E136

High Speed Rail (West Midlands - Crewe)

Environmental Statement

Volume 5: Technical appendices

CA3: Stone and Swynnerton

Flood risk assessment (WR-003-003)

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 Stone to Swynnerton area (CA3), 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 of:

- Hydraulic modelling report – Filly Brook (Background Information and Data: BID-WR-004-007); and
- Hydraulic modelling report – Meece Brook (Background Information and Data: BID-WR-004-008).

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 Stone and Swynnerton area. Temporary works have not been assessed unless they are of a significant scale compared with 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,* www.gov.uk/hs2

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

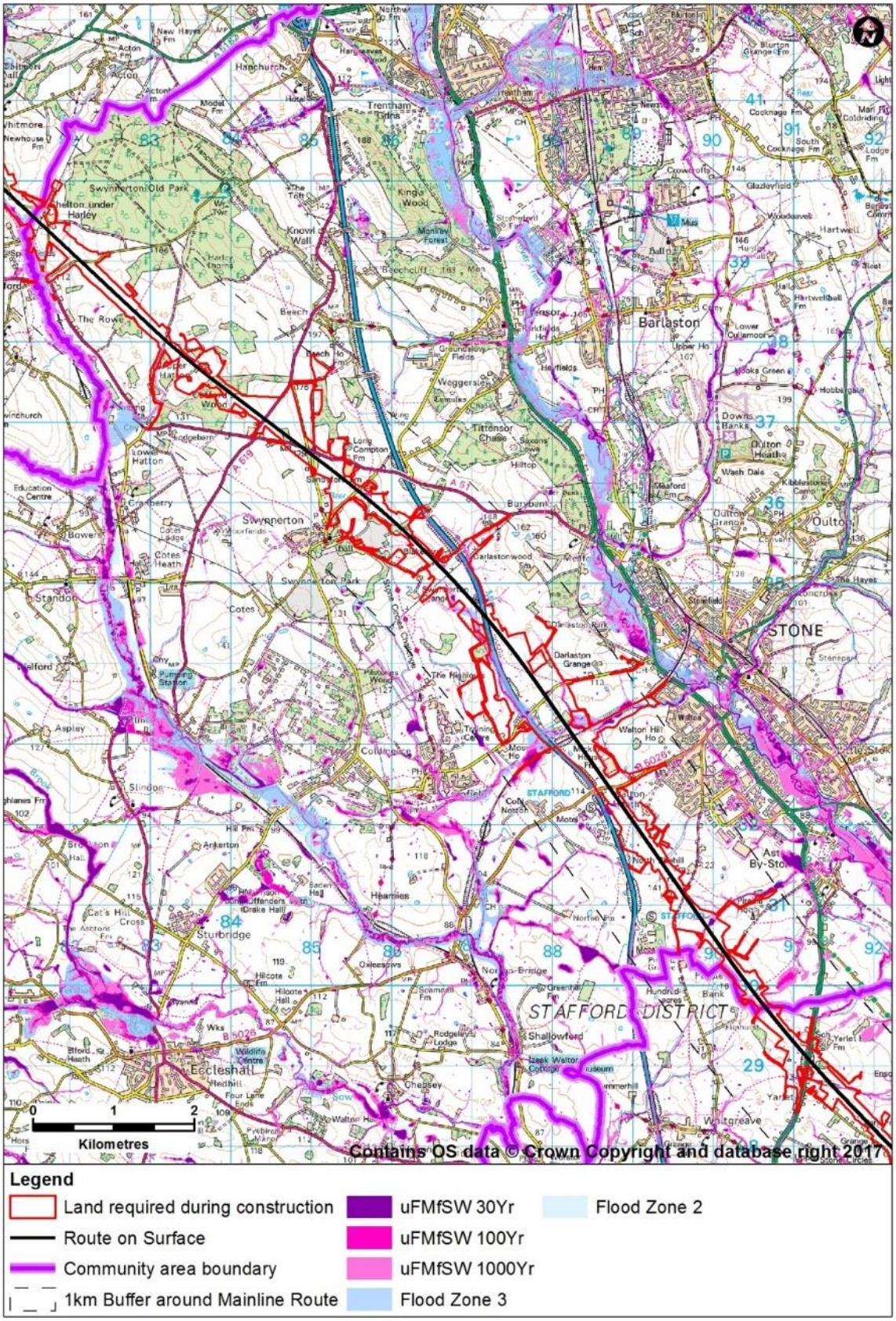
1.3.1 The location and extent of the study area is shown in Figure 1. The study area extends 1km from the centreline of the route of the Proposed Scheme. All flood risk receptors have been identified within these limits. If modelling assessments identified potential impacts beyond these limits, the study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

1.3.2 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 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 Stone and Swynnerton 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) Stoke-on-Trent City Council and Newcastle-under-Lyme Borough Council have produced a Strategic Flood Risk Assessment that cover their administrative boundaries[7,8]. The key flood risk objectives outlined in these SFRAs are to: seek flood risk reduction through spatial planning and site design, reduce surface water runoff from new developments and agricultural land, enhance and restore the river corridor, protect and promote areas for future flood alleviation schemes and improve flood awareness and emergency planning. The Proposed

[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] Halcrow (2008), *Stoke-on-Trent Strategic Flood Risk Assessment*
[8] Halcrow (2008), *Newcastle-under-Lyme Strategic Flood Risk Assessment*

Scheme design has sought to align with these objectives where reasonably practicable.

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 of Sustainability[9] 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 without increasing flood risk.

3.4.2 A minimum of 600mm freeboard above the 1 in 100 (1%) annual probability plus climate change design flood 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 design flood 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 as far as is reasonably practicable. 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.

[9] 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 wherever practicable to ensure access to riverbanks for inspection and maintenance purposes. Piers have been set eight metres back from the bank top, wherever reasonably practicable.

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 flood, with an allowance for climate change.

3.8 Climate change allowance

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[10]. The details of how this guidance should be applied in practice to the Proposed Scheme, as outlines below, 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 Stone and Swynnerton 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

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

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 each receptor has then been classified using Table 2 of the planning practice guidance on flood risk and coastal change, which is aligned 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.

[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.

3.8.7 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

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

H++ scenarios

3.8.9 This extreme scenario represents a credible upper limit to the changes that could potentially occur beyond the end of this century. Sensitivity analysis 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 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, CIRIA Publication C624 'Development and flood risk: guidance to the construction industry' and the Design Manual for Roads and Bridges (DMRB)[13]. 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)[14] 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)[15] 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'[14]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 (OS) mapping information and address point data. Receptor vulnerability is based on the definitions in Table 52 of the SMR, which is aligned with Table 2 of the planning practice guidance on flood risk and coastal change.

[13] Highways Agency, Design for Roads and Bridges, http://www.standardsforhighways.co.uk/ha/standards/dmrb/
[14] Gov.uk, *Flood map for planning*, https://flood-map-for-planning.service.gov.uk//
[15] 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
[16] British Geological Survey, *Susceptibility to groundwater flooding*, http://www.bgs.ac.uk/products/hydrogeology/groundwaterFlooding.htm

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 below, 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 very few detailed records of flooding available for the Stone and Swynnerton area. The PRFA and SFRA provide high level regional examples of historic flood flooding, but little dates relating to specific events. The SFRA indicates an historic fluvial flooding event at Meece Brook at Stableford, located approximately 500m to the east of the route within the community area. Recent flood events experienced within the Borough of Stafford area (between 2000 and 2010) are also detailed. These largely refer to surface water flooding incidents, but also include reference to the significant flood event of summer 2007, wherein 'the entire Stafford Borough area is reported to have been affected by a combination of pluvial and fluvial flooding from prolonged rainfall'.

5.2 Risks associated with rivers and ordinary watercourses

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

- Filly Brook to the west of Stone, and
- Meece Brook to the south of Whitmore.

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.

Filly Brook

5.2.3 A 2D hydraulic model of Filly 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 and their vulnerability located downstream (to the east) of the Proposed Scheme where it crosses Filly Brook are listed below:

- Stone Golf Club (water compatible);
- Filly Brook Pump house (water compatible); and
- Norton Bridge to Stone Railway (essential infrastructure).

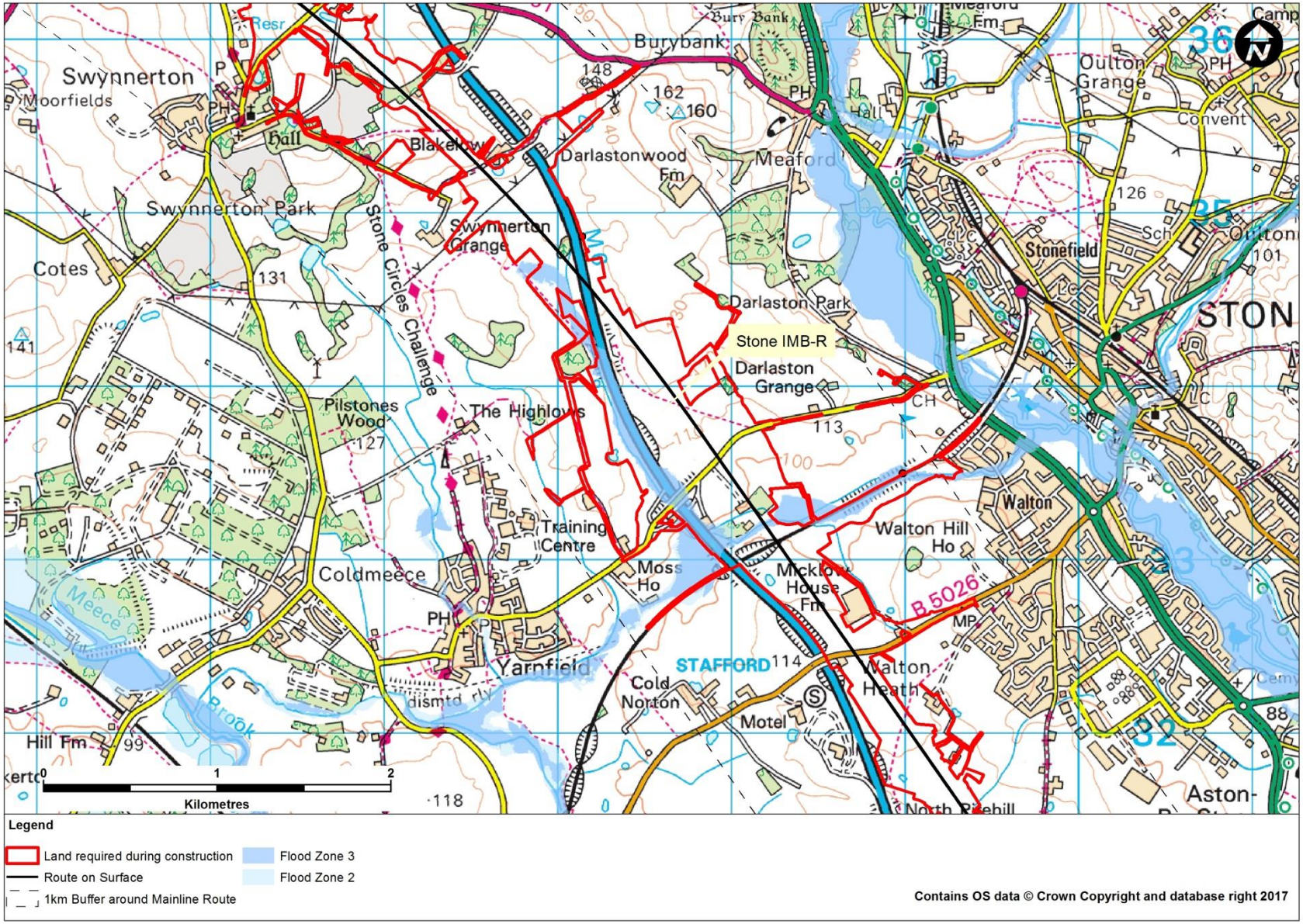
5.2.5 The receptors and their vulnerability located downstream (to the south) of the Proposed Scheme where it crosses Meece Brook are listed below:

- Agricultural land (less vulnerable);
- Stableford caravan park (highly vulnerable);
- West Coast Main Line (WCML) (essential infrastructure); and
- The A51 Stone Road (essential infrastructure).

5.2.6 The receptors located upstream (to the north) of the Proposed Scheme where it crosses Meece Brook are limited to agricultural land, which is classed as less vulnerable to flooding.

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

Figure 2: Flood risk associated with Filly Brook west of Stone



Meece Brook

5.2.8 A 2D hydraulic model of Meece 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 3.

5.2.9 The receptors and their vulnerability located downstream (to the south) of the Proposed Scheme where it crosses Meece Brook are listed below:

- agricultural land (less vulnerable);
- Stableford caravan park (highly vulnerable);
- WCML (essential infrastructure); and
- the A51 Stone Road (essential infrastructure).

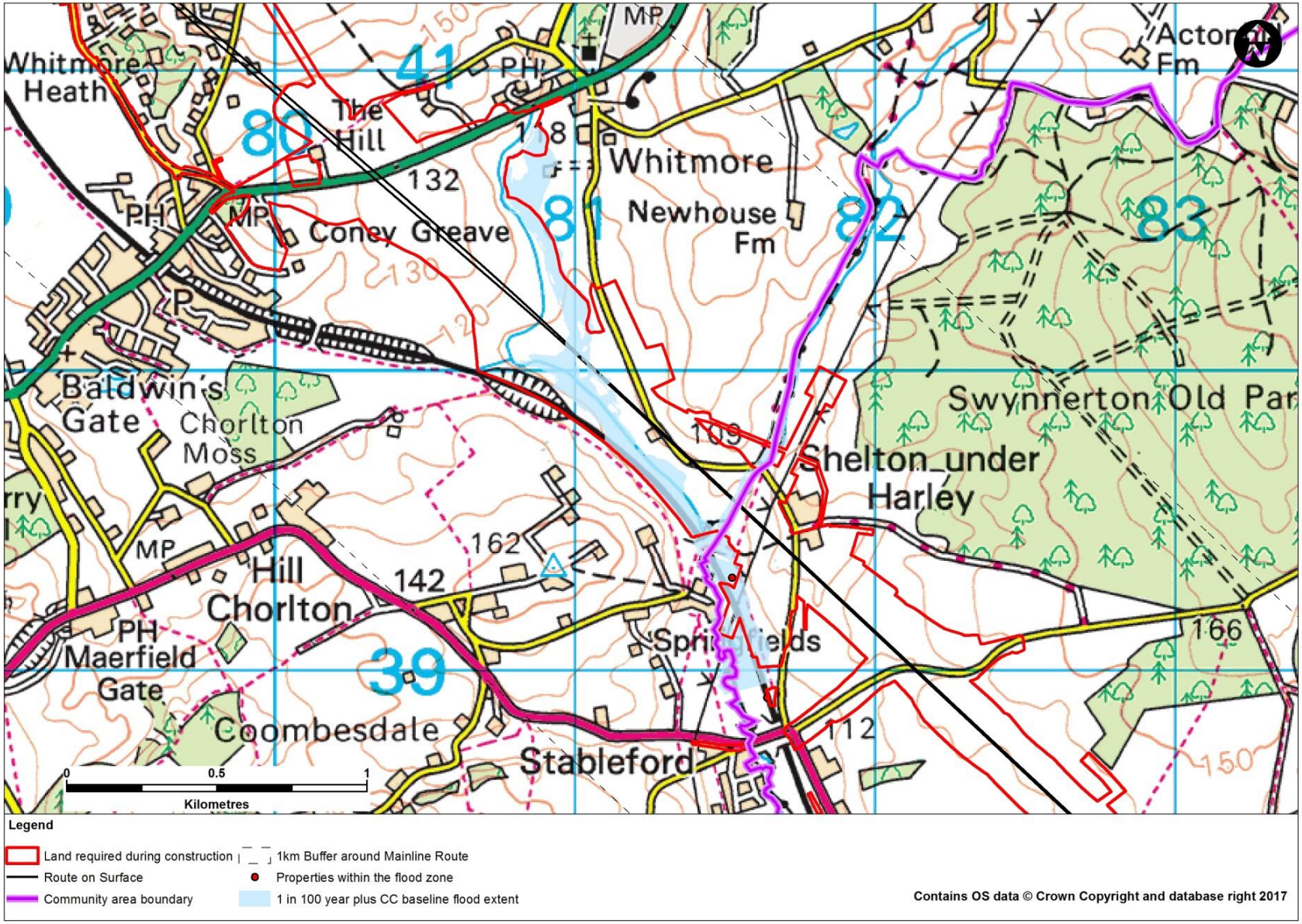
5.2.10 The receptors located upstream (to the north) of the Proposed Scheme where it crosses Meece Brook are limited to agricultural land, which is classed as less vulnerable to flooding.

5.2.11 The receptors and their vulnerability located upstream (to the west) of the Proposed Scheme where it crosses Filly Brook are listed below:

- agricultural land west of the M6 and north of Yarnfield Lane (less vulnerable);
- agricultural land west of Moss Farm (less vulnerable); and
- Norton Bridge to Stone Railway (essential infrastructure).

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

Figure 3: Flood risk associated with Meece Brook



5.3 Risks associated with surface water

5.3.1 This section presents the risk associated with surface water as shown by the Environment Agency's uFMfSW data set for the 1% (1 in 100) annual probability flood extent with climate change allowance, as presented in Figure 4: Surface water flood risk (southern part of the study area) and Figure 5.

5.3.2 The following additional receptors are at risk of flooding from surface water:

- residential properties at Monks Way, Swynnerton (more vulnerable);
- Norton Bridge to Stone Railway (essential infrastructure);
- Caravan at Brook House, Yarnfield Lane (highly vulnerable);
- Caravan at Moss Farm, Yarnfield Lane (highly vulnerable);
- M6 (essential infrastructure);
- telecommunication site, Jervis Lane (less vulnerable);
- Bent Lane and the A51 Stone Road (essential infrastructure);
- the WCML (essential infrastructure); and
- Agricultural Land (less vulnerable).

5.3.3 A climate change allowance comprising a 40% increase in peak flows has been adopted at these crossings as they all have catchment areas of less than 5km^2.

Figure 4: Surface water flood risk (southern part of the study area)

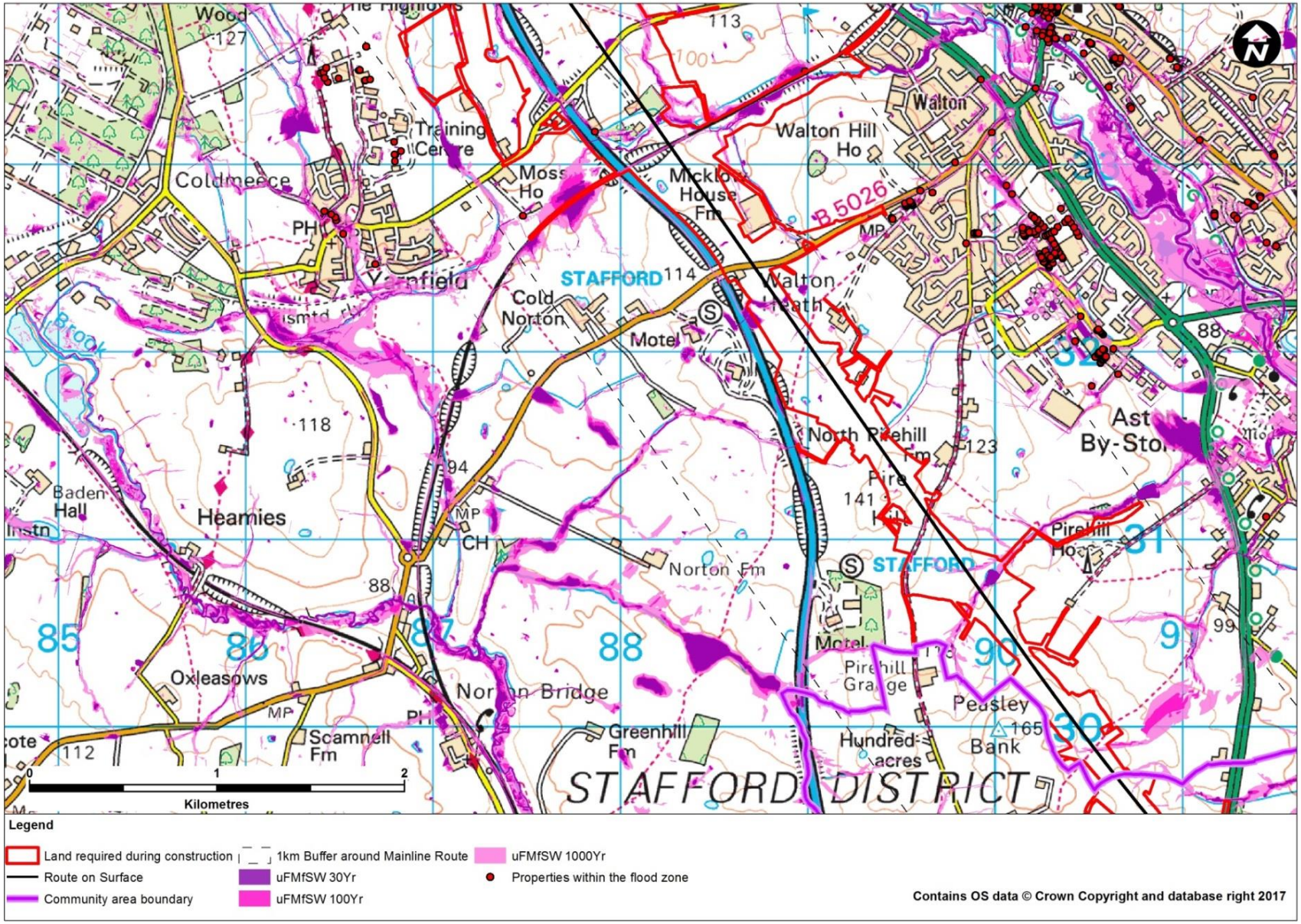
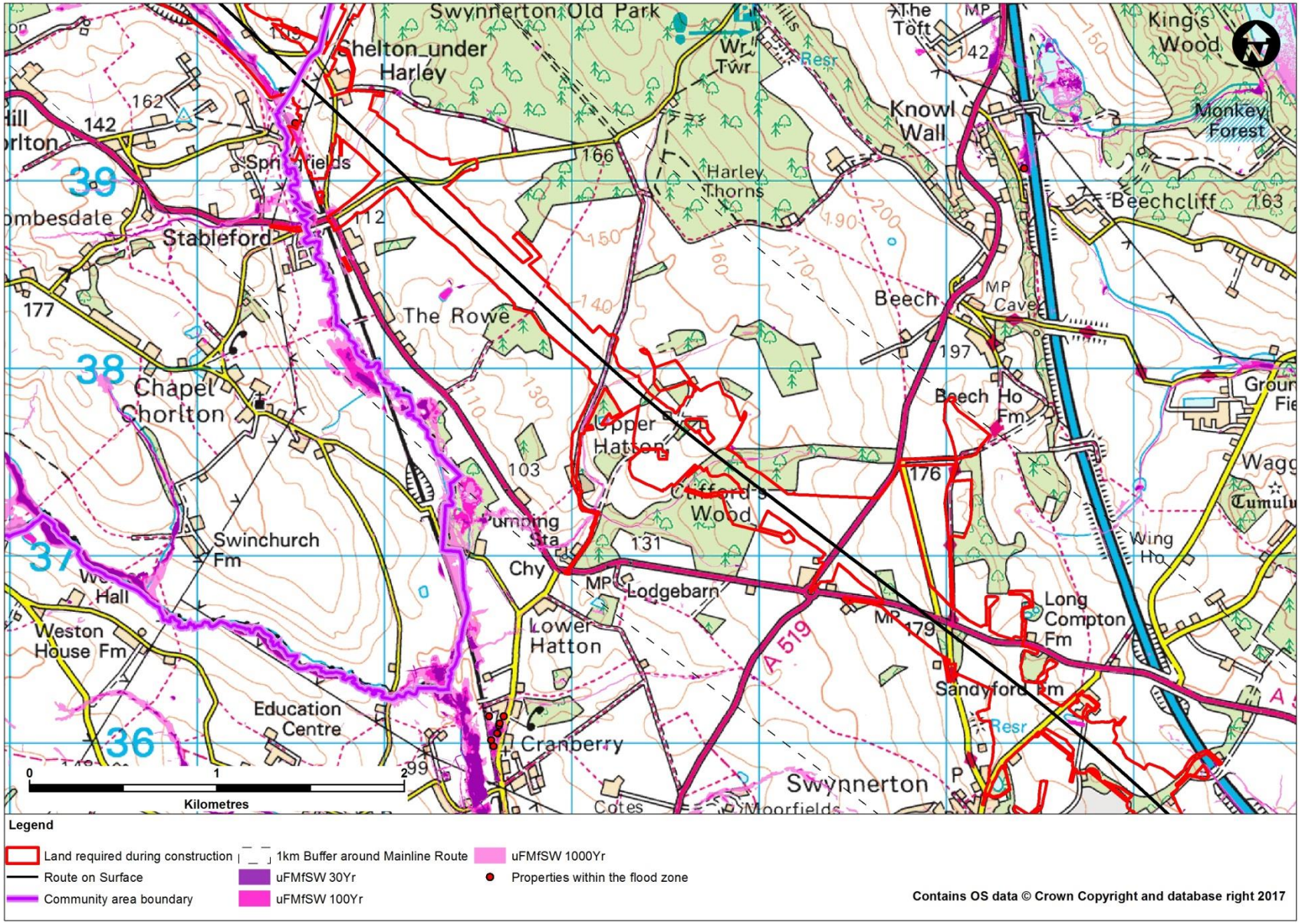


Figure 5: Surface water flood risk (northern part of the study area)



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 AStGWF in the Stone and Swynnerton area generally follow the main river networks, specifically Filly Brook and Meece Brook, and outside the study area along the River Trent. Much of the central and elevated area of the catchments away from the main floodplains have limited susceptibility to, or are not considered to be prone to, groundwater flooding.

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 due to failure of an impounding structure, such as a dam of canal embankment, which is a retaining structure that impounds water. The following features have been identified within the study area that are 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 10,000m^3, the River Trent floodplain area, in the vicinity of Stone could be affected. This is outside of the study area, and would have no effect on the Proposed Scheme.
- Bromley Pool Reservoir is located approximately 5km to the west of the Proposed Scheme. In the event of a failure of the retaining structure, the Environment Agency's 'Flood risk from reservoirs' mapping indicates that the flood inundation area would not affect the Proposed Scheme; and
- major water supply pipelines and sewerage (foul and surface water) infrastructure have been identified and are accounted for on the Proposed Scheme drawings.

5.5.2 There are no canals located within the community area.

5.6 Summary of baseline flood risk

5.6.1 Table 4 provides a summary of all the relevant sources of flood risk identified, the receptors potentially affected, their relative vulnerability and the climate change allowances used in the modelling assessments and calculations.

Table 4: Summary of baseline flood risk

Source / Pathway	Receptors	Data Source	Highest Receptor Vulnerability Level	Climate Change Allowance used for assessment
Filly Brook	Agricultural land west of the M6 and north of Yarnfield Lane	1 in 100 (1%) annual probability flood extent with allowance for climate change	Essential Infrastructure	50%
	Agricultural land west of Moss Farm			
	Stone Golf Club course			
	Norton Bridge to Stone Railway			
	Filly Brook Pump House			
Meece Brook	Agricultural land	1 in 100 (1%) annual probability flood extent with allowance for climate change	Essential infrastructure	50%
	Stableford Caravan Park			
	WCML			
Surface water flow paths	Residential properties west of Stone	uFMfSW 1% Annual Exceedance Probabilities (AEP)	More Vulnerable	40%
	Residential properties at Monks Way, Swynnerton	uFMfSW 1% AEP	More Vulnerable	40%
	Norton Bridge to Stone Railway	uFMfSW 1% AEP	Essential infrastructure	40%
	Manor Road, Bower End Lane and the A525 at to the west of Madley	uFMfSW 1% AEP	Highly Vulnerable	40%

Source / Pathway	Receptors	Data Source	Highest Receptor Vulnerability Level	Climate Change Allowance used for assessment
	Caravan at Brook House, Yarnfield Lane	uFMfSW 1% AEP	Highly Vulnerable	40%
	Caravan at Moss Farm, Yarnfield Lane	uFMfSW 1% AEP	Highly Vulnerable	40%
	M6	uFMfSW 1% AEP	Essential infrastructure	40%
	Telecommunication Site, Jervis Lane	uFMfSW 1% AEP	Less Vulnerable	40%
	Bent Lane	uFMfSW 1% AEP	Less Vulnerable	40%
	WCML	uFMfSW 1% AEP	Essential Infrastructure	40%
	Agricultural land	uFMfSW 1% AEP	Less Vulnerable	40%

6 Flood risk impacts and effects

6.1 Rivers and ordinary watercourses

Viaducts

6.1.1 The Proposed Scheme within the Stone and Swynnerton area includes crossings of two watercourses on viaducts Filly Brook and Meece Brook.

6.1.2 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.

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

Filly Brook

6.1.4 Filly Brook will be crossed at two locations by two separate viaducts. At its southern extent, Filly Brook will be crossed by Filly Brook viaduct, under which Filly Brook will be de-culverted and realigned around the southern end of the Stone Infrastructure and Maintenance Base – Rail (IMB-R). Further north, Filly Brook is also crossed by the M6 Meaford Viaduct, although the primary purpose of this viaduct is to allow the Route of the Proposed Scheme to cross the M6 Motorway.

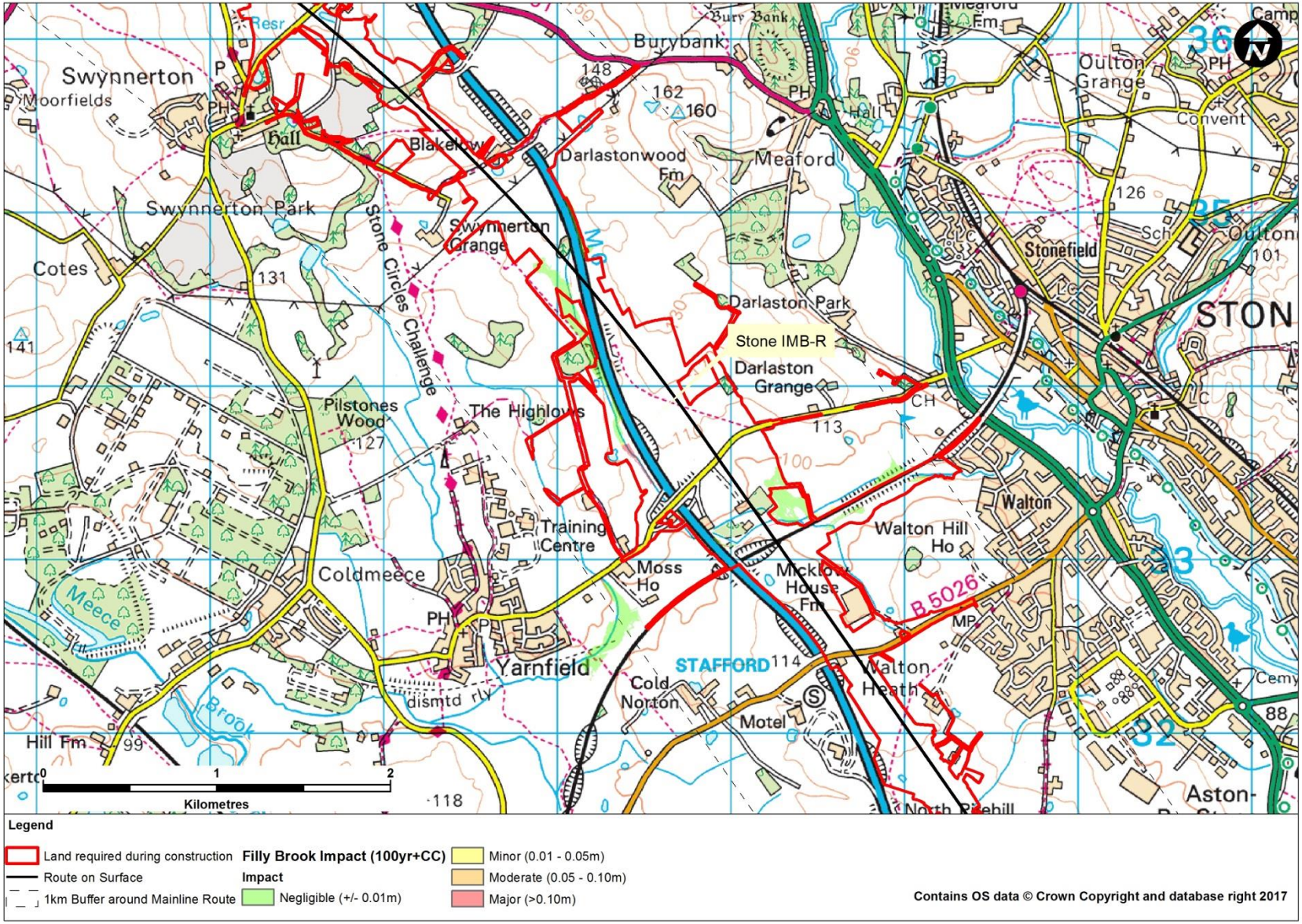
6.1.5 Throughout the modelling and design process, it has become apparent that the IMB-R reception tracks and existing Network Rail infrastructure could be at risk of flooding from Filly Brook. As such, an online flood water attenuation structure, incorporating an online flood storage area has been incorporated in the design of the Proposed Scheme and the hydraulic model of Filly Brook.

6.1.6 The results of the hydraulic model study of Filly Brook (Figure 6) indicate that, at Filly Brook viaduct the capacity of the realigned channel will be sufficient to convey the 1 in 100 (1%) annual probability flood flow plus allowance for climate change. The green areas on Figure 6 show that the piers of the proposed Filly Brook viaduct will have a negligible impact on peak flood levels.

6.1.7 Further upstream, the M6 Meaford Viaduct will result in a minor increase in peak flood level, indicated by the yellow shading on Figure 6. This will affect an area of undeveloped land to the west of the M6. As such it would be a minor impact affecting a moderate value receptor and so is a minor adverse effect, which is not significant.

6.1.8 Figure 6 also shows an area of agricultural land to the north of Yarnfield Lane which will experience a major increase in peak flood level (indicated by the red shading). This area represents the online flood storage area, which is designed to be flooded. As this area will be owned and maintained by HS2 for the purposes of flood alleviation, this is not identified as a major impact and is therefore not significant.

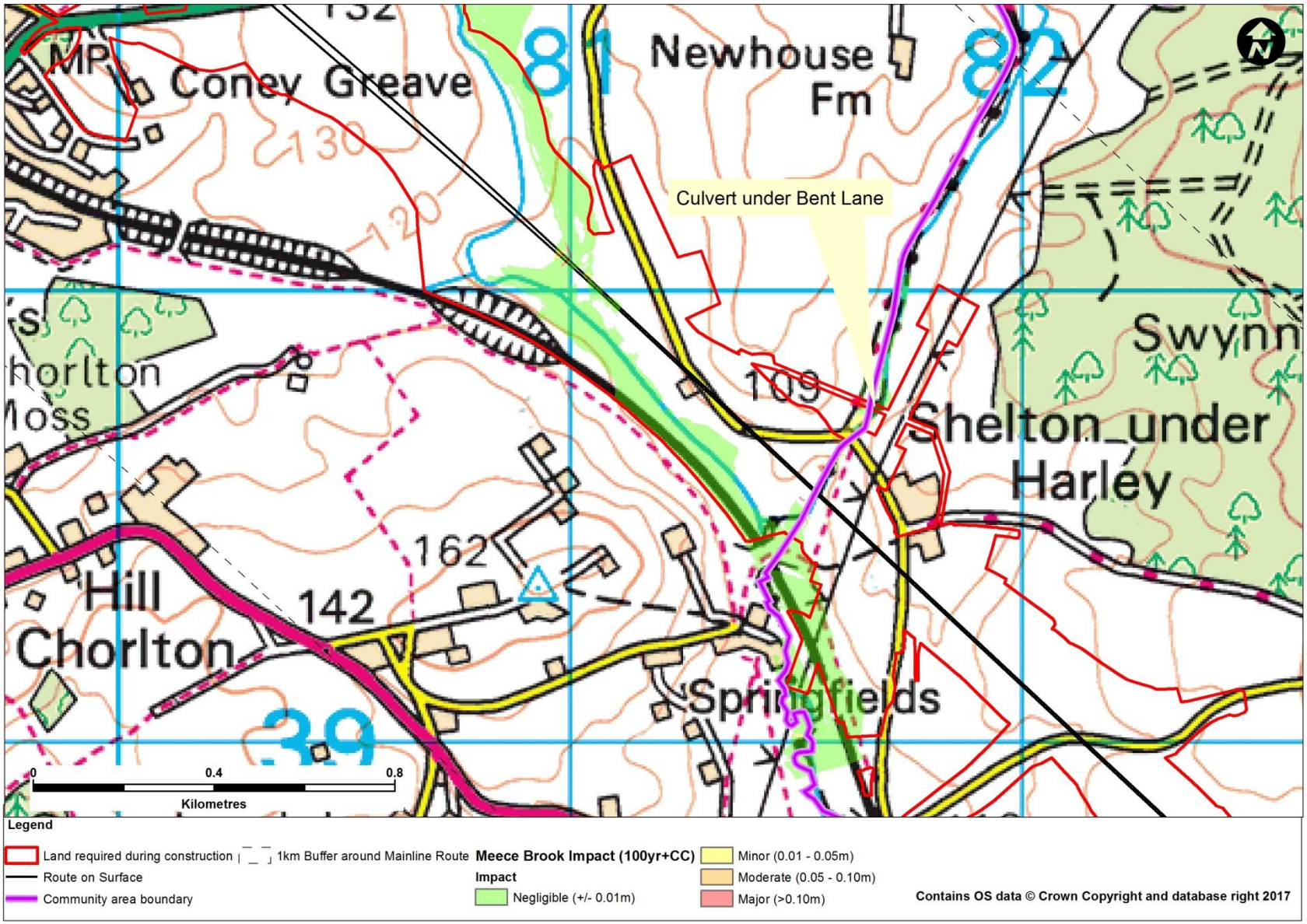
Figure 6: Post development flood risk on Filly Brook



Meece Brook

6.1.9 Figure 7 shows that the construction of Meece Brook viaduct (which is located in CA4) will result in a negligible change in the predicted 1 in 100 (1%) annual probability plus climate change flood level, as indicated by the green shading on the figure. This negligible change in flood level will affect a small area of agricultural land which is considered less vulnerable, and thus a moderate value receptor. As such this would be a negligible impact on a moderate value receptor and as is negligible effect, which is not significant.

Figure 7: Post development flood risk on Meece Brook



Culverts and channel diversions

6.1.10 The uFMfSW data set has been used to indicate the potential flood extent generated and the receptors affected along smaller watercourses (see Section 5.3), where culvert crossings are proposed.

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

- 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;
- determination of the appropriate climate change allowance to be applied following the procedure outlined in Section 3.8;
- determination of the existing gradient of the watercourse using OS Mapping and LiDAR data;
- determination of the likely roughness characteristics of the proposed culverts;
- 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; and
- ensuring a minimum of 300mm freeboard to the pipe 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 River Trent	Pirehill Culvert	2.00	40%	1.35 x 1.35	3.09
Tributary of Filly Brook	Swynnerton culvert	0.13	40%	1.35 x 1.35	1.41
Tributary of Meece Brook	Plantation Culvert	0.35	40%	1.35 x 1.35	1.41

6.1.13 Table 5 illustrates that the minimum culvert dimension proposed, 1.35m x 1.35m, has ample capacity to convey the predicted peak flows. As such the magnitude of the flood risk impacts on local receptors is likely to be negligible.

6.1.14 Each of these ordinary watercourse crossings is associated with a minor localised channel realignment to reduce the length of culvert required as far reasonably practicable.

6.1.15 With regard to the tributary of Meece Brook which passes underneath the Proposed Scheme via the Swynnerton Footpath 10 Accommodation Underbridge, this culvert

structure was included in the hydraulic modelling exercise due to its proximity to Meece Brook viaduct. As shown on Figure 7, there is a minor impact (yellow shading) on water levels upstream of the Bent Lane realignment, at the inlet to the culvert under Bent Lane, which feeds into the underbridge (this area is labelled on Figure 7).

6.1.16 The receptor affected by this increase in water level is agricultural land, which is classed as less vulnerable, and thus of moderate value. As such, the impact on this land is assessed as minor adverse, which is not significant. The design in the Proposed Scheme includes for an area of flood compensation, which will mitigate this increase following further design development.

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

- Bent Lane (North) diversion, affecting a tributary of Meece Brook;
- Reception Sidings, affecting Filly Brook;
- Yarnfield Lane (West) realignment, affecting Filly Brook;
- Yarnfield Lane (East) realignment, affecting a tributary of Filly Brook; and
- Titterson Road diversion, affecting tributary of Filly Brook.

6.1.18 The design of channels and culverts required to convey water under highways and permanent access roads will follow the procedures 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 5.3, the uFMfSW data set and inspection of topographical survey information has identified surface water flow paths that are not represented by any formal channel features and so are not classed as formal watercourses.

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

6.2.3 The design process outlined in Section 6.1.11 has also been followed to size these culverts and their associated channels. In this way the existing flow paths are preserved and the flood response 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)
Tributary of Meece Brook	Dog Lane drop inlet culvert	0.18	40%	1.35 x 1.35	1.41
Tributary of Meece Brook	Shelton culvert	0.20	40%	1.35 x 1.35	1.41

6.2.5 By following this design approach the local flood risk characteristics are preserved and the risk to the receptors outlined in Section 5.3 is unchanged. As such the magnitude of flood risk to these receptors is deemed to be negligible.

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 The assessment has shown that there are no features of the Proposed Scheme in the Stone and Swynnerton 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 As presented in Section 5.5, the artificial sources of flooding identified present no risk of flooding to the Proposed Scheme in the Stone and Swynnerton Area. As such, there is no risk to the scheme from such sources, and there is no risk that the construction of the scheme could result in the consequences of flooding from such sources being made worse.

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 drawings. This infrastructure has been identified and diverted where appropriate. Measures will be taken to safeguard the local receptors during this diversion process.

6.4.3 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 design flood, with an allowance for climate change.

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 above activities will be undertaken in close consultation with the Environment Agency, the LLFA, and if residual effects are identified, with the affected landowners.

7.1.3 The aim will be to ensure that no parties are affected by unacceptable increases in levels of 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 Stone and Swynnerton area.

9 Conclusions

9.1.1 The analysis undertaken indicates that it is likely that it should be possible to develop a detailed design for the Proposed Scheme that does not increase flood risk. Further modelling and localised refinement of the embedded mitigation measures will be undertaken at the detailed design stage.

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