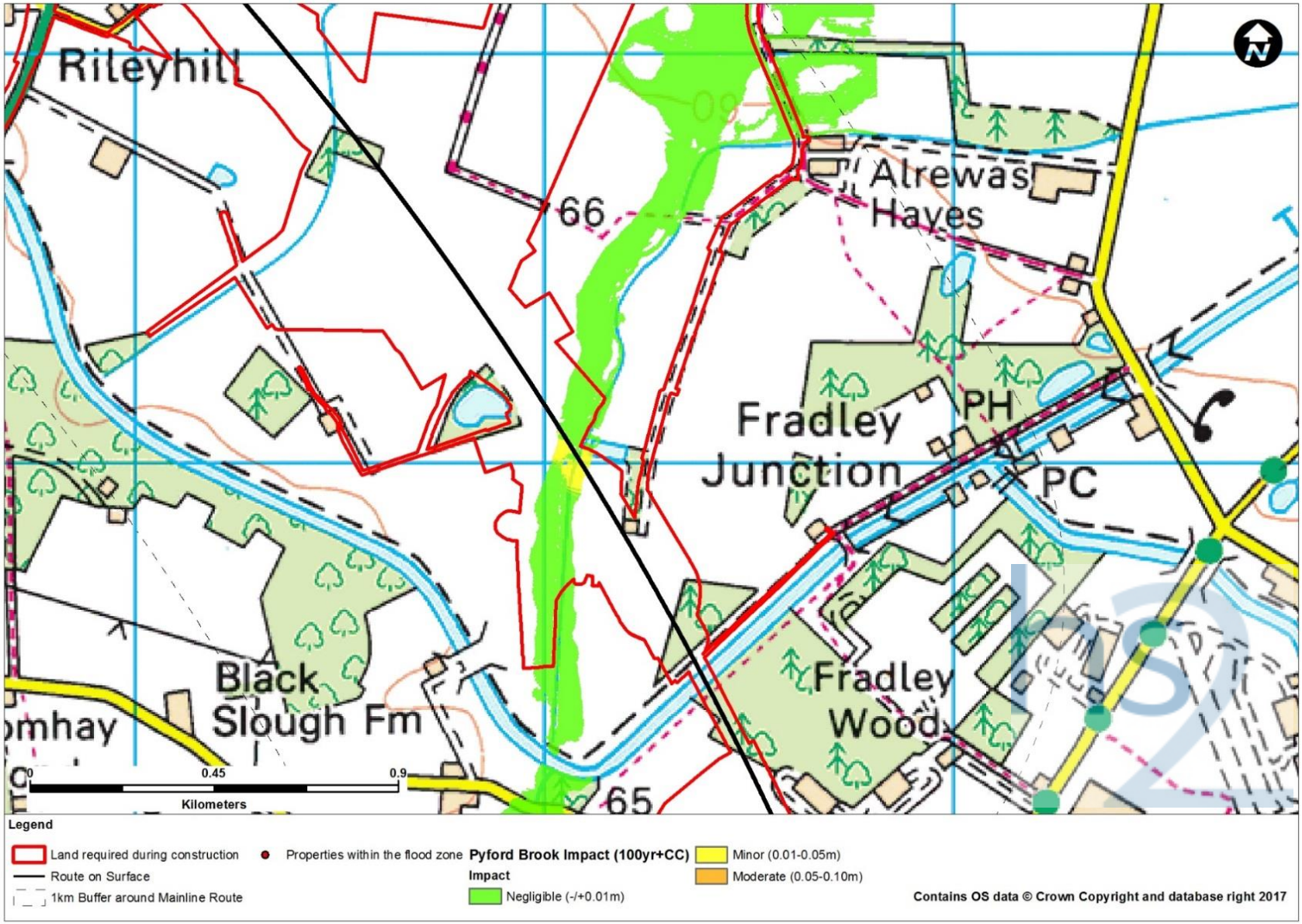
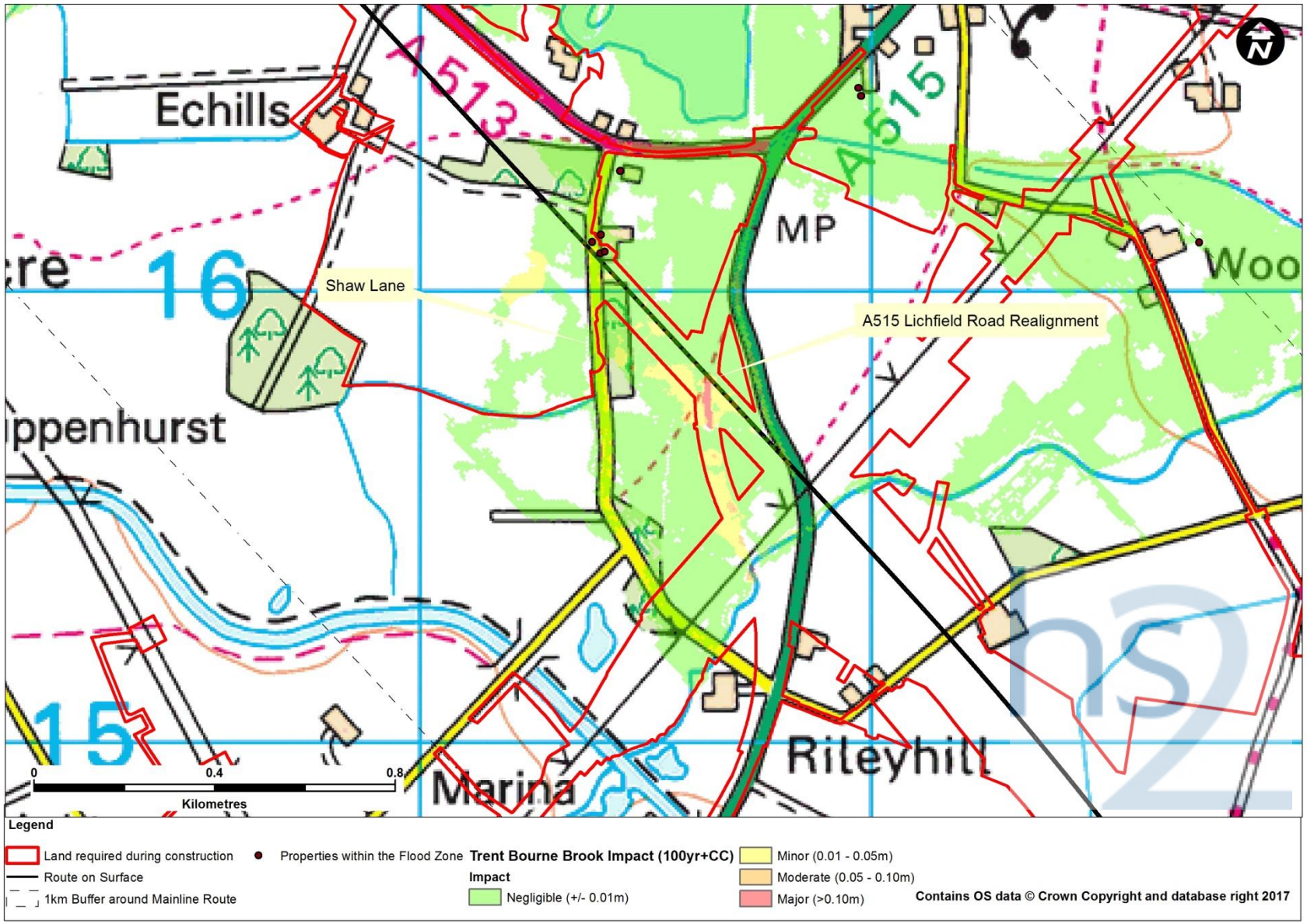


Figure 9: Post development flood risk on Bourne Brook and Crawley Brook at Kings Bromley



River Trent

6.1.8 The impact of the proposed River Trent viaduct crossing is shown in Figure 10. The viaduct also spans the Luth Burn and three ordinary watercourse channels located within the floodplain.

6.1.9 Figure 10 indicates that the viaduct piers will cause a local change in peak flood level of less than 50mm. This is considered a minor impact affecting a moderate value receptor and so is a minor adverse effect, which is not significant.

6.1.10 Figure 10 also indicates a change in peak flood levels at Hall Farm in close proximity to the northern abutment of the River Trent viaduct. These changes are associated with proposed landscape mitigation, which have the potential to alter the hydraulic performance of existing overland flow paths.

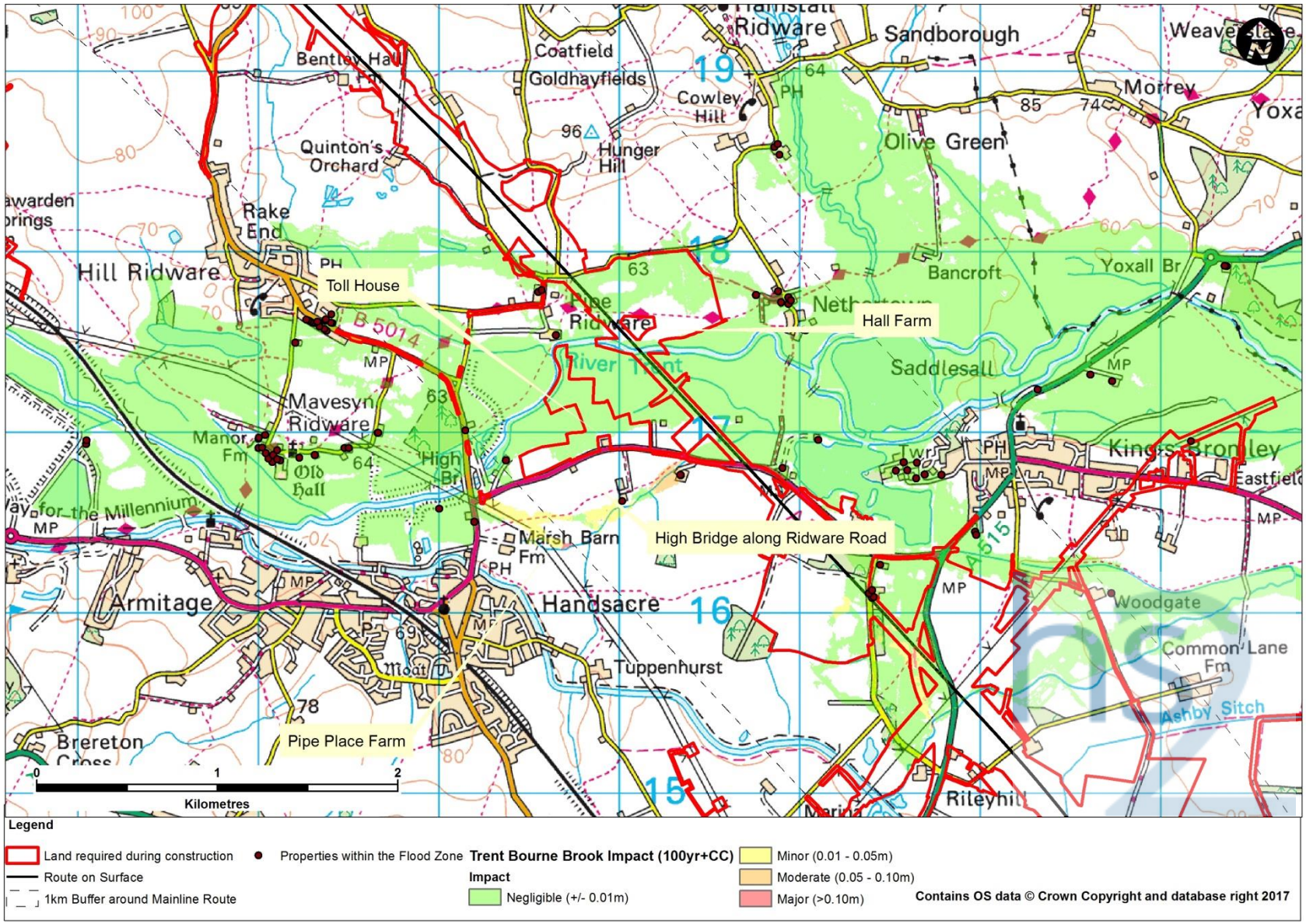
6.1.11 The change in peak flood level at Hall Farm is up to 50mm affecting an agricultural building, which is a moderate value receptor. Residential properties are not affected. This is considered a minor impact leading to a minor adverse effect, which is not significant. The other changes in peak flood level in the area near Hall Farm are less than 10mm.

6.1.12 Figure 10 indicates an area to the east of the Proposed Scheme, in the vicinity of High Bridge, along Ridware Road, where peak water levels will increase by up to 50mm. One residential property (Toll House) within the 1km buffer and a residential property (Pipe Place Farm) located outside the 1km buffer will also be affected. These residential properties are more vulnerable receptors and so the effect will be a moderate adverse effect, which is significant.

6.1.13 The changes in peak flood level in this area are a function of model sensitivity which in itself is related to the limitations of the modelling. This is discussed in greater detail in the hydraulic modelling report (see BID[1]).

6.1.14 An area of compensatory storage has been identified to address the loss of floodplain caused by the intermediate piers in the River Trent floodplain. This will ensure that there is no net loss of floodplain storage at this location.

Figure 10: Post development flood risk on the River Trent at Kings Bromley



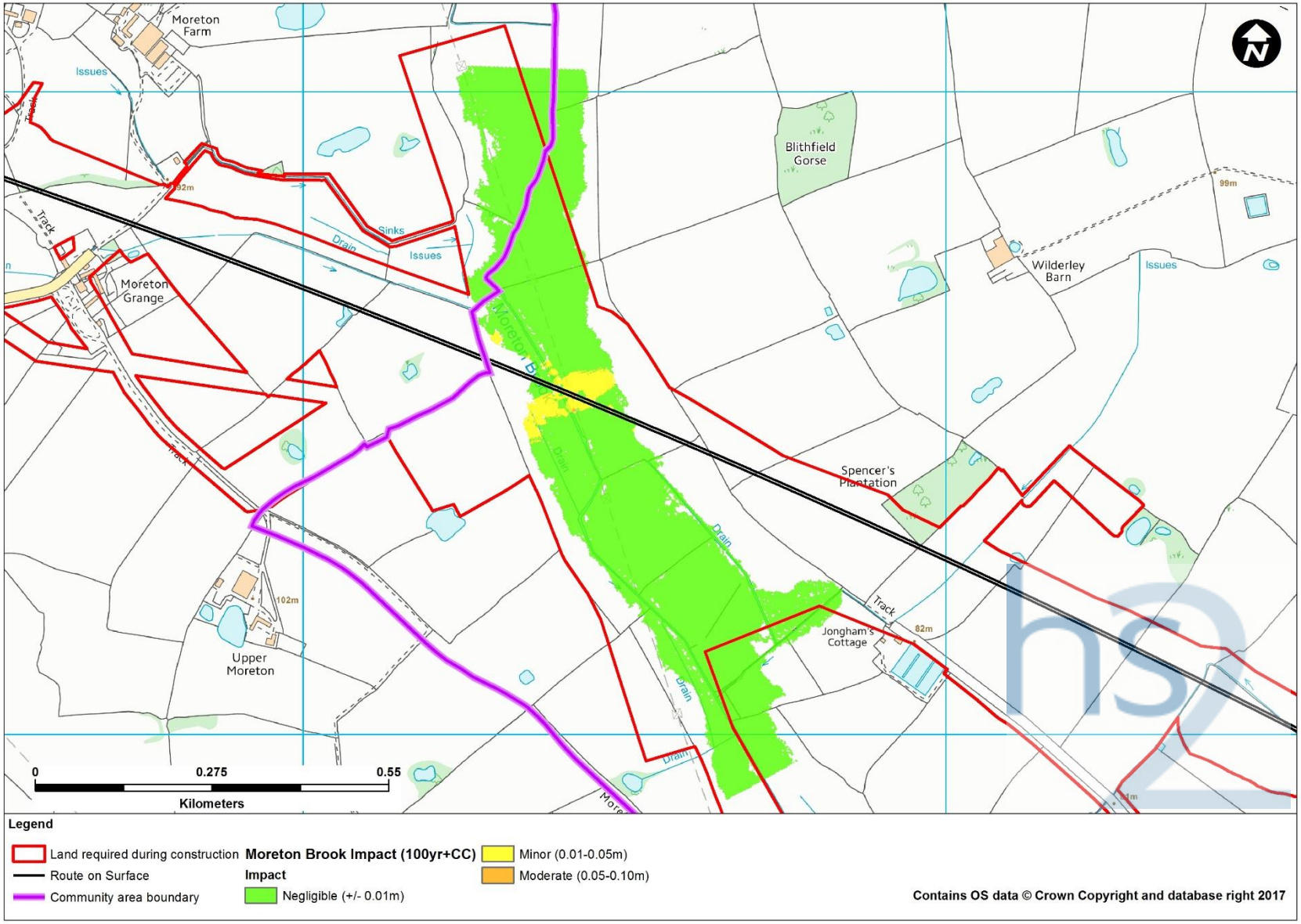
Moreton Brook

6.1.15 The impact of the proposed Moreton Brook viaduct crossing is shown in Figure 11.

6.1.16 Figure 11 indicates that the viaduct piers will cause a local change in water level of up to 50mm. Based on the assessment methodology this is considered a minor impact affecting a moderate value receptor and so is a minor adverse – not significant effect.

6.1.17 An area of compensatory storage has been identified at this location to address the loss of floodplain caused by the placement of the intermediate piers in the floodplain. This will ensure that there is no net loss of floodplain storage at this location.

Figure 11: Post development flood risk at Moreton Brook



Culverts and channel diversions

6.1.18 The Proposed Scheme will culvert a tributary watercourse of the Moreton Brook in the vicinity of Stockwell Heath. Newlands Lane is to be realigned under the proposed route, affecting the existing culvert. Moor Lane is to be diverted, which will also require a culvert crossing. On the basis of the number of design features affecting the watercourse, and the proximity of sensitive receptors, a fluvial and surface water hydraulic model of this watercourse has been developed.

6.1.19 The modelled impact of the Proposed Scheme on peak flood levels is shown in Figure 12. This indicates the potential for localised changes in peak flood level in excess of 100mm at three specific locations:

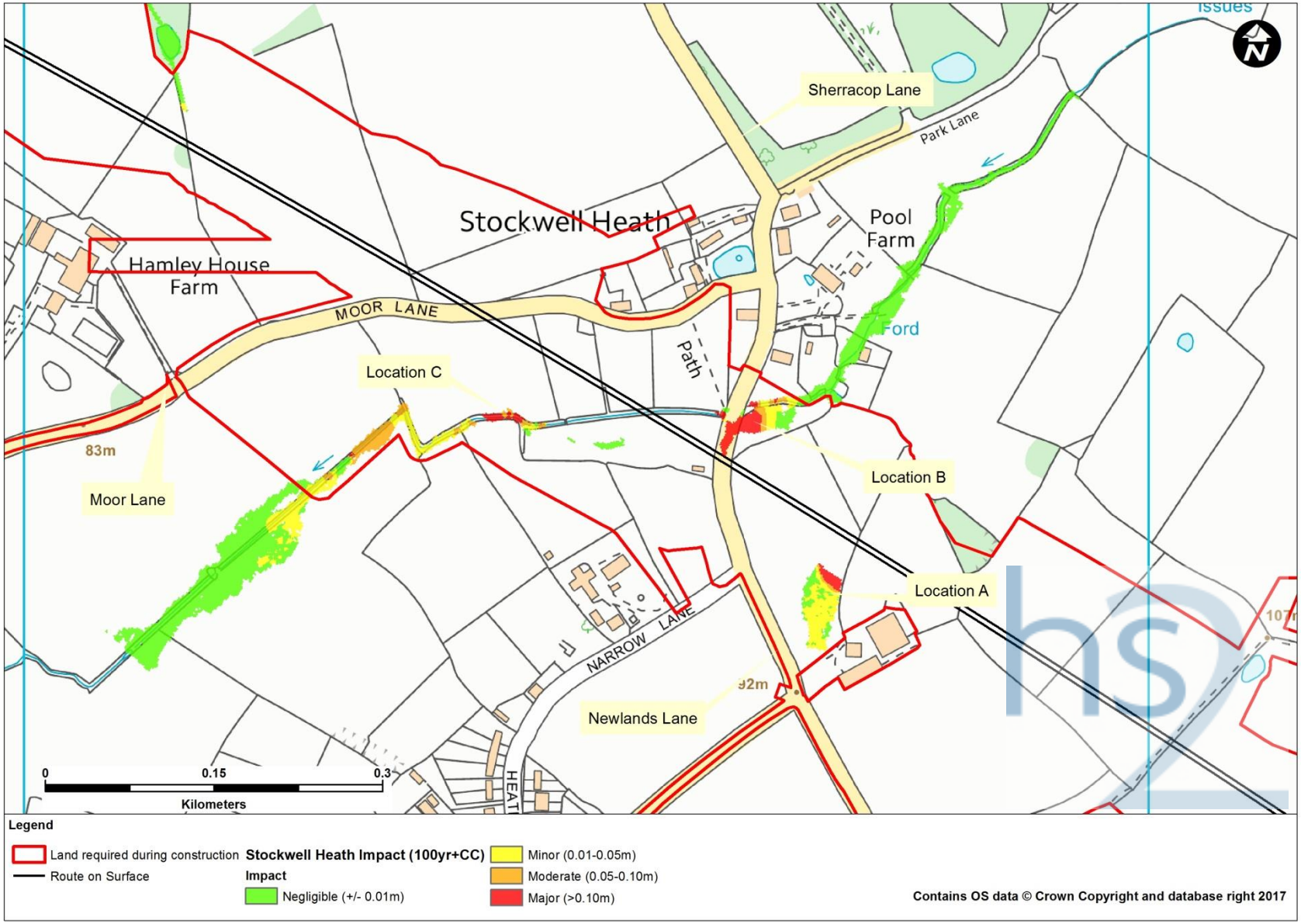
- 60m east of Newlands Lane (Location A on Figure 12);
- at Newlands Lane (Location B on Figure 12); and
- approximately 120m to the west of the Proposed Scheme (Location C on Figure 12).

6.1.20 A new perimeter drainage feature is proposed at Location A. Whilst increases in the peak flood level are predicted, the floodwater would be contained within the new channel, such that there would be negligible impacts on flood risk.

6.1.21 At Location B the predicted increases in peak flood level are caused by the proposal to raise Newlands Road. Given that Newlands Road is the only receptor potentially affected, and the depth of flooding on the road will be reduced as a consequence of the road raising operation, the Proposed Scheme will actually have a beneficial impact on flood risk at this location.

6.1.22 At Location C the change in peak flood level is restricted to a small section of the existing channel. No receptors would be affected. This is considered to be a minor impact on a low vulnerability (water compatible) receptor resulting in a negligible effect, which is not significant.

Figure 12: Post development flood risk at Stockwell Heath



6.1.23 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[15]. Therefore, the uFMfSW[3] data set has been used to indicate the potential flood extent generated and the receptors affected along these watercourses.

6.1.24 At the locations where these ordinary watercourses cross the Proposed Scheme culverts are required to convey the water under the route. 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 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.

6.1.25 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)
Ashby Sitch	Ashby Sitch culvert	0.39	20	1.35x1.35	1.41
Tributary of the Bentley Brook	Blithbury drop inlet culvert	2.24	40%	3x1.35	4.00
Tributary of the Bentley Brook	Blithbury West drop inlet culvert	3.89	40%	4x1.35	5.70
Tributary of the Moreton Brook at B5013 Uttoxeter Road	Hamley South	1.35	40%	1.35x1.35	2.36
Tributary of the Moreton Brook from Wilderley Barn	Hamley North drop inlet culvert	1.38	20%	1.35x1.35	1.99

6.1.26 By following this design approach the flood risk to the receptors identified will be unchanged.

6.1.27 Each of the ordinary watercourse crossings in Table 5 is associated with a channel realignment to reduce the length of culvert required as far as is reasonably practicable. The ordinary watercourses identified are also affected by highway diversions and permanent access requirements at the following locations:

- B5014 Uttoxeter Road affecting a tributary of Bentley Brook (channel appears to be culverted in baseline condition);
- Blithbury Road realignment affecting the upstream section of a tributary of the Bentley Brook that crosses the proposed route at Blithbury West drop inlet culvert;
- realignment of Newlands Lane and Moor Lane diversion affecting the tributary of Moreton Brook in Stockwell Heath. However, the arrangement of the culverts and the associated flood risk have already been discussed;
- B5013 Uttoxeter Road affecting the tributary of the Moreton Brook that crosses the proposed route at Hamley (south) culvert; and
- changes to Jonghams Lane affecting tributaries of the Moreton Brook crossed by the proposed route at Hamley (south) culvert and Hamley (north) drop inlet culvert.

6.1.28 In addition, a surface water drain located along Stonyford Lane that feeds into the Bentley Brook will have to be realigned in association with the proposed highway diversion. The sizing of this feature will based on its existing dimensions.

6.1.29 The diverted and realigned channels will have the same hydraulic capacity as the existing channel unless it is identified at the detailed design stage that a change in size would be beneficial in flood risk terms. The design of the channels will follow the procedures outlined above for culverts, with the aim of ensuring that there are no significant impacts on flood risk.

6.2 Surface water

6.2.1 As outlined previously the uFMfSW[3] 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 not 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 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 characterises of the local area will 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 Woodhouse Farm	Woodhouse culvert	0.51	40%	1.35x1.35	1.41
Surface water flow path draining area Hurstwood Pit	Hurstwood drop inlet culvert	0.80	40%	1.35x1.35	1.41
Surface water flow path that drains the area around Finners Hill	Finners culvert	2.43	20%	1.5x1.35	3.21

6.2.5 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.

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.

6.3.3 There are four borrow pits proposed in the Fradley to Colton area, all within the River Terrace Deposits or Glaciofluvial Deposits Secondary A aquifer. The 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 lower permeability than the existing material. The restoration plans will include land drainage measures. These will be designed in detail following ground investigation and monitoring to ensure no overall increase in groundwater flood risk.

6.3.4 The assessment has shown that there are no other features of the Proposed Scheme in the Fradley to Colton 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

6.4.1 Blithfield Reservoir is a reservoir with a volume in excess of 25,000m^3 and as such it is shown on the Environment Agency's Flood risk from reservoirs mapping[3]. This data set indicates that in the event of a failure of this asset, the River Trent floodplain area in the vicinity of Kings Bromley will be affected by the resulting flood. However, as this is a large raised reservoir, subject to the requirements of reservoir safety legislation[17], 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.

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

6.4.3 The Trent and Mersey canal is located in the Fradley to Colton study area. However, the Proposed Scheme does not include any activities which could affect the flood risk posed by the canal network nor does the canal network pose any risk to the Proposed Scheme.

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

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 flood, with an allowance for climate change, as set out in Section 3.

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 all impacts on peak flood level being mitigated as far as is reasonably practicable.

7.1.2 The detailed hydraulic analysis of Bourne Brook (and tributaries) and the River Trent at Kings Bromley indicates that the Proposed Scheme has potential to lead to moderate adverse significant effects at these locations. If the updated models continue to indicate a potential for increases in flood risk at these locations, localised refinement of the design may be required in order to distribute floodwater in a manner that better replicates existing patterns of flooding.

7.1.3 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 would also be consulted. 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 The potential for moderate adverse significant effects related to flood risk has been identified at two locations:

- approximately 1km upstream of the River Trent viaduct at High Bridge, along Ridware Road, where peak water levels will increase by up to 50mm. This has potential to adversely affect Toll House and Pipe Place Farm; and
- in the vicinity of the proposed A515 Lichfield Road realignment.

8.1.2 The additional measures outlined in Section 7 will focus on ensuring that these localised effects are mitigated to as low a level as is reasonably practicable.

9 Conclusions

9.1.1 The analysis undertaken indicates that the viaduct crossings of Pyford Brook, Bourne Brook (and tributaries) and Moreton Brook will potentially result in minor adverse effects related to flood risk at these watercourse crossings. Whilst these are not significant, consideration will be given to how impacts on peak flood levels could be reduced as far as is reasonably practicable as the detailed design proceeds.

9.1.2 The hydraulic analysis indicates a minor beneficial effect, due to a reduction in peak flood depths along the realigned Newlands Road, at Stockwell Heath.

9.1.3 Potentially significant adverse changes in flood risk have been identified approximately 1km upstream of the River Trent viaduct at High Bridge, along Ridware Road and in the vicinity of the A515 Lichfield Road realignment within the Bourne Brook floodplain. The additional flood risk management measures identified in this assessment will focus on addressing these issues at the detailed design stage.

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 (2012), *National Planning Policy Framework.*

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

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.

HS2 Ltd (2017), High Speed Two (HS2) Phase 2a (West Midlands – Crewe), HS2, Appraisal of Sustainability. Available online 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.

HS2 Ltd (2017), High Speed Two (HS2) Phase 2a (West Midlands – Crewe), Background Information and Data, *CA1: Fradley to Colton, Hydraulic modelling report – Pyford Brook* (BID WR- 004-001). Available online at: www.gov.uk/hs2.

HS2 Ltd (2017), High Speed Two (HS2) Phase 2a (West Midlands – Crewe), Background Information and Data, *CA1: Fradley to Colton, Hydraulic modelling report – River Trent and Bourne Brook* (BID WR- 004-002). Available online at: www.gov.uk/hs2.

HS2 Ltd (2017), High Speed Two (HS2) Phase 2a (West Midlands – Crewe), Background Information and Data, *CA1: Fradley to Colton, Hydraulic modelling report – Moreton Brook* (BID WR- 004-003). Available online at: www.gov.uk/hs2.

HS2 Ltd (2017), High Speed Two (HS2) Phase 2a (West Midlands – Crewe), Background Information and Data, *CA1: Fradley to Colton, Hydraulic modelling report – Stockwell Heath* (BID WR- 004-004). Available online at: www.gov.uk/hs2.

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

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

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

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