

A46 Coventry Junctions (Walsgrave) Scheme Number: TR010066

6.3 Environmental Statement Appendices Appendix 13.1 Flood Risk Assessment

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A46 Coventry Junctions (Walsgrave) Development Consent Order 202[x]

ENVIRONMENTAL STATEMENT APPENDICES Appendix 13.1 Flood Risk Assessment

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1. Introduction

1.1. Scope of work

- 1.1.1. Sweco UK Ltd (Sweco) have been appointed by National Highways to undertake a Flood Risk Assessment (FRA) to support the proposed redevelopment of the A46 Walsgrave Junction (the Scheme).
- 1.1.2. The Scheme is an upgrade to the A46 Walsgrave Junction which aims to alleviate congestion along the A46 corridor. The A46 corridor is an essential road network which connects major employment sites to the wider motorway network, forming a crucial interlink for travel between the north and south of England. The A46 provides an alternative route for journeys to the Southwest which avoids congestion around Birmingham. The A46 is classified as part of the national Strategic Road Network, linking the M6 and M69 with the M40 and the M5.
- 1.1.3. This report evaluates the risk of flooding and its relevant impacts as a result of the Scheme. The report is aligned with the relevant national and local planning policies and offers appropriate mitigation measures where necessary.
- 1.1.4. This report has been completed in accordance with current guidance contained in the National Policy Statement for National Networks (NPS NN), for guidance on Nationally Significant Infrastructure Projects (NSIPs) on the road network along with the National Planning Policy Framework (NPPF) and the supporting online Planning Practice Guidance (PPG) for Flood Risk and Coastal Change.
- 1.1.5. The assessment has been undertaken in accordance with National Highways' technical guidance provided in Design Manual for Roads and Bridges (DMRB) LA 113 Road Drainage and the Water Environment. The assessment acknowledges the Coventry City Council (CCC), Rugby Borough Council (RBC) and Warwickshire County Council (WCC) local plans and flood risk management plans relevant to the Scheme.
- 1.1.6. This report has been informed by a walkover survey carried out in October 2023.

1.2. Previous studies

1.2.1. A FRA for the Scheme was completed at the options selection stage to inform the initial design stages of the junction improvements. This report makes reference to the options selection stage FRA hereafter referred to as the '2021 FRA' (National Highways, 2021a).



1.3. Data sources

- 1.3.1. The following data sources have been used to inform this assessment:
 - The 2021 A46 Walsgrave Junction FRA (National Highways, 2021a)
 - Coombe Pool Modelling Report (JBA Consulting, 2021)
 - LiDAR data (National LiDAR Programme, 2024)
 - Environment Agency Flood Map for Planning (Environment Agency, 2024a)
 - Drainage Data Management System (DDMS) (National Highways, 2024)
 - Long Term Flood Risk Map (Environment Agency, 2024b)
 - Environment Agency Historic Flood Map (Environment Agency, 2024c)
 - Climate Change Allowances (Department for Environment Food & Rural Affairs, 2024)
 - BGS Viewer (British Geological Society, 2024)
 - Coventry Local Plan (2011-2031) (Coventry City Council, 2017a)
 - Warwickshire Strategic Flood Risk Assessment (Warwickshire County Council, 2013)
 - Rugby Borough Council Local Plan 2011-2031 (Rugby Borough Council, 2019)
 - Drainage Strategy Report (National Highways, 2024)



2. Planning policy and legislative framework

2.1. National Policy Statement for National Networks

- 2.1.1. The National Policy Statement for National Networks (NPS NN) (2024) outlines that the NPPF is clear that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary, it should be made safe without increasing flood risk elsewhere.
- 2.1.2. Applications for projects in the following locations should be accompanied by a Flood Risk Assessment:
 - applications in flood Zones 2 and 3, which represent a medium and high probability of river and sea flooding.
 - applications in flood Zone 1 (a low probability of river and sea flooding) involving sites of 1 hectare or more; land which has been identified by the Environment Agency as having critical drainage problems; land identified in a strategic flood risk assessment as being at increased flood risk in future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.
- 2.1.3. The Flood Risk Assessment should identify and assess the risks of all forms of flooding and coastal erosion to and from the project and demonstrate how these flood risks will be managed, taking climate change into account.
- 2.1.4. In preparing a Flood Risk Assessment the applicant should:
 - consider the risk of all sources of flooding arising from the project (including in adjacent parts of the United Kingdom), in addition to the risk of flooding to the project, and demonstrate how these risks will be managed and, where relevant, mitigated, so that the development remains safe throughout its lifetimes.
 - take the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made.
 - demonstrate how proposals can be adapted over their predicted lifetimes to remain resilient to a credible maximum climate change scenario.
 - demonstrate how residual risks from reservoirs will be safely managed and/ or mitigated.
 - consider the vulnerability of those using the infrastructure including arrangements for safe access and escape.
 - include the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken into account and demonstrate that these risks can be safely managed.



- consider if there is a need to remain operational during a worst-case flood event over the development's lifetime.
- provide the rationale for the Secretary of State on the application of the sequential test and exception test, as appropriate.

2.2. National Planning Policy Framework

- 2.2.1. The NPPF (Department for Levelling Up, Housing & Communities, 2023) aims for current and future development proposals to meet the challenge of climate change, flooding, and coastal change.
- 2.2.2. Developments that are proposed within areas at risk of flooding should be avoided by directing development away from areas at highest risk. Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere.
- 2.2.3. Proposals and policies should be informed by a strategic FRA and should also consider cumulative impacts in, or affecting, local areas susceptible to flooding.
- 2.2.4. Proposed developments should consider all sources of flood risk and the current and future impacts of climate change. The residual risks should be managed by:
 - applying the sequential test and then, if necessary, the exception test.
 - safeguarding land from development that is required, or likely to be required, for current or future flood management.
 - using opportunities provided by new development and improvements in green and other infrastructure to reduce the causes and impacts of flooding, (making as much use as possible of natural flood management techniques as part of an integrated approach to flood risk management).
 - where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to relocate development, including housing, to more sustainable locations.
- 2.2.5. Annex 3 of the NPPF assigns vulnerability type to land use in terms of vulnerability to the impact of flooding. The NPPF classifies new developments into one of five categories that range from water-compatible to essential infrastructure:
 - essential infrastructure
 - highly vulnerable
 - more vulnerable
 - less vulnerable



water-compatible development.

2.3. DMRB LA 113 Road drainage and the water environment

- 2.3.1. The DMRB LA 113 (Highways England, 2020) requires the latest climate change allowances to be applied in accordance with relevant national legislation requirements. LA 113 details that all projects on motorways and all-purpose trunk roads shall be designed to:
 - remain operational and safe for users in times of flood
 - result in no net loss of floodplain storage
 - not impede water flows
 - not increase flood risk elsewhere.

2.4. Flood risk and coastal change PPG

- 2.4.1. The Flood Risk and Coastal Change PPG (the PPG) is published by the Department for Levelling Up, Housing and Communities and the Ministry of Housing. This guidance advises how to take account of and address the risks associated with flooding and coastal change in the planning process. A FRA is required for all developments proposed:
 - in flood zones 2, 3 or 3b
 - within flood zone 1 with a site area of 1 hectare or more
 - in areas with critical drainage problems
 - within flood zone 1 where the local planning authorities' (LPA's) strategic flood risk assessment (SFRA) shows it will be at increased risk of flooding during its lifetime
 - that increases the vulnerability classification and may be subject to sources of flooding other than rivers or sea

2.5. Flood zones

2.5.1. The PPG utilises Flood Zones to indicate the probability of river and coastal flooding. These Flood Zones are mapped on the Flood Map for Planning to identify the predicted extents of the floodplain for the Scheme. The guidance identifies three zones, with Flood Zone 3 being split into two further zones. The definitions refer to the probability of river or sea flooding for each Flood Zone are shown in Table 2-1.



Table 2-1: Flood zones

Flood Zone	Definition
Flood Zone 1 (Low probability)	Land having a less than 0.1% annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map for Planning – all land outside Zones 2, 3a and 3b)
Flood Zone 2 (Medium probability)	Land having between a 1% and 0.1% annual probability of river flooding; or land having between a 0.5% and 0.1% annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Flood Zone 3a (High probability)	Land having a 1% or greater annual probability of river flooding; or Land having a 0.5% or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map)
Flood Zone 3b (The functional floodplain)	This zone comprises land where water from rivers or the sea has to flow or be stored in times of flood. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Functional floodplain will normally comprise:
	• land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively; or
	• land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as 0.1% annual probability of flooding).
	Local planning authorities should identify in their Strategic FRAs areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map)

Flood risk compatibility

- 2.5.2. Annex 3 of the NPPF assigns vulnerability type to land use in terms of vulnerability to the impact of flooding. The NPPF classifies new developments into one of five categories that range from water-compatible to essential infrastructure.
- 2.5.3. The aim of proposed developments under the NPPF guidance and policies is to steer new development to the lowest Flood Zone in areas that do not impact essential infrastructure; however, this cannot always be achieved. Therefore, there are measures to ensure that suitable development can occur in higher risk areas, this is through the use of vulnerability classifications and Flood Zone compatibility and the sequential test and exception tests.
- 2.5.4. Table 2-2 shows the NPPF flood risk vulnerability and Flood Zone compatibility assessment as taken from Table 3 of the PPG. The table details the types of development that are appropriate within each Flood Zone and if an exception test is required. An explanation of the sequential and exception tests is outlined in Section 3.0.



Table 2-2: Compatibility matrix between flood risk and vulnerability classifications of infrastructure

Flood risk, vulnerability classification matrix	Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Flood Zone 1	✓	✓	✓	✓	✓
Flood Zone 2	✓	exception test required	✓	✓	✓
Flood Zone 3a	exception test required †	Х	exception test required	✓	✓
Flood Zone 3b	exception test required *	Х	Х	Х	√ *

Key: √ proposed development is acceptable. X development should not be permitted.

- · remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere.

2.6. Flood and Water Management Act 2010

- 2.6.1. The Flood and Water Management Act (FWMA) 2010 provides for better and more comprehensive management of flood risk for people, homes and business estates. The Act states that the LLFAs, either unitary authorities or county councils, are responsible for developing, maintaining and applying a strategy for local flood risk management in their areas and for maintaining a register of flood risk assets. They are responsible for managing the risk of flooding from surface water, groundwater and ordinary watercourses.
- 2.6.2. The new responsibilities that the Act assigns to LLFAs include:
 - Prepare and maintain a strategy for local flood risk management in their areas, coordinating views and activity with other local bodies and communities through public consultation and scrutiny, and delivery planning
 - Investigate significant local flooding incidents and publish the results of such investigations
 - Play a lead role in emergency planning and recovery after a flood event.

[&]quot;†" In Flood Zone 3a- Essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

[&]quot;*" In Flood Zone 3b (functional floodplain)- Essential infrastructure that has passed the exception test, and water-compatible uses, should be designed and constructed to:



- 2.6.3. The Department for Environment Food and Rural Affairs (DEFRA) has governing national responsibility for policy on flood and coastal erosion risk management (FCERM) in England. The department provides funding for flood risk management through grants to the Environment Agency, local authorities and internal drainage boards.
- 2.6.4. The FWMA introduced the role of Risk Management Authorities (RMA) to manage local flood risk, these include:
 - Environment Agency
 - Lead Local Flood Authorities
 - District and Borough Councils
 - Coast protection authorities
 - Water and sewerage companies
 - Internal Drainage Boards
 - Highways authorities.
- 2.6.5. These risk management authorities and others have their own responsibilities and powers that they can use in order to carry out these responsibilities (DEFRA, 2015). They must also:
 - co-operate with each other in the interests of flood risk management and may share information for this purpose
 - aim to contribute towards the achievement of sustainable development
- 2.6.6. National Highways are responsible for providing and managing highway drainage as an identified Risk Management Authority (RMA). As a RMA, they must work within the Environment Agency's national FCERM strategy and the Lead Local Flood Authorities (LLFAs) local flood risk management strategy when:
 - carrying out highway drainage works
 - filling in roadside ditches
 - diverting or carrying out works on part of a watercourse

2.7. Local planning policies

2.7.1. The A46 Walsgrave Junction is located on the border between two LLFAs, CCC and WCC. Unlike CCC, WCC are a two tier authority whereby WCC are the LLFA and RBC are the Local Planning Authority (LPA).



Coventry City Council

- 2.7.2. The Scheme west of the Walsgrave junction is in the CCC administrative area. Therefore, the Coventry Local Plan (2011-2031) (Coventry City Council, 2017a) is applicable. The following policies relevant to flood risk described within the local plan are listed below:
 - Policy EM1: Planning for Climate Change Adaptation. This aims for proposed developments to minimise vulnerability to flood risk by locating development in areas of low flood risk where possible and include mitigation measures within the proposed development. Proposed developments must aim to seek opportunities to make space for water and develop new blue infrastructure to accommodate climate change.
 - Policy EM2: Building Standards. This requires proposed developments to acknowledge the need for conserving water and minimising flood risk including flood resilient construction.
 - Policy EM4: Flood Risk Management. All major developments must be assessed in respect of the level of flood risk from all sources. Opportunities to reduce flood risk in the surrounding area must be taken, including creating additional flood storage. For sites in Flood Zone 3a, development should not impede flow routes, reduce floodplain storage or consume flood storage in a 'flood cell' within a defended area without appropriate compensatory floodplain storage elsewhere.
 - Policy EM5: Sustainable Drainage Systems (SuDS). All development must apply SuDS and should ensure that surface water runoff is managed as close to its source as possible.
- 2.7.3. The Coventry Strategic Flood Risk Assessment (SFRA) (Coventry City Council, 2015) sets out the local flood risks within the area and the findings from the SFRA aim to provide a baseline flood risk to proposed developments within the local area.
- 2.7.4. The Coventry Local Flood Risk Management Strategy (LFRMS) (Coventry City Council, 2022a) is a strategy plan set out by CCC that aims to reduce and manage local flood risk for the betterment of the local area.
- 2.7.5. The Coventry Preliminary Flood Risk Assessment (PFRA) (Coventry City Council, 2017b) is a high-level assessment aiming to identify local sources of flood risk. The assessment also includes guidance on future flood risk.
- 2.7.6. The Coventry Surface Water Management Plan (SWMP) (Coventry City Council, 2023) aims to gain a comprehensive understanding of flood risk from surface water. It also aims to understand the impact of current and future developments on flood risk and drainage provisions, and to subsequently agree planning mitigation measures.



Warwickshire County Council

- 2.7.7. The Scheme east of the Walsgrave junction is in the WCC administrative area and thus the WCC is the LLFA for this part of the Scheme, the following documents provide pertinent local information:
- 2.7.8. The Warwickshire Local Flood Risk Management Strategy (LFRMS) (Warwickshire County Council, 2016) is a strategy plan set out by WCC that aims to reduce and manage local flood risk for the betterment of the local area.
- 2.7.9. The Warwickshire Preliminary Flood Risk Assessment (PFRA) (Warwickshire County Council, 2011) is a high-level assessment aiming to identify local sources of flood risk. The assessment also includes guidance on future flood risk.
- 2.7.10. The Warwickshire Surface Water Management Plan (SWMP) (Warwickshire County Council, 2015) aims to understand the impact of current and future developments on flood risk and drainage provisions.

Rugby Borough Council

- 2.7.11. The Scheme also lies within the RBC administrative area, in their role of Local Planning Authority (LPA). Therefore, the RBC Local Plan (2011-2031) (Rugby Borough Council, 2019) is applicable. The following policies relevant to flood risk described within the local plan are listed below:
 - Policy SDC5: Flood Risk Management. A sequential test is required to
 identify the most appropriate location where possible in order to steer new
 development to areas with the lowest probability of flooding. Following the
 required tests and NPPF matrix described above, development must not
 increase flood risk elsewhere as a result of the Scheme. Developments must
 incorporate the appropriate flood mitigation measures.
 - Policy SDC6: Sustainable Drainage. This encourages the use of sustainable drainage techniques to reduce the potential impact of flood risk.
 - Policy SDC7: Protection of the Water Environment and Water Supply.
 Ensures the proposed development is in accordance with the Water
 Framework Directive Objectives and does not adversely affect the water bodies.
- 2.7.12. The RBC Strategic Flood Risk Assessment (SFRA) (2013) aims to:
 - provide an assessment of the impact of all potential sources of flooding in accordance with NPPF
 - enable planning policies to be identified specific to local flooding issues
 - provide information required to apply the sequential test for identification of land suitable for development in line with the principles of the NPPF



- provide recommendations of suitable mitigation measures including the objectives of SuDS.
- 2.7.13. The RBC Local Plan is currently being reviewed; no updated policies are currently publicly available. However, an updated SFRA forms part of the publicly available evidence base, once adopted this aims to provide a comprehensive and robust evidence base on flood risk issues to support, review and update of the Coventry and Warwickshire Authorities Local Plans and associated Planning Policy documents using the best available information.



3. NPPF sequential and exception tests Sequential test

- 3.1.1. According to the NPPF, all developments are required to pass a sequential test. The sequential test aims to steer developments away from areas of high flood risk to areas of lower flood risk. This ensures that areas at little or no risk of flooding from any source are developed in preference to areas at higher risk.
- 3.1.2. The location of the Scheme is fixed, as a result of a need to improve the existing A46 strategic road network corridor to provide alternative routes away from congestion. Due to this, there are no reasonably available, lower-risk sites, suitable for the proposed development, to which the development could be steered. Therefore, the Scheme has been identified as the only applicable site and has passed the sequential test.

Exception test

3.1.3. The Scheme is classified as essential infrastructure with areas along the B4082 within Flood Zone 3b, therefore in accordance with the NPPF flood risk vulnerability and Flood Zone compatibility assessment (Table 3-1) an exception test is required.

Table 3-1: Flood ris	sk vulnerability and	d flood zone 'incompatibilit	y'
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Flood risk, vulnerability classification matrix	Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Flood Zone 1	✓	√	√	√	✓
Flood Zone 2	✓	exception test required	✓	✓	✓
Flood Zone 3a	exception test required †	×	exception test required	✓	✓
Flood Zone 3b	exception test required *	х	х	Х	√ *

- 3.1.4. The exception test requires the following elements to be satisfied (as set out in the Flood Risk and Coastal Change PPG):
 - development that has to be in a flood risk area will provide wider sustainability benefits to the community that outweigh flood risk
 - the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.



- 3.1.5. The first part of the exception test is considered to be passed as the Scheme will upgrade the existing Walsgrave Junction to alleviate congestion and improve journey times along the A46 corridor. In turn, this will provide multiple socioeconomic benefits for communities and businesses within the wider area. The Scheme also provides a range of environmental benefits which are detailed within the Environmental Statement (TR010066/APP/6.1, Chapter 13).
- 3.1.6. The wider sustainability objectives for CCC are defined within the Sustainability Appraisal/Strategic Environmental Assessment (CCC, 2016). The assessment, adopted in 2017, lists multiple wider sustainability objectives for Coventry which are met by the Scheme. Objectives such as "1. Improve accessibility to and use of basic services and amenities to all residents" and "4. Improve health, reduce health inequalities and promote active living" will be of betterment by the Scheme.
- 3.1.7. The second part of the exception test is addressed within this FRA and Section 10.-



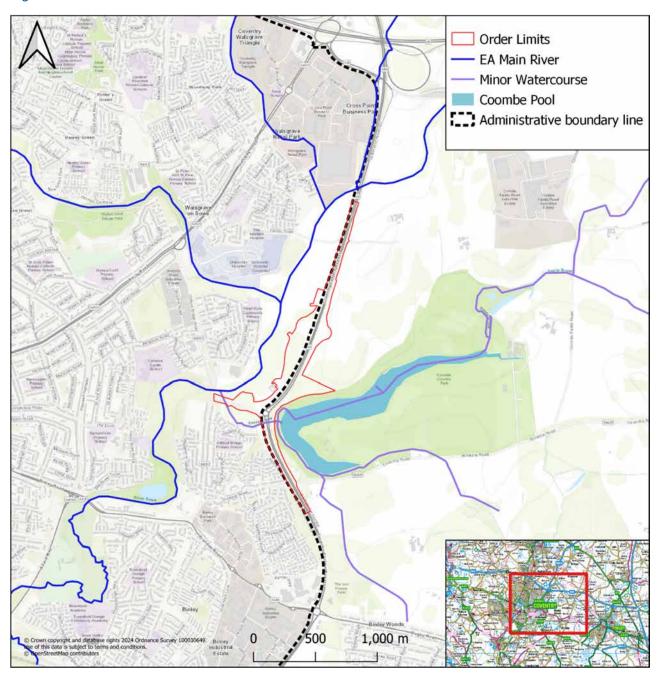
4. Existing site

4.1. Site location (SP 38362 79296)

- 4.1.1. The Scheme is located approximately five kilometres (km) east of Coventry and lies on the border between CCC (east of the administrative border) and WCC/RBC (west of the administrative border) (Figure 4-1).
- 4.1.2. The Scheme is located at Walsgrave Junction connecting the B4082 to the A46. The primary LLFA and local planning authority within the Order Limits is CCC, as it is responsible for the areas downstream of Walsgrave Junction. The secondary LLFA and local planning authority is WCC, which is responsible for the areas upstream of Walsgrave Junction. Coombe Pool which is located within the administrative boundaries of WCC but is owned by CCC who are the reservoir undertaker. CCC are responsible for all maintenance and operation of the reservoir.



Figure 4-1: Site location and administrative boundaries



- 4.1.3. The surrounding land use within the Order Limits predominantly includes areas of agricultural land use and woodland. Coombe Country Park is included within the Order Limits which features Coombe Pool, a large water body, primarily used for private fishing. The west of the Scheme, within the Order Limits is predominantly residential areas associated with the eastern edge of Coventry as well as recreational grounds and arable land.
- 4.1.4. There are no designated flood defence structures within the Order Limits.

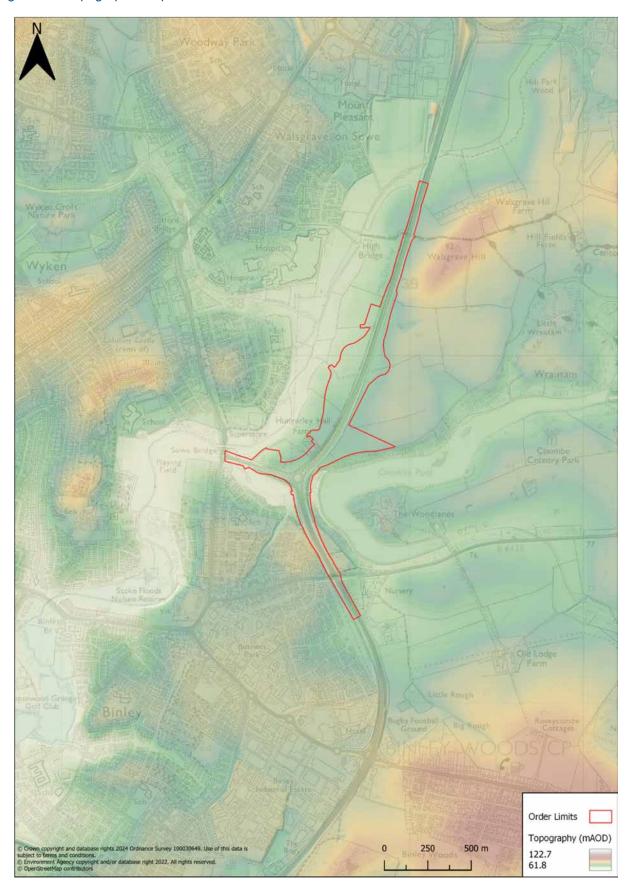


4.2. Landscape and topography

- 4.2.1. The Scheme sits in an area of low topography (77m Above Ordnance Datum (AOD)) (Environment Agency, 2024d). The surrounding area gently slopes down towards the adjacent River Sowe (72m AOD) 330m west of the Walsgrave Junction. Areas of higher topography are 1.5km to the north-east of the A46 Walsgrave Junction (90m AOD).
- 4.2.2. The existing A46 road network within the Scheme and the A46 Walsgrave Junction sit at an approximate level of 75mAOD. The A46 is lined with two bunds either side of the highway that reach heights of 78mAOD.
- 4.2.3. The Coombe Pool embankment surrounding Coombe Pool sits at an approximate level of 74.0mAOD. The topographic variations of the Scheme are shown in Figure 4-2 using data taken from the National LIDAR Programme (Environment Agency, 2024).
- 4.2.4. The surrounding landscape of the Scheme, within the Order Limits is a mixture of arable pastureland and suburban extents.



Figure 4-2: Topographic map



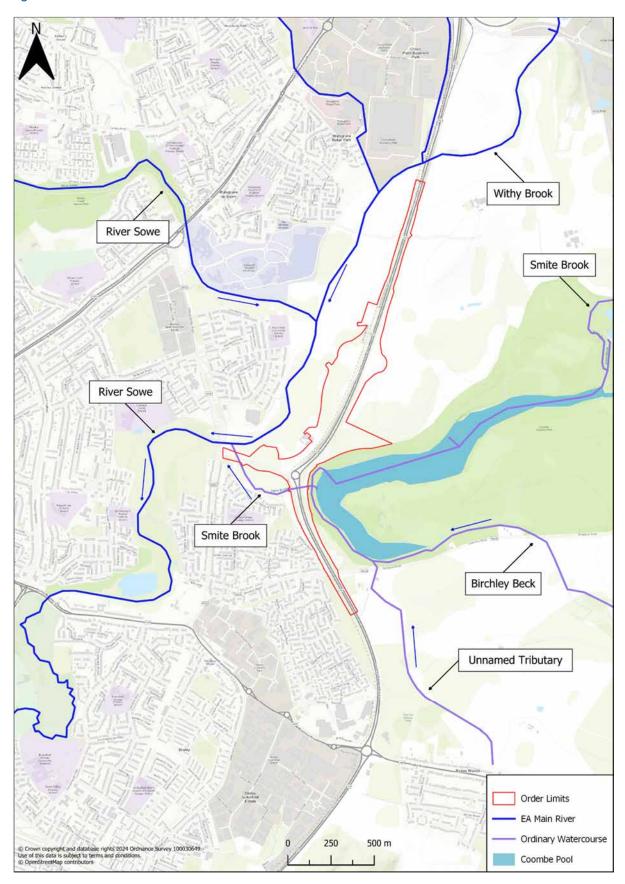


4.3. Hydrology

- 4.3.1. There are a number of watercourses within the vicinity of the Scheme (Figure 4-3).
- 4.3.2. Coombe Pool is a 32-hectare (ha) large raised reservoir under the Reservoirs Act 1975, located 150m to the east of the Scheme. Coombe Pool is part of the wider Coombe Country Park and Abbey. A bellmouth structure, sluice gates and a spillway discharge overflows into Smite Brook and Birchley Beck.
- 4.3.3. Birchley Beck is an ordinary watercourse originating southeast of the Order Limits and flows northwest. Birchley Beck is culverted beneath the B4027, a dilapidated footbridge and overtops heavily vegetated naturally formed weirs. Birchley Beck and an unnamed tributary originate south of Coombe Pool and flow northwest before they confluence with the Smite Brook.
- 4.3.4. Smite Brook is an ordinary watercourse which flows west of Coombe Pool and is culverted beneath the A46 Eastern Bypass. Smite Brook then flows north-west passing beneath the B4082 before its confluence with the River Sowe, an Environment Agency Main River.
- 4.3.5. Withy Brook is an Environment Agency Main River which forms as a tributary of the River Sowe and originates north of the Scheme. It flows south, discharging into the River Sowe, approximately 250m southeast of University Hospital Coventry & Warwickshire.
- 4.3.6. The River Sowe flows south approximately 300m west of the Walsgrave junction. It is hydrologically connected to the surrounding watercourses directly or via Smite Brook.



Figure 4-3: Waterbodies local to Order Limits





4.4. Geology and hydrogeology Geology

- 4.4.1. The regional superficial geology at 1:50,000 scale is presented in Annex A of the groundwater assessment (TR010066/APP/6.1). The descriptions provided below are extracted from the groundwater assessment
- 4.4.2. The surrounding areas outside the Scheme have extensive Pleistocene superficial deposits overlying mid-late Triassic mudstone bedrock with early-mid Triassic sandstone beneath 1 to 2 km to the west. The superficial deposits are predominantly sands and gravels with lenses of silt, clay, and peat as well as glacial lacustrine muds and diamicton. The superficial geology and bedrock are described in further detail below.
- 4.4.3. Within the groundwater assessment, the underlying bedrock geology described in the Order Limits consists of the Mercia Mudstone Group. The superficial deposits within the Order Limits are varied, with areas underlain by Alluvium to the west and south of the Walsgrave Junction, Wolston Glacigenic Formation to the north, Baginton Sand and Gravel Formation to the east.

Hydrogeology

- 4.4.4. The geology of the area can be an important influencing factor on the way the water runs off the ground surface causing adverse flood risk affects elsewhere. This is largely due to variations in the superficial (permeable, unconsolidated deposits) and bedrock (solid permeable) stratigraphy.
- 4.4.5. The superficial Alluvium and Baginton Sands and Gravels is classified as a Secondary 'A' aquifer. Secondary A aquifers are permeable layers capable of supporting water supplied at a local, rather than strategic scale, and in some cases, form an important source of baseflow to rivers.
- 4.4.6. The Mercia Mudstone Group is classified as a Secondary B aquifer, defined as a lower permeability layer that may store and yield limited amounts of groundwater through characteristics such as cracks, openings, and eroded layers.
- 4.4.7. The Wolston Glacigenic Formation is classified as a Secondary (undifferentiated) aquifer. Secondary (undifferentiated) aquifers are classified as such due to the formation previously having been designated as both a minor aquifer and non-aquifer (now defined as Secondary A and Secondary B respectively) in different locations, due to variable characteristics of the rock type. As such Secondary (undifferentiated) aquifers are likely to contain lower permeability layers and perched aquifers.



4.5. Existing drainage

4.5.1. Existing drainage information has been collected and reported within the drainage strategy (Drainage Strategy Report, National Highways, 2024). Based upon information in the drainage strategy and DDMS there are eight existing outfalls draining from catchments within the Order Limits (Table 4-1).

Table 4-1 : Existing outfalls

Asset ID	Asset Owner	OS Easting	OS Northing
SP3879_3320d	National Highways	438335	279206
SP3879_0537a	National Highways	438052	279378
SP3879_0338c	National Highways	438039	279379
SP3879_0439a	National Highways	438043	279398
SP3879_7690a	National Highways	438763	279908
SP3880_7316a	National Highways	438733	280168
SP3880_4708a	National Highways	438471	280082
SP3980_0666b	National Highways	439068	280661

- 4.5.2. Outfalls draining the southern catchments within the Order Limits drain runoff directly into Smite Brook. Outfalls draining the northern catchments within the Order Limits drain runoff either directly into the River Sowe or through a drainage ditch which then discharges into the River Sowe.
- 4.5.3. The Scheme is located within a largely rural catchment with urban areas located to the southwest of Walsgrave Junction. Surface water drainage along the B4082 is managed by the highway authority (CCC). The A46 forms a part of the Strategic Road Network (SRN); therefore, it is managed by National Highways.



5. Summary of consultation

Environment Agency

- 5.1.1. Consultation with the Environment Agency was undertaken on the 17 November 2023 which included a discussion on the pluvial and fluvial flood risk elements across the Scheme, along with the proposed surface water drainage design.
- 5.1.2. In relation to the approach to the FRA, it was agreed that no changes from the options selection stage baseline model were required and that the peak river flow higher central (32%) climate change allowance would be used for the design of any structures and central (21%) climate change allowance would be used for flood compensatory storage (if required).
- 5.1.3. The Environment Agency stated they had no issues or concerns and agreed with the approach proposed.
- 5.1.4. The Environment Agency accepted the Flood Risk Assessment on 18 October 2024 (Appendix Annex C).

Coventry City Council

- 5.1.5. A meeting with CCC was undertaken on 25 July 2023 predominantly to discuss the surface water drainage strategy. As part of this meeting CCC raised the following points relevant to flood risk:
 - the A46 southbound embankment is predicted to breach in extreme circumstances and assessments have been undertaken on providing flood prevention measures.
 - flood modelling for the Scheme should be undertaken.
- 5.1.6. A further meeting with CCC was held on 14 February 2024 predominantly to discuss the Statement of Common Ground. During this meeting the design of the existing southbound A46 eastern verge, which will be affected by the proposed works was discussed. The A46 embankment will be reinstated with an impermeable covering to the design level of 74.0mAOD (1% AEP event plus 32% climate change including an allowance of 600mm freeboard).

Warwickshire County Council

5.1.7. Consultation with WCC was undertaken on the 25 August 2023. The consultation provided an overview of the Scheme and described the approach to flood risk and drainage.



5.1.8. WCC raised no major concerns with the Scheme, having already commented on previous stages, although did state they would hope for an overall flood risk betterment.

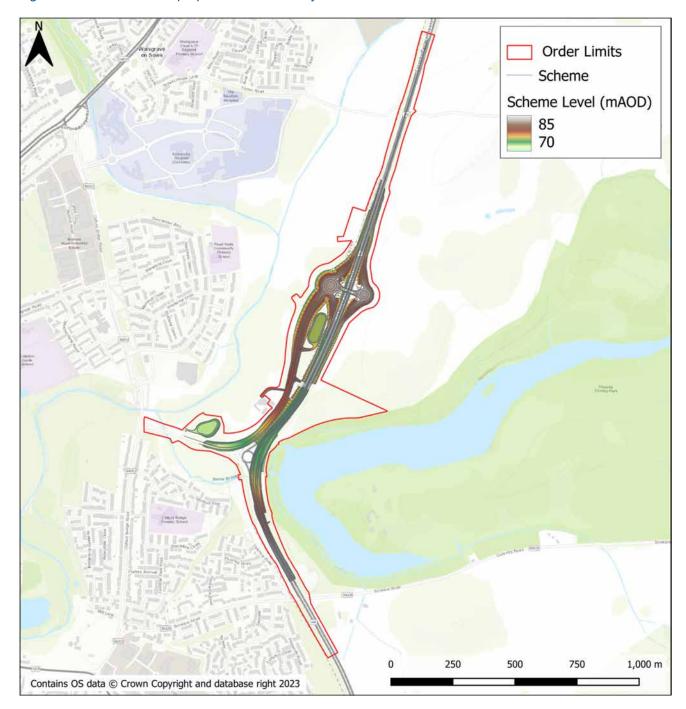


6. The Scheme

- 6.1.1. The Scheme borders the eastern suburban area of the City of Coventry within a predominantly rural area. The Scheme involves improvements to the B4082 which runs eastwards from Clifford Bridge Road to the A46 Walsgrave roundabout and the A46 (Coventry Eastern Bypass) which runs north-south to the east of Coventry. Binley Junction, located on the A46, is approximately 1.7km to the south of the existing Walsgrave Junction and the M6 and M69 junctions are approximately 2.5km to the north of the existing Walsgrave Junction.
- 6.1.2. The Scheme aims to alleviate congestion along the A46 corridor by improving the B4082 and providing easier access onto the A46 via proposed slip roads. Figure 6-1 shows the plan of the Scheme. A general arrangement of the Scheme is detailed in TR0100066/APP/2.6.
- 6.1.3. The proposed full grade separated dumb-bell junction is approximately 800m north of the existing Walsgrave Junction roundabout and consists of north and southbound diverge and merge slip roads connecting to an overbridge with roundabouts to the east and west. The proposed Walsgrave overbridge spans across the A46 between the two roundabouts and carries a two-lane single carriageway.
- 6.1.4. The A46 southbound embankment, south of the existing Walsgrave Junction, currently provides protection to flood waters from flooding the A46 carriageway. The current embankment has a slope of approximately 1 in 2.5 and is unlikely to have been constructed to have a flood defence function. Protection will be reinstated along the southbound carriageway to the 1% AEP plus climate change level with the addition of 600mm freeboard to prevent flood waters entering the highway. The Scheme does not involve any improvements to culverts.
- 6.1.5. The Scheme proposes to remove the top layer of the existing A46 southbound embankment and replace it with a layer of clay to prevent seepage and potential undermining of the proposed highway, during large magnitude flood events. The new top layer of the southbound embankment will be graded to match the existing slope (1 in 2.5) or shallower to ensure that the Scheme does not result in a loss / adverse change to the floodplain.



Figure 6-1: The Scheme – proposed levels and layout





7. Climate change

- 7.1.1. Paragraph 002 of the PPG defines the design flood as a flood event of a given annual flood probability, which is generally taken as:
 - "river flooding likely to occur with a 1% annual probability (a 1 in 100 chance each year)
 - tidal flooding with a 0.5% annual probability (1 in 200 chance each year)
 - surface water flooding likely to occur with a 1% annual probability (a 1 in 100 chance each year)

including an appropriate allowance for climate change."

- 7.1.2. The Environment Agency provide guidance on applying climate change allowances in FRAs. A range of allowances are provided depending on the lifetime and vulnerability of the scheme with allowances provided for river, rainfall, and tidal sources for different catchment areas of England.
- 7.1.3. In terms of lifetime of the Scheme, this is considered to be 100 years and in relation to the vulnerability of the scheme the Scheme is considered to be essential infrastructure.
- 7.1.4. As the Scheme is classified as 'essential infrastructure', with a lifetime of 100 years and parts of the Scheme fall within Flood Zones 2 and 3, the guidance states that the fluvial higher central climate change allowance applies (Table 7-1). As the Scheme is in the Avon Warwickshire Management Catchment the fluvial higher central allowance is 32%. As defined on the DEFRA climate change allowance map (DEFRA, 2024a). This was agreed with the Environment Agency on 17 October 2023.
- 7.1.5. The NPS NN guidance stipulates that for Development Consent Order (DCO) applications, the applicant should be able to demonstrate how proposals can be adapted over their predicted lifetimes to remain resilient to a credible maximum climate change scenario. In the case of the Scheme, the credible maximum climate change scenario is the upper end allowance for peak river flow. The Upper End allowance has therefore been simulated in addition to the Higher allowance.

Table 7-1: Peak river flow allowances for the Avon Warwickshire Management Catchment.

	Central	Higher	Upper
2020s	7%	12%	22%
2050s	8%	14%	31%
2080s	21%	32%	59%



7.1.6. The Climate Change Allowances for Peak Rainfall Map (DEFRA, 2024b) defines the climate change allowances for peak rainfall intensity (Table 7-2). In the Avon Warwickshire Management Catchment, the upper end climate change allowances, which are required for development with a lifetime beyond 2100 are 25% and 40% for the 1% annual exceedance probability event in accordance with E/1.11.3 of DMRB LA113.

Table 7-2: Peak rainfall allowances for the Avon Warwickshire Management Catchment.

		Central Allowance	Upper end allowance
1% annual exceedance rainfall event	2050s	20%	40%
	2070s	25%	40%
3.3% annual exceedance rainfall event	2050s	20%	35%
	2070s	25%	35%



8. Sources of flood risk

8.1. Sources of potential flooding

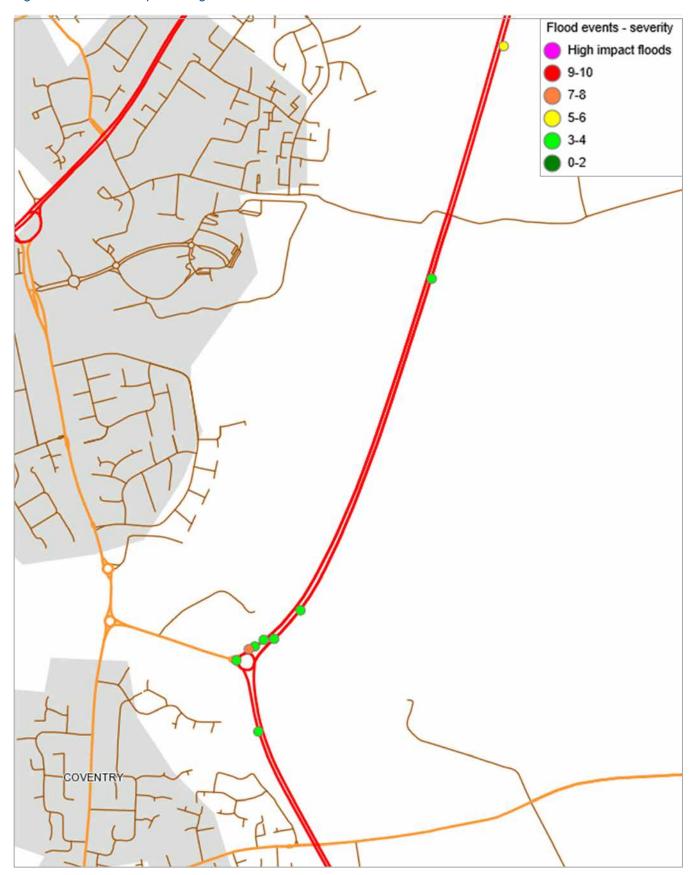
- 8.1.1. The following sources of flood risk have been identified as potential to impact the Scheme or be impacted by the Scheme:
 - fluvial (rivers)
 - pluvial (surface water)
 - groundwater
 - artificial infrastructure
- 8.1.2. The Scheme is not at risk from tidal flooding and there are no canals within the Scheme locality, therefore these are not considered further.

8.2. Historical flooding

- 8.2.1. The Environment Agency Historic Flood Map (Environment Agency, 2024c) indicates no historic instances of tidal, coastal, or fluvial flooding within the Order Limits. The SFRA makes no reference of flooding within or in proximity to the Order Limits.
- 8.2.2. DDMS (National Highways, 2024) identified nine previous flooding events within the Scheme (Figure 8-1). The National Highways Flood Severity Index (FSI) defines the overall index of flood severity which considers the road classification and size, Annual Average Daily Traffic flows, maximum effect on the carriageway and the duration of impact. Of the nine recorded flood events, seven were recorded at a FSI of four and one was recorded at a FSI of seven. The FSI scale ranges from 0 (lowest) to 10 (highest)
- 8.2.3. One of the recorded flood events at a FSI of four was located on the west side of the Walsgrave Junction. Three recorded flood events including the one recorded at a FSI of seven were to the north of the Walsgrave Junction and one to the south of Walsgrave Junction, all heading northbound. Three flood events were recorded heading southbound towards the Walsgrave Junction. The recorded flood events were caused by defective gullies and blocked drains after persistent rainfall. The Scheme sits within a very high hotspot status.



Figure 8-1 : DDMS map showing flood events within the Scheme.





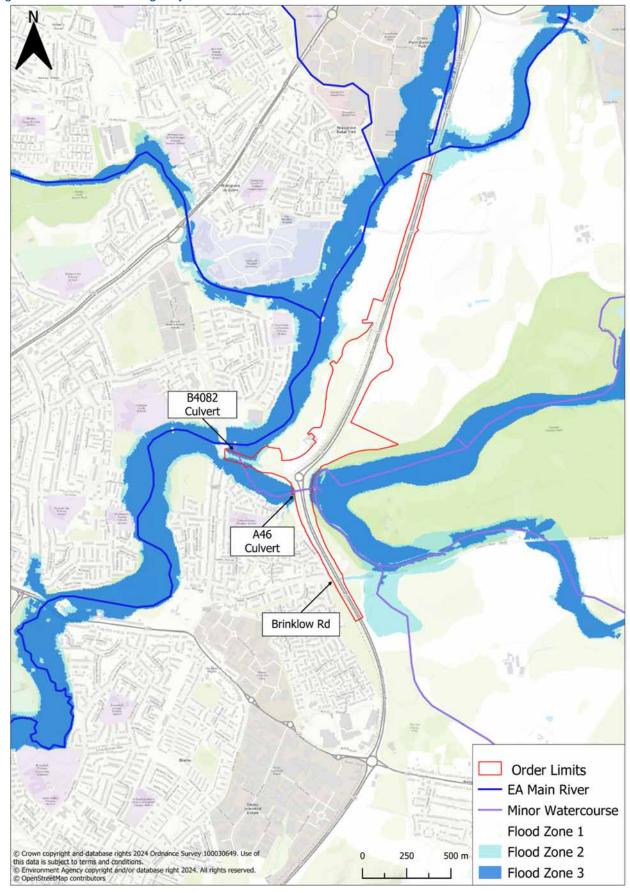
8.3. Fluvial flooding

Baseline

- 8.3.1. Fluvial flooding occurs due to an increase in water level within a watercourse causing it to burst its banks and flood the surrounding area.
- 8.3.2. According to the Environment Agency Flood Map for Planning (Environment Agency, 2024a), the majority of the Scheme boundary falls within Flood Zone 1 (Figure 8-2). However, there are areas of the Scheme that fall within Flood Zones 2 and 3:
 - The A46 culvert south of Walsgrave Junction lies within Flood Zones 2 and 3.
 - Smite Brook is throttled at the B4082 culvert and excess flow spills onto the B4082 which is located within Flood Zone 2.
 - Flood Zone 2 extends along Brinklow Road which passes beneath the A46, 600m south of the existing Walsgrave Junction.



Figure 8-2: Environment Agency Flood Zones





Hydraulic modelling

- 8.3.3. It is understood that the latest Environment Agency Flood Zones in the vicinity of Walsgrave Junction were derived from a hydraulic modelling study completed by AECOM for the options selection stage A46 Walsgrave Junction project (2022). The hydraulic model used for the options selection stage assessment was a 1D/2D model of the River Sowe, Withy Brook, Smite Brook and its tributaries. This model has formed the basis for this part of the assessment and has been updated to the latest versions of Flood Modeller Pro (v6.2) and TUFLOW (v2023-03-AA).
- 8.3.4. Updates were made to the options selection stage model to increase confidence in assessing the impacts of the Scheme on fluvial flood risk these are summarised below and include:
 - Hydrological estimates although, the options selection stage hydrological assessment, completed in 2021, used FEH methods to estimate design flows for input to the hydraulic model, a full hydrological assessment was carried out to make use of the latest releases of the NRFA peak flow dataset v12 (National River Flow Archive, 2024) and ReFH2 hydrology software v2.4 (Wallingford, 2023).
 - Digital Terrain Model the scheme wide topographic survey was commissioned for this assessment and used to increase the accuracy of the ground model.
- 8.3.5. The hydraulic model was simulated for the following AEPs (Annual Exceedance Probability):
 - 50% AEP (1 in 2-year event)
 - 5% AEP (1 in 20-year event)
 - 2% AEP (1 in 50-year event)
 - 1% AEP (1 in 100-year event)
 - 1% AEP + 32% CC (1 in 100-year plus 32% climate change event)
 - 0.1% AEP (1 in 1000-year event)
- 8.3.6. The 1% AEP + 32% climate change event is termed the 'design event'.
- 8.3.7. Baseline flood depth and extent maps are provided in Appendix Annex A. Further details on the hydraulic model build and results are provided in Annexpendix B.
- 8.3.8. The updated baseline model was reviewed by the Environment Agency which resulted in minor amendments to river chainage and bank levels. The Environment Agency approved the hydraulic model on 1st October 2024 (Appendix Annex C).



- 8.3.9. The updated hydrology reduced the peak inflows within the hydraulic model which resulted in reduced extents and depths.
- 8.3.10. The updated 1% AEP results predicted similar flood extents to those shown in the options selection stage Model / the Environment Agency Flood Zone 3 mapping (Figure 8-3). The updated 0.1% AEP results predicted similar flood extents to those shown in the options selection stage Model / Environment Agency Flood Zone 2 mapping (Figure 8-4). The greatest reduction in peak flows is within the eastern catchments of the Smite Brook and tributaries. These reductions in flows combined with smaller catchments and flatter floodplains resulted in this area having the largest reduction in flood extents.
- 8.3.11. The predicted flood extents along the Withy Brook and River Sowe remained generally unchanged.
- 8.3.12. Differences of note within the vicinity of Walsgrave Junction include Coombe Pool and the Birchley Beck floodplain. Due to modelling complexities the Coombe Pool reservoir is represented as a 1D storage node within the hydraulic model and does not show as 2D flooding which is used as basis for the flood mapping. The hydraulic model is truncated to the B4428 and any out of bank flooding upstream is not captured within the model.



Figure 8-3: Flood Zone 3 comparison

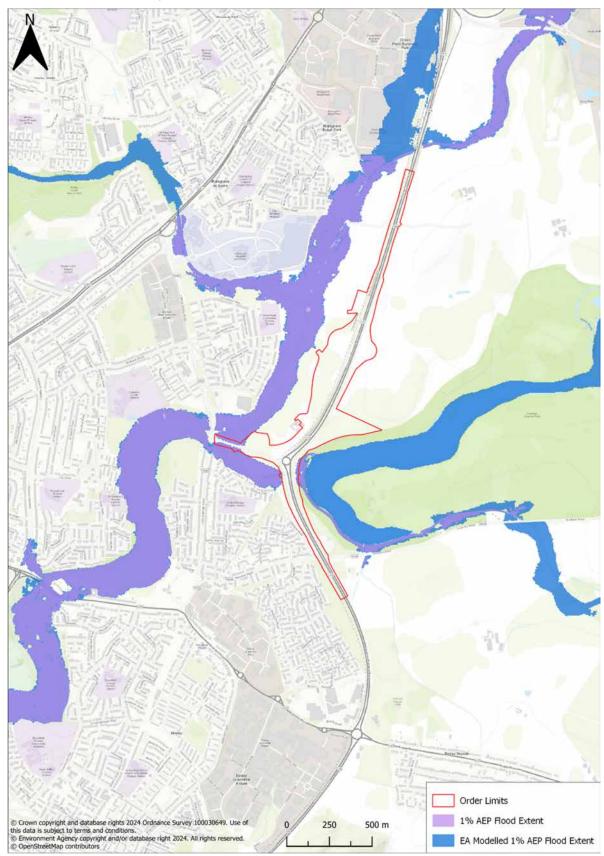
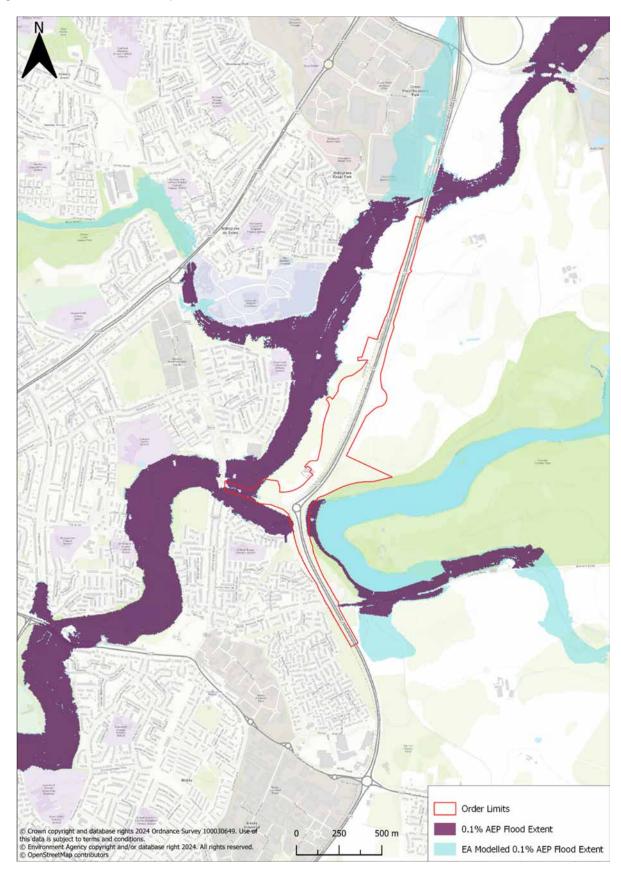




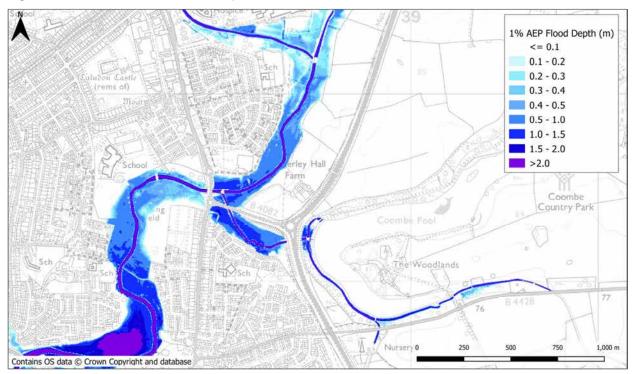
Figure 8-4: Flood Zone 2 comparison





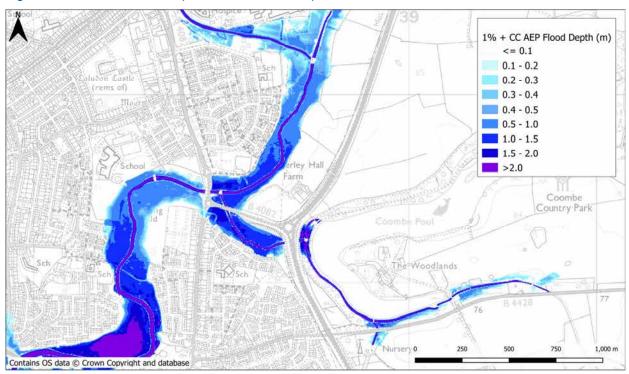
8.3.13. Figure 8-5 shows the predicted flood depths for the 1% AEP event within the vicinity of Walsgrave Junction.

Figure 8-5: Baseline 1% AEP flood depths



8.3.14. The baseline model was assessed against the long-term implications of climate change. Figure 8-6 shows the predicted flood depths for the 1% AEP plus 32% climate change event within the vicinity of the Walsgrave Junction.

Figure 8-6: Baseline 1% AEP plus 32% CC flood depths





Post-development

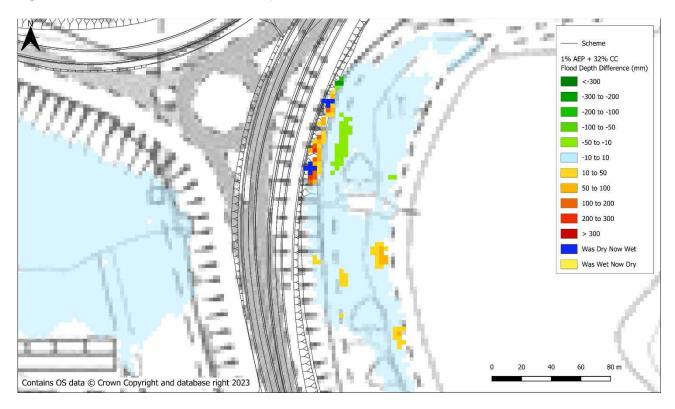
- 8.3.15. Changes were made to the hydraulic model to represent the Scheme. The Scheme 3D ground model was superimposed onto the baseline ground model and changes were made to roughness values to account for change in material.
- 8.3.16. The hydraulic model predicts the majority of the Scheme lies outside of the flood extents for the design event. The areas which are within flood extents for the design event, are limited to the area along the Smite Brook downstream of Coombe Pool. However, the hydraulic modelling demonstrates that these are largely within model tolerance (+/- 10mm), as shown in Figure 8-7 and Figure 8-8.

Scheme 1% AEP + 32% CC Flood Depth Difference (mm) <-300 -300 to -200 -200 to -100 -100 to -50 -50 to -10 -10 to 10 10 to 50 50 to 100 100 to 200 200 to 300 > 300 Was Wet - Now Dry Was Dry - Now Wet The Woodlands 250 500 1,000 m Contains OS data © Crown Copyright and database right 2023

Figure 8-7: 1% + 32% CC Scheme flood depth difference



Figure 8-8: 1% +32% CC Scheme flood depth difference of the A46 southbound embankment



- 8.3.17. The flood maps show that the Scheme does not result in changes in flood risk other than to some very limited areas of fluctuation around the upstream face of the A46 southbound embankment. This is due to a minor localised slackening of the embankment within the ground model which has created marginal additional floodplain storage. Slackening of the slope has resulted in increased depths along the embankment and a handful of additional model cells receiving flood waters.
- 8.3.18. This slackening has occurred as a result of the top layer of the existing southbound embankment being removed and replaced with a layer of clay. This is to prevent seepage and potential undermining of the proposed highway, during large magnitude flood events. The new top layer of the southbound embankment will be graded to match the existing slope (1 in 2.5) or shallower to ensure that the Scheme does not result in a loss / adverse change to the floodplain. There will be no earthwork volume gain (which would result in a loss of floodplain) between the existing and proposed southbound embankments below the design event plus 600mm freeboard level.
- 8.3.19. A comparison of modelled levels and flows taken from selected nodes upstream and downstream of the A46 Walsgrave Junction (Figure 8-9) are detailed in Table 8-1 and Table 8-2. The model predicts the Scheme has no impact on levels and a minor impact on flows. The changes in flow are a result of spikes in flow fluctuations as water is channelled through the A46 culvert and do not last for longer than a modelled timestep. The Scheme has no overall impact on the



shape and size of flow hydrograph passing through the culvert. The fluctuations subside downstream of the confluence with River Sowe and the Scheme has zero impact on the receiving watercourse.

Figure 8-9: Locations of reported 1D nodes

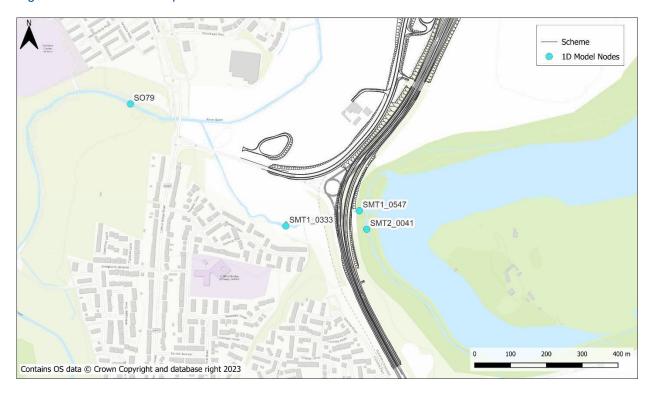


Table 8-1: Modelled flows taken from selected nodes within vicinity of the A46 Walsgrave Junction for the 1% AEP + 32% CC

1D Model Node	Baseline (m³/s)	Option (m³/s)	Change (%)
SMT2_0041	7.26	7.14	-1.65
SMT1_0547	18.11	18.66	3.04
SMT1_0333	22.45	22.34	-0.49
SO79	51.56	51.56	0.00

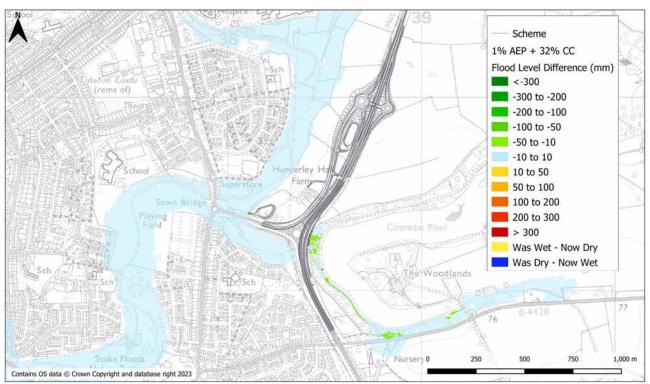
Table 8-2: Modelled levels taken from selected nodes within vicinity of the A46 Walsgrave Junction for the 1% AEP + 32% CC

1D Model Node	Baseline (mAOD)	Option (mAOD)	Change (%)
SMT2_0041	73.23	73.23	0
SMT1_0547	73.19	73.19	0
SMT1_0333	71.72	71.72	0
SO79	70.3	70.3	0



- 8.3.20. Appendix Annex D shows a cross-section taken at the existing embankment low point (75.44mAOD). Further information on the flood modelling is included in the Hydraulic Modelling Report (Annex ppendix B).
- 8.3.21. The Scheme model was run for an additional credible climate change scenario of 59% uplift to peak flow (Figure 8-10). As in the design event, the model predicts limited areas of fluctuation around the upstream face of the A46 southbound embankment due to the marginal floodplain storage created by the slackening of the embankment (Figure 8-11). This increase in depths is more pronounced in the 59% climate change run due to the increase in proposed flood level rising up the sloped embankment. In turn, this has resulted in a marginal decrease in depths propagated upstream along Smite Brook. Critically, the hydraulic model predicts the proposed embankment level of 74.0mAOD ensures no flooding to the highway and ensures the Scheme remains resilient to the credible maximum climate change scenario.

Figure 8-10: 1% + 59% CC Scheme flood depth difference





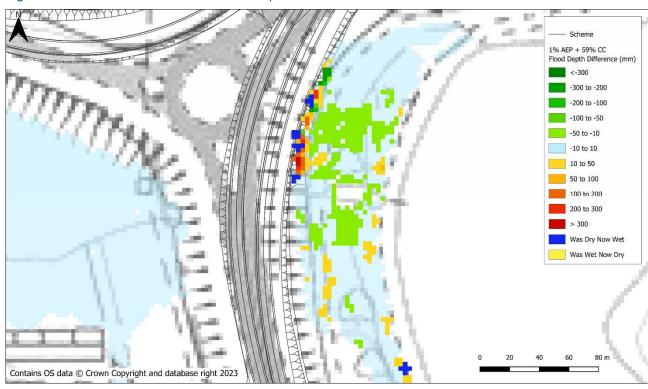


Figure 8-11: 1% + 59% CC Scheme flood depth difference of the A46 southbound embankment

Mitigation

- 8.3.22. The proposed A46 southbound carriageway level of at least 74.0mAOD is maintained the full length of the Scheme design. This ensures no flooding of the carriageway itself during the design event and ensures the Scheme adheres to DMRB LA 113 guidance for projects on motorways.
- 8.3.23. The proposed southbound embankment will be graded to existing slope or shallower and ensures no net gain in material below the design level. Therefore, there is no loss of floodplain and thus flood compensatory storage is not required for the Scheme.

Summary

8.3.24. A fluvial source of flooding is present adjacent to the Scheme, and hydraulic modelling has been used to quantify this risk. The hydraulic modelling predicts the Scheme does not result in changes in fluvial flood risk other than to some very limited areas of fluctuation due to a proposed slacker slope along the A46 southbound embankment. The Scheme does not result in a loss / adverse change to the floodplain and no flood compensation is required. The Scheme ensures no flooding of the carriageway during the design event and the Scheme will remain safe for its 100-year design life.

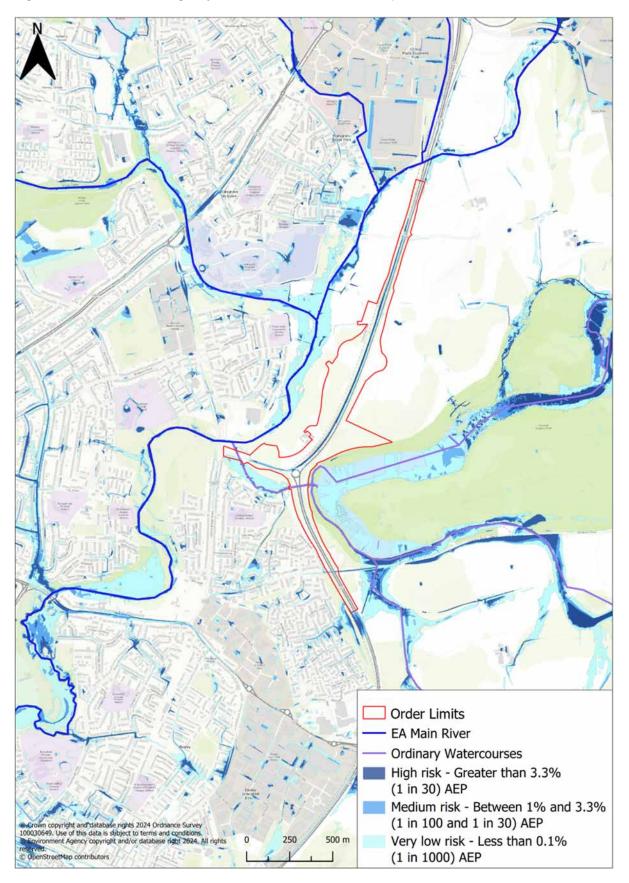


8.4. Pluvial (surface water) flood risk Baseline

- 8.4.1. Pluvial flooding is caused when the capacity for managing large volumes of rainfall is exceeded. The overland flow is guided by topographical features and accumulates in areas of low-lying topography and along barriers. Saturated ground conditions can also result in surcharged drains and sewers which are then unable to convey surface water away.
- 8.4.2. The Environment Agency Long-term Flood Risk Map (Environment Agency, 2024b) indicates that the Order Limits lie in areas of very low, low, and high surface water flood risk (Figure 8-12). High flood risk areas are along the existing A46 carriageway and B4027. There is also a high risk of pluvial flooding to the south of the Walsgrave Junction where Smite Brook is culverted beneath the A46. This map does not show any additional flow routes across the Scheme than assessed in the fluvial flood risks section, noting that the mapping does show a primary overland flow route along the A46. It is important to note that the Environment Agency long-term flood risk map is a broad-scale mapping and does not explicitly take into account surface water drainage.



Figure 8-12: Environment Agency Surface Water Flood Risk Map





Post-development

- 8.4.3. The Scheme has the potential to increase surface water runoff rate and volume due to increases in areas of hardstanding. An increase in the rate of surface water runoff tends to exacerbate downstream flood risk by, for example, overloading sewers or gullies, exceeding the capacity of watercourses, culverts and other associated drainage infrastructure. All surface water runoff would be discharged to ground.
- 8.4.4. The Scheme is predominantly surrounded by agricultural land which can be expected to generate runoff at typical greenfield rates. An increase in areas of hardstanding as part of the Scheme will, without mitigation, alter and increase rates and volumes of runoff when compared to greenfield conditions. Any interception of surface water flood flow pathways made by construction of the Scheme could cause localised flooding by diverting flood risk on to others or to the Scheme itself.

Mitigation

- 8.4.5. A drainage strategy has been developed for the Scheme that aims to reduce the impact of pluvial flood risk through the use of SuDS. The drainage strategy ensures that surface water flow routes are managed within the Scheme and would not pose an increase in surface water flood risk to others.
- 8.4.6. The drainage strategy states that where possible, the proposed drainage will replicate the existing drainage arrangement and conditions. Surface water will be collected through a combination of gullies, surface water channels and filter drains. The run-off would then be conveyed to outfalls via a combination of carrier drains, ditches and attenuation basins.
- 8.4.7. A visual site walkover survey was undertaken on 19 February 2024, to observe the existing ditches, west of the A46 mainline. The walkover survey confirmed that there is a continuous flow path from the proposed outfall location, westward into the River Sowe via a ditch network. The ditch was observed to have a consistent channel profile, except for two culverted sections. However, water was observed flowing through the culverts. A topographical survey of the ditch confirms the observations made on site.
- 8.4.8. The preliminary design stage Drainage Strategy Report (National Highways, 2024) proposes to use a single outfall from the northern catchments, into the adjacent ditch watercourse, that flows west into the River Sowe. This will provide a sustainable solution, that will provide enhanced water treatment to flows entering the River Sowe. Flows from the new impermeable area will be restricted to the greenfield runoff QBAR (mean annual flood), with the intention to not exceed the capacity of the ditch. Providing enhanced water treatment at outfall



- and discharging at greenfield runoff rates will ensure the design provides a betterment and reduce the risk of pluvial flooding.
- 8.4.9. There are no new proposed outfalls to drain the southern catchments of the A46. The existing outfalls drain southern catchments directly into Smite Brook.
- 8.4.10. A kerb and gully system is proposed to the B4082, whereas a more rural approach, without a kerb, is proposed for the rest of the Scheme. Gullies would be designed in accordance with DMRB CD526.
- 8.4.11. The drainage strategy proposes attenuation in the form of detention basins. The detention basins will capture and hold runoff from the Scheme to mitigate the impact of surface water flooding. Outflow would be controlled through orifices or vortex flow controls, depending on the preference of the adopting authority. The detention basins would be designed to allow for minimum 300mm freeboard in the event of rainfall of 100-year return period with 20% climate change. A sensitivity test would be carried out for 40% climate change to ensure the proposed basin does not flood.
- 8.4.12. The drainage basis of design includes modelling of the proposed drainage networks (Drainage Strategy Report, National Highways, 2024). The summary of the modelling results are given in Table 3-6 of the drainage strategy report.
- 8.4.13. The modelling results demonstrate that the proposed flows will be controlled to replicate the existing scenarios.
- 8.4.14. The proposed drainage strategy mitigates any increase in pluvial flooding as a result of the Scheme.

Summary

8.4.15. A pluvial source of flooding is present adjacent to the Scheme and analysis of the long term surface water flood risk map and comparison with the post-development arrangement has been used to quantify this risk. Mitigation is proposed in the form of a drainage strategy which includes a combination of gullies, surface water channels, filter drains and attenuation in the form of detention basins to capture and hold surface water runoff. The mitigation ensures flows from the new impermeable area will be restricted to greenfield runoff rates and that the development remains safe for its 100-year design life.

8.5. Groundwater flood risk

8.5.1. The following groundwater information is based upon the groundwater assessment in Appendix 13-4 of the Environmental Statement (TR010066/APP/6.1).

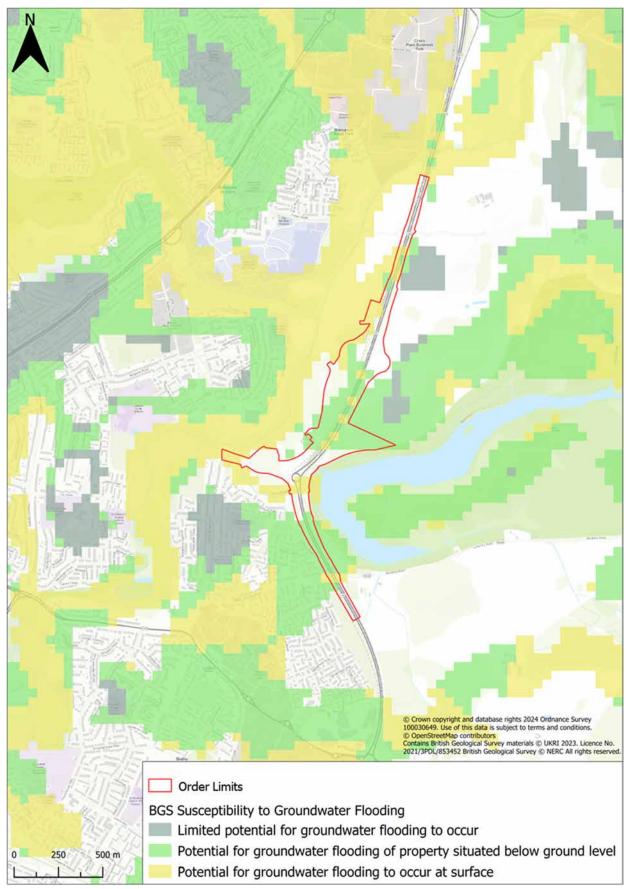


Baseline

- 8.5.2. The WCC and CCC SFRAs indicate the susceptibility to groundwater flooding within the Scheme area to be between 25% and 75%.
- 8.5.3. The BGS susceptibility to groundwater flooding map (Figure 8-13) indicates that much of the Scheme area has the potential for groundwater flooding to occur at surface or the potential for groundwater flooding of property situated below ground level. Permeable superficial deposits associated with the River Sowe and Smite Brook have potential for groundwater flooding to occur at surface, including where Smite Brook crosses the Scheme.
- 8.5.4. Groundwater levels across the study area are highest in proximity to Hungerley Hall farm at the local groundwater high (WS103, BH109, 110, 111 and 112) and to the north-east of the Order Limits at WS106 and BH123 across a range of different aquifers. It is therefore assumed that there is a moderate level of continuity between aquifer units and water level is more closely related to topographical variation, this is also evidenced by groundwater level lows in proximity to the River Sowe and Smite Brook, which receive a component of baseflow from groundwater.
- 8.5.5. It should be noted, the derived BGS groundwater susceptibility dataset is hazard based not risk-based and has an effective resolution of 50m by 50m.
- 8.5.6. The Groundsure report within Appendix C of the options selection stage Preliminary Sources Study Report (National Highways, 2021b) indicates no reported incidents of groundwater flooding within the Scheme area at the time the report was prepared but does note there is a moderate to high risk due to where the River Sowe intrudes into the Order Limits.
- 8.5.7. Climate change predictions suggest that the future annual recharge volumes for groundwater are broadly stable although the groundwater recharge season is likely to condense into a shorter period, leading to more variable groundwater levels and a greater drought vulnerability.



Figure 8-13: BGS susceptibility to groundwater flooding





Post-development

- 8.5.8. Operation of the Scheme has the potential to increase groundwater flooding as a result of:
 - increased discharges to groundwater due to routine road drainage such as filter drains locally increasing groundwater levels
 - road cuttings intercepting shallow groundwater levels
 - redirection of shallow groundwater flows and groundwater mounding around underground structures
- 8.5.9. These are all of particular concern when occurring in areas where there is a potential for groundwater flooding to occur both at surface and below ground.

Mitigation

8.5.10. Mitigation to address groundwater flood risks will be embedded into the Scheme design. Any additional volumes of groundwater that may enter the road drainage system will be included in the road drainage strategy. Additional sub-surface drainage will be included in areas with shallow groundwater levels to reduce the risk of flooding. The groundwater assessment takes into account risks to groundwater and is used to inform both road drainage and structures design.

Summary

8.5.11. Large areas of the Scheme have the potential for groundwater flooding, this FRA and the groundwater assessment have been used to quantify this risk. The Scheme has the potential to increase groundwater flooding. However, additional volumes of groundwater that may enter the road drainage system will be included in the road drainage strategy. As well as this, additional sub-surface drainage will be included in areas with shallow groundwater levels to reduce the risk of flooding. This ensures that the development remains safe for its 100 year design life.

8.6. Artificial infrastructure

Baseline

Sewers

8.6.1. The Scheme borders the eastern edge of the City of Coventry, however, lies within a predominantly rural area to the east. The only drainage infrastructure in the surrounding area is pertinent to the existing A46 carriageway and the B4082 leading to the Walsgrave Junction. Only the areas west of the Order Limits are contained within an urbanised area of Coventry. Information via DDMS shows the drainage network of the existing A46 carriageway is isolated from the local networks.



8.6.2. The WCC SFRA shows no instances of sewer flooding in the Scheme area. However, the CCC SFRA indicates there have been two instances of sewer flooding within the CV3 2 postcode area. The CV3 2 postcode area incorporates the majority of the Scheme. Although the location of the two incidents of sewer flooding is unknown.

Summary

8.6.3. A risk of flooding from sewers has been identified. However, the baseline risk of flooding from sewers is low. The Scheme does not increase the risk of flooding from sewers and the development will remain safe for its 100-year design life.

8.7. Reservoir Flood Risk

- 8.7.1. Although the PPG includes reservoir flooding as a source of potential flood risk to schemes, it goes on to state that flooding caused by a failure of a reservoir is a residual risk. The PPG outlines that the residual flood risk should be minimised as the sequential test (Section 3) is unable to steer development to lower risk areas and the design needs to ensure people are not exposed to hazardous flooding, irrespective of the development's vulnerability classification.
- 8.7.2. A residual risk is one that remains after taking mitigating actions. The mitigating actions in this case are that across England and Wales there is a robust legislative approach to the management of reservoirs, as they are regulated under the Reservoirs Act 1975, as amended by the Flood and Water Management Act 2010, and this is enforced by the Environment Agency in England. The Reservoirs Act requires all undertakers (owners / operators) of reservoirs to register them with the Environment Agency. Those designated high-risk (such as Coombe Pool, which is owned and maintained by CCC (the undertaker)) are subject to inspection and supervision (at all times) by reservoir engineers. The undertakers are required to follow these recommendations and/or directions of the reservoir engineers to reduce the risk of dam failure. The compliance of the undertakers to follow these recommendations/directions is monitored by the Environment Agency.
- 8.7.3. Furthermore, although the consequences of a sudden reservoir embankment failure would be extremely severe, regulators within the UK consider that "Reservoir Flooding is extremely unlikely to happen" (Natural Resources Wales, 2023). Furthermore, there has been no loss of life in the UK from reservoir flooding since 1925 (Environment Agency, 2011).

Baseline

8.7.4. The best available information on the potential flood risk associated with a failure of Coombe Pool is available from the Environment Agency's reservoir flood maps. These maps are derived from the Environment Agency Reservoir Flood

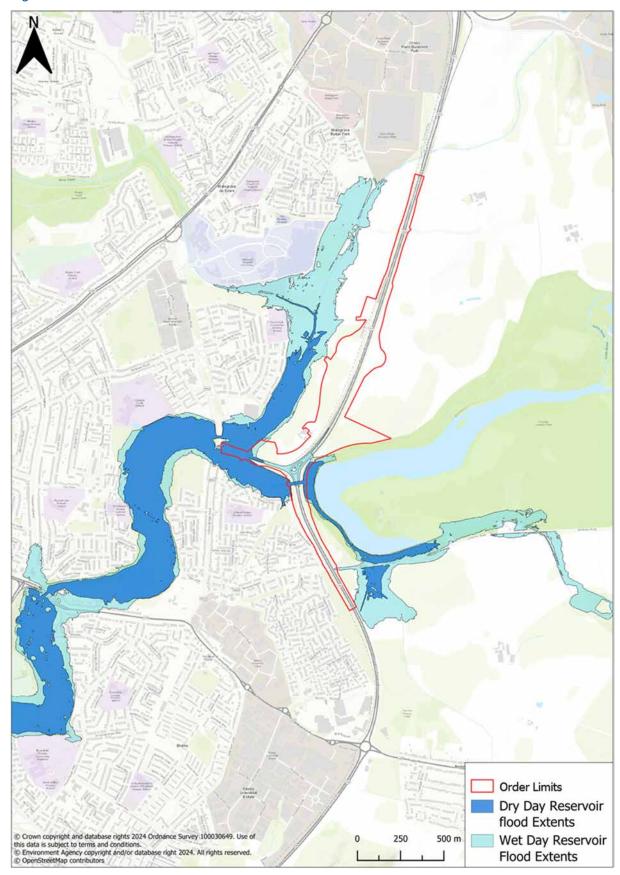


Mapping (RFM) hydraulic modelling, which was completed in 2020. The maps show where water may go in the unlikely event of a reservoir failure. The publicly available maps predict two flooding scenarios:

- Dry Day scenario Flooding that would occur if the reservoir failed when river levels are at a 'normal' level.
- Wet Day scenario Flooding that would occur if the reservoir failed when rivers are experiencing an extreme natural flood (0.1% AEP).
- 8.7.5. The wet-day and dry-day flood extents for the Scheme area are shown in Figure 8-14. The dry-day flood extents largely resemble the predicted 1% AEP plus 32% climate change fluvial flood extents modelled for this assessment albeit with increased predicted extent along Smite Brook and its tributaries. The wet-day extents show significantly increased floodplain coverage including a section of the A46 adjacent to the Coombe Pool spillway.



Figure 8-14: Reservoir flood extents





- 8.7.6. The Environment Agency advise that whilst the maps were originally developed for emergency planning purposes they can be used for other purposes. However, care should be taken to understand the limitations of the maps and the assumptions made in the modelling before using the maps for other purposes.
- 8.7.7. The Environment Agency have stated (Appendix Annex E) that they are unable to provide the underlying model for interrogation / use in this study to enable an assessment to be undertaken as to how the Scheme may impact the associated flood risk. This is because they perceive that the use of the information in this instance "would adversely affect National Security and Public Safety". Whilst they have made some additional GIS based information available to National Highways, this will not aid the assessment for the details outlined below.
- 8.7.8. Despite being unable to release the information to National Highways, the Environment Agency have previously released their underlying model to CCC for further investigation of the flood risks associated with failure of the reservoir, as part of the Coombe Pool Modelling Report (JBA Consulting, 2021).
- 8.7.9. The Coombe Pool Modelling Report builds upon the Environment Agency's RFM model, which was a national desk-based assessment which did not include accurate detail of structures. Therefore, the Coombe Pool Modelling Report improved the modelled representation of both the B4082 and A46 Smite Brook culverts based upon estimated structure dimensions from photographs (i.e., not from a topographical survey). Despite these improvements, the report highlights that the model still did not provide realistic water levels upstream of the A46 southbound embankment, as it states, "the modelling needs to assume a breach of the A46 to prevent artificial water levels emerging on the upstream side of the A46 embankment". The report does not provide any further details as to why a breach was required or indeed how it was modelled (i.e., the associated width and height). Therefore, it has to be assumed that this is due to model instabilities from significant volumes of impounding water discharging from Coombe Pool into Smite Brook.
- 8.7.10. As the underlying model (along with sufficient information regarding the embankment breach, including its width and invert levels in relation to the estimated A46 culvert) is not available to inform this study, the subsequent flood maps cannot be considered to suitably represent the baseline scenario. Indeed, the inclusion of the breach may be more representative of the post development scenario.
- 8.7.11. As a result of the uncertainties in the Environment Agency's RFM, the Coombe Pool Modelling Report attempted to provide an alternative assessment of potential intervention scenarios, by starting the model downstream of the A46 (i.e., removing both the A46 culvert and the embankment breach) and



representing the flows through the A46 culvert via a variation of the orifice equation shown below:

$$Q = CA\sqrt{2g(h1 - h2)}$$

- 8.7.12. However, no further information is provided in the report, so it is therefore assumed h1 and h2 represent a head gradient through the structure, but it is not possible to give any weight to the subsequent findings. Especially, as the report highlights the limitations in the method and states how it may not be representative of the structure conditions in the real breach event.
- 8.7.13. This assessment was undertaken for three A46 culvert blockage scenarios:
 - 0% blocked scenario
 - 66% blocked scenario
 - 100% blocked scenario
- 8.7.14. As would be expected, both the 0% blockage and 66% blockage scenarios predicted a reduction in affected downstream properties compared to the Environment Agency RFM outputs. This is considered likely due to the removal of the artificial A46 embankment breach and the reduction in volumes passed downstream through the culvert blockage. Whilst the 100% blockage scenario was a volume assessment of the area upstream of the A46 culvert which lies below the top water level of the reservoir. The extent resembles the Environment Agency RFM Dry Day flood extent.
- 8.7.15. The Coombe Pool Modelling Report concludes that in the unlikely event of a breach of the Coombe Pool dam (which is considered a residual risk by the PPG) then "by allowing less water to pass through the A46 embankment there is a lower risk to properties within Coventry." In order "to achieve this however, it is fundamental the A46 embankment remains intact and can withstand a reservoir breach."
- 8.7.16. CCC have also completed a feasibility study, the Coombe Pool Flood Risk Mitigation Scheme (FRMS) (Coventry City Council, 2022), that focused on the implications of a fluvial event within the catchment (the 1% AEP plus climate change event in the Coombe Pool catchment) with no reservoir breach to Coombe Pool itself. High level estimations were made for the hydrological inflows with no consideration for detailed hydraulic modelling. This identified that potential mitigation options include:
 - steel sheet pile barrier within A46 embankment.
 - reinforced concrete retaining wall within A46 embankment



- natural stone revetment constructed into A46 embankment
- 8.7.17. However, importantly CCC recognise in the report that the A46 embankment is unlikely to have been built to a standard required to function as a water retaining structure to enable it to serve as a secondary line of defence. Therefore, it is considered unlikely that the benefits outlined in the CCC assessment could be achieved, without significant engineering works for which CCC have been unable to secure funding.

Post-development

- 8.7.18. The Scheme includes the removal of the existing roundabout and widening of the existing highway. However, as a result of the alignment of the existing highway and the curvature of the bend, the widening of the road has to occur on the eastern side. This results in the need to reduce the height of the A46 southbound embankment (which currently extends higher than the elevation of the road). There is no potential to maintain the current height of the A46 southbound embankment as this would result in additional land take and incurring substantial loss / adverse impacts to Coombe Pool SSSI, biodiversity (especially tree coverage) and adverse impacts on the reservoir.
- 8.7.19. Additionally, the Scheme will result in an alignment which requires the existing speed limit to be reduced from 70mph to 50mph throughout the extents of the Scheme. It is not possible to alter the curvature of the bend further to reduce the impacts on the A46 southbound embankment without further reductions in speed limit. Any further reductions are not feasible whilst maintaining the traffic flows within the strategic road network.
- 8.7.20. Although the top level of the highway embankment is reduced due to the Scheme, as previously outlined, CCC acknowledge that it is unlikely the embankment was constructed to have a flood defence function. In the event of a reservoir breach, the flows would likely be of such a magnitude that under both the baseline and Scheme scenarios the topsoil of the highway embankment will likely be compromised and washed away until the level of the surface of the carriageways is reached, as the hard top of the highway itself would prevent further erosion, this is therefore considered the critical level for assessing the impacts of the residual risk associated with reservoir failure.
- 8.7.21. A comparison of long sections taken along the existing and proposed highways has been undertaken (appendix Annex F), this shows that between existing bund chainage 340m and 660m, the proposed A46 Northbound carriageway levels are above the existing A46 Northbound carriageway levels. Beyond chainage 660m, the proposed A46 Northbound proposed carriageway levels drop below the existing.



- 8.7.22. However, the B4082 lies to the west of the junction and is being upgraded as part of the Scheme. Beyond chainage 660m, the Scheme proposes to raise the B4082 carriageway levels between chainage 660m to 910m, above the existing A46 Northbound carriageway levels.
- 8.7.23. The combined effect of the A46 Northbound carriageway and the B4082 ensures the proposed highway is above existing for the full extent of the location of a Coombe Pool reservoir breach.
- 8.7.24. During a reservoir breach, the hardtop of the highway will form a barrier to flow. In the vicinity of Coombe Pool, the proposed highway levels are above that of existing. Therefore, the Scheme does not increase the residual risk of reservoir flood risk due to lowering of the highway embankment.
- 8.7.25. Furthermore, in the post-construction scenario the A46 will:
 - ensure users are not exposed to hazardous flooding for the 1% AEP plus climate change fluvial event
 - be of sufficient height to provide continued protection downstream for the 1% AEP plus climate change fluvial level.
- 8.7.26. The inclusion of the clay layer will help to reduce the likelihood of the A46 becoming significantly breached and hopefully give CCC additional time to implement the emergency plan. This emergency plan should include measures (including warnings and alerts) to enable National Highways to manage traffic flows (potentially including closure of appropriate sections of the A46) to reduce the risk of users of the Scheme. However, as in the baseline scenario this remains a residual risk.
- 8.7.27. The DEFRA / Environment Agency Evidence Report (SC080046/R1) Lessons from historical dam incidents, outlines that "Tighter emergency management procedures can reduce the likelihood of failure and risk of casualties should a failure occur."
- 8.7.28. It is the responsibility of CCC (as the undertaker) to maintain the asset to a high standard to prevent the unlikely event of reservoir breach to occur.

Mitigation

- 8.7.29. No mitigation, beyond that embedded within the Scheme design is required as part of the Scheme to manage reservoir flood risk.
- 8.7.30. It is considered that the residual risk is safely managed as the CCC emergency planner will already have an emergency plan in place to manage the risk of reservoir flooding and that this should be sufficient to manage the risk post-scheme.



9. Construction related flood risk and mitigation

9.1. Flood warning service

9.1.1. A flood emergency response plan will be developed as part of the Second Iteration Environmental Management Plan (EMP) to manage the flood risk impacts during construction and to ensure construction workers are not exposed to increased levels. The Scheme is within an area that receives Environment Agency flood warnings and alerts, and the contractor should sign up for West Midlands alerts and areas near the Walsgrave Junction. The flood emergency response plan shall specify safe access and egress routes for all construction areas in the event of anticipated flooding.

9.2. Construction related flood risk

- 9.2.1. This section details the potential impacts on flood risk to the Scheme and elsewhere during the construction phase. Further details of the construction approach are available in Volume 6 of the Environmental Statement, Chapter 2 The Scheme (TR010066/APP/6.1).
- 9.2.2. During construction there would be an increase in new areas of hardstanding, including the compounds and infilling of ponds, which, if not mitigated, would increase the volume and flow rate of runoff from the construction areas. This could result in increased localised flooding to the Scheme and other flood-sensitive downstream receptors. Additionally, this could adversely impact upon downstream flood-sensitive receptors, aquatic environments, value to economy, water quality and recreational users of surface water features. These features include the River Sowe, Smite Brook, Withy Brook, Coombe Pool, and ordinary watercourses including Birchley Beck and an unnamed tributary.
- 9.2.3. It should be noted, there are no proposed temporary laydown areas or construction compounds within the floodplain that would lead to the displacement of flood waters.
- 9.2.4. During construction, there is an increased risk of flooding during and following extreme rainfall events, including those areas identified as at risk of surface water flooding. Works may lead to temporary changes in the surface water runoff regime by the alteration of ground elevations and overland flow pathways. This could cause localised flooding to the Scheme and nearby receptors due to changes in surface water flow pathways. Indirectly, overloading of the temporary drainage system could adversely impact on surface water features including the River Sowe, Smite Brook, Withy Brook, Coombe Pool, and ordinary watercourses including Birchley Beck and an unnamed tributary.



- 9.2.5. During construction, there is an increased risk of groundwater flooding. The increase to groundwater flood risk includes the removal of topsoil allowing for additional recharge to groundwater and any excavation works that may intercept shallow groundwater (i.e., drainage pond construction, excavate and replace ground treatment works at the overbridge bankseat abutment and construction of road cuttings). These are all of particular concern when occurring in areas where there is a potential for groundwater flooding to occur both at surface and below ground.
- 9.2.6. Construction dewatering will be required to control groundwater seepages into excavations and from cutting slopes. Discharges associated with these activities may also increase flood risk however. Although the temporary dewatering discharge points are yet to be confirmed they may either be direct to ground via infiltration galleries or to surface water bodies. Any infiltration galleries placed in locations of shallow groundwater may result in groundwater mounding and increased groundwater flood risk. Alternatively, groundwater discharges to surface water bodies may temporarily increase the flood risk to downstream areas.

9.3. Mitigation of construction related flood risk

- 9.3.1. This section sets out the proposed mitigation to ensure the construction phase of the Scheme is not at significant flood risk to construction workers nor does it pose additional flood risk elsewhere.
- 9.3.2. Any temporary drainage arrangements would be implemented before construction of the relevant section. The potential increase in flood risk and negative impacts on surface water receptors shall be managed by the implementation of a construction-phase drainage system, where the construction will take place offline.
- 9.3.3. During construction, best practice methods for mitigation of temporary flood risk to and from the Scheme will be implemented as part of the wider EMP.
- 9.3.4. A temporary works drainage strategy shall be specified within the EMP that will include measures to attenuate runoff from construction sites, compounds and material lay down areas. In addition, the temporary works drainage strategy will propose how flood risk from surface water flow pathways will be managed. SuDS will be implemented to attenuate runoff to greenfield runoff rates, or as a minimum for existing road drainage or impermeable areas, existing runoff rates as well as provide water treatment. Discharges to surface water or ground will only be made with the appropriate consents or permits in place and infiltration features will be suitably designed that consider local ground conditions.



9.3.5. Suitable and proportional mitigation measures will be implemented during the design phase to mitigate the risk of groundwater flooding. Preliminary dewatering assessments are undertaken to identify any structures or excavations requiring dewatering, including consideration of the discharge arrangements. Groundwater level monitoring prior to and during the construction phase will help to inform the assessments and therefore mitigate the risks of groundwater flooding.



10. Part b of the Exception Text

- 10.1.1. The above sections of the FRA demonstrate compliance with Part b of the Exception Test, as set out in paragraph 170 of the NPPF. This is how the development will be safe for its lifetime taking account of the vulnerability of its users and without increasing flood risk elsewhere.
- 10.1.2. Following Acceptance of the Application for Development Consent, the Planning Inspectorate responded to this FRA by providing section 51 advice in a letter dated 12 December 2024 (TR010066-s51 advice), stating the following:
- 10.1.3. "Whilst it is noted that the exception test appears to consider the requirements of Flood Zone 3b, the FRA does not provide specific information to differentiate between land within Flood Zones 3a and 3b. It is also unclear from the information presented whether the Proposed Development would result in no net loss of floodplain storage. The Applicant should respond to the Inspectorate as soon as practicable to confirm the location and extent of Flood Zones 3a and 3b and how this corresponds to the application of the exception test and the proposed flood mitigation/ compensation. If components would be located within Flood Zone 3b, the Applicant should provide confirmation that there would be no net loss of floodplain storage, in line with the principles of the exception test."
- 9.3.5.10.1.4. The Applicant's response to the section 51 advice is contained in Annex G, a technical note, which provides further clarity and links to key sections of this FRA to demonstrate that Part b of the Exception Test is passed.



10.11. Conclusion

- 10.1.1.1.1.1. The assessment of flood risk to the Scheme and the risk posed by the Scheme has been undertaken in accordance with the NPS NN, the NPPF, its associated PPG for flood risk and coastal change along with the DMRB LA 113.
- 10.1.2.11.1.2. In line with the NPS NN a FRA should identify and assess the risks of all forms of flooding and coastal erosion to and from the project and demonstrate how these flood risks will be managed, taking climate change into account. This FRA has identified and assessed all risks of all forms of flooding present and the latest climate change allowances within accordance to the DMRB LA 113 and meeting the requirements of the NPPF.
- 10.1.3. 11.1.3. The Flood Risk and Coastal Change PPG utilises Flood Zones to indicate the probability of river and coastal flooding. These Flood Zones are considered within this FRA and the Flood Risk and Coastal Change PPG advises this FRA upon how to take account of and address the risks associated with flooding and coastal change in the planning process.
- 40.1.4. 11.1.4. Local planning policies relative to the Scheme have been considered within the FRA. The CCC and RBC Local Plans describe local policies such as Flood Risk Management, Planning for Climate Change Adaptation and SuDS. This FRA has identified the flood risk of each source, accounted for future climate change and evaluated the proposed flood risk management strategies and SuDS to determine the residual risk to the Scheme.
- <u>10.1.5.11.1.5.</u> According to the Environment Agency's Flood Map for Planning, the majority of the Scheme is located within Flood Zone 1. However, there are areas located within Flood Zones 2 and 3. The flood risk maps indicate the Scheme is not in an area benefitting from flood defences. The Scheme is not at risk of tidal flooding.
- 40.1.6. 11.1.6. Hydraulic modelling of the River Sowe, Withy Brook, Smite Brook and its tributaries was carried out to increase confidence in assessing the impacts of the Scheme on fluvial flood risk. The model results predicted similar flood extents to those shown in the Environment Agency flood maps albeit with slight reductions in flood extents in the Smite Brook and its tributaries.
- 10.1.7.11.1.7. The hydraulic model demonstrates that the majority of the Scheme lies outside of the design event extent. This resulted in changes to flood depths local to Walsgrave Junction virtually all within the model tolerance of +/- 10mm. The proposed A46 southbound carriageway level of at least 74.0mAOD (the 1% AEP plus climate change and 600mm freeboard) is maintained the full length of the Scheme design. This ensures no flooding of the carriageway itself and



ensures the Scheme adheres to DMRB LA 113 guidance for projects on motorways.

- The Scheme includes the widening of the road on the eastern side. This results in the need to reduce the height of the A46 southbound embankment. Whilst the height of the embankment will be reduced, it will remain at a sufficient elevation to provide continued protection for the 1% AEP plus climate change fluvial level with an addition of 600mm freeboard. Therefore, in the post construction scenario the A46 will ensure users are not exposed to hazardous flooding for the 1% AEP plus climate change fluvial and the A46 southbound embankment will remain at sufficient height to provide continued protection downstream for the 1% AEP plus climate change fluvial level.
- that most of the Scheme is at very low risk from surface water map indicates that most of the Scheme is at very low risk from surface water flooding. There are areas where the risk of surface water flooding is identified as being low to high, with significant high-risk areas being observed along the western edge of the A46 extending northwards within the Order Limits.
- 10.1.10.11.1.10. Increase in areas of hardstanding due to the Scheme will, without mitigation, alter and increase rates and volumes of runoff when compared to greenfield conditions. To combat the potential increase in pluvial flooding, mitigation measures such as SuDS and attenuation ponds will be implemented. Attenuation in the form of detention basins will capture and hold runoff from the additional hardstanding proposed within the Scheme to mitigate the impact of surface water flooding. The proposed SuDS system includes a kerb and gully system along the B4082. For the more rural areas outside of the strategic road network and the B4082, a more suitable approach (i.e., without a kerb) is proposed.
- 10.1.11. The WCC and CCC SFRAs indicate the susceptibility to groundwater flooding within the Scheme area to be between 25% and 75%. The groundwater flood risk figure indicates that much of the Scheme area has the potential for groundwater flooding to occur at surface or below ground level. Groundwater flood risk mitigation is embedded into the Scheme design through inclusion of sub-surface drainage for structures and consideration of additional groundwater flows to the drainage design.
- 40.1.12.11.1.12. With regard to the residual risk, the reservoir flood model extents show the dry-day flood extents largely resemble the predicted 1% AEP plus 32% climate change fluvial flood extents modelled for this assessment albeit with increased predicted extent along Smite Brook and its tributaries. The wet-day extents show significantly increased floodplain coverage including a section of the A46 adjacent to the Coombe Pool spillway.



- 40.1.13. However, the Environment Agency have stated that they are unable to provide the underlying model for interrogation / use in this study to enable an assessment to be undertaken as to how the Scheme may impact the associated flood risk. This is because they perceive that the use of the information in this instance "would adversely affect National Security and Public Safety". As the underlying model is not available to inform this study, the subsequent flood maps cannot be considered to suitably represent the baseline scenario.
- 10.1.14.11.1.14. No mitigation, beyond that embedded within the Scheme design is required as part of the Scheme to manage the residual reservoir flood risk.
- 10.1.15. A flood emergency response plan will be developed as part of the EMP to manage the flood risk impacts during construction and to ensure construction workers are not exposed to increased levels.
- 40.1.16.11.1.16. During construction there would be an increase in new areas of hardstanding, including the compounds and infilling of ponds, which, if not mitigated, would increase the volume and flow rate of runoff from the construction areas to downstream receptors. During construction, there is an increased risk of flooding following extreme rainfall events. Works may lead to temporary changes in the surface water runoff regime by the alteration of ground elevations that could cause localised flooding to the Scheme. During construction, there is an increased risk of groundwater flooding from the removal of topsoil allowing for additional recharge to groundwater and any excavation works that may intercept groundwater. Construction dewatering discharges may also either increase groundwater flood risk, at the location of infiltration galleries or increase flood risk to downstream areas if discharged to surface water bodies. Groundwater level monitoring prior to and during construction and preliminary dewatering assessments undertaken at design stage will identify any areas requiring dewatering, and allow for suitable and proportional mitigation measures.
- 40.1.17.11.17. A construction-phase drainage system will manage any increase in flood risk during the construction phase. Any temporary drainage arrangements would be implemented before construction of the relevant section. During construction, best practice methods for mitigation of temporary flood risk to and from the Scheme will be implemented as part of the wider EMP. A temporary works drainage strategy shall be specified within the EMP that will include measures to attenuate runoff from construction sites, compounds and material lay down areas. SuDS will be implemented to attenuate runoff to greenfield runoff rates, or as a minimum for existing road drainage or impermeable areas, existing runoff rates as well as provide water treatment. Discharges to surface water or ground will only be made with the appropriate consents or permits in place.



- <u>11.1.18.</u> The Scheme has been identified as the only reasonable site. The Scheme has therefore passed the sequential test however, an exception test is required.
- 10.1.18.11.1.19. -This FRA (in conjunction with the Drainage Strategy Report, National Highways 2024) demonstrates that the Scheme will be safe for its lifetime and will not increase flood risk elsewhere. This is achieved through:
 - ensuring the A46 southbound embankment remains set above the 1% plus climate change flood level
 - improvements to the structure of the A46 southbound embankment to enable it to act as a secondary defence
 - __inclusion of SuDS to manage the surface water runoff from the additional areas of hardstanding.
 - Not increasing flood risk within Flood Zone 3b with no requirement for floodplain compensation.
- 10.1.19.11.1.20. Therefore, the Scheme meets the requirements of the exception test and the flood risk requirements of the NPS NN section 5.94.



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Annex A. Flood maps

Figure A1: Baseline Flood Extents

Figure A2: Baseline 50% AEP Depth

Figure A3: Baseline 5% AEP Depth

Figure A4: Baseline 2% AEP Depth

Figure A5: Baseline 1% AEP Depth

Figure A6: Baseline 1% AEP + 32% Depth

Figure A7: Baseline 1% AEP + 59% Depth

Figure A8: Baseline 0.1% AEP Depth

Figure A9: Proposed Flood Extents

Figure A10: Proposed 1% AEP Depth

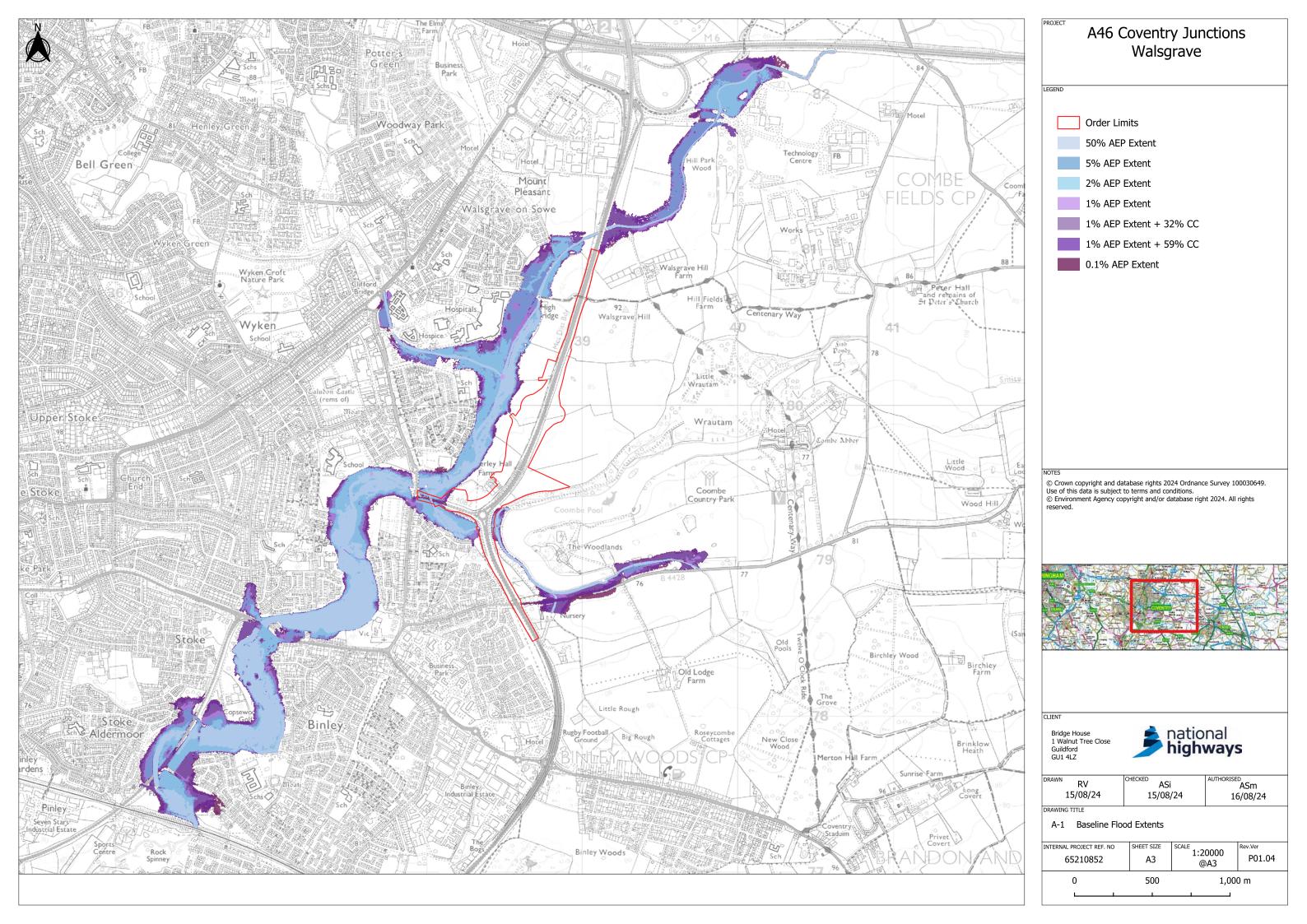
Figure A11: Proposed 1% AEP + 32% Depth

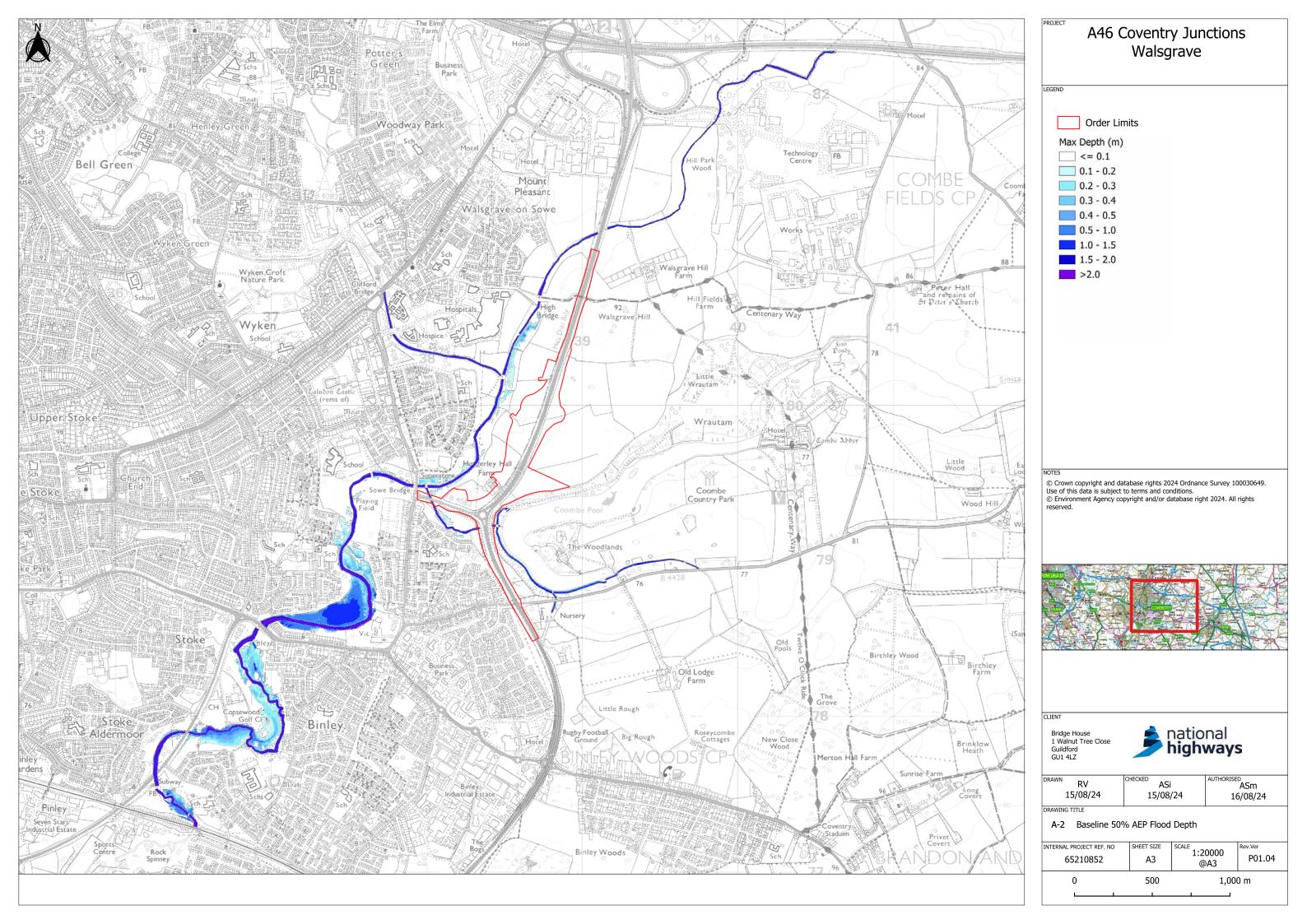
Figure A12: Proposed 1% AEP + 59% Depth

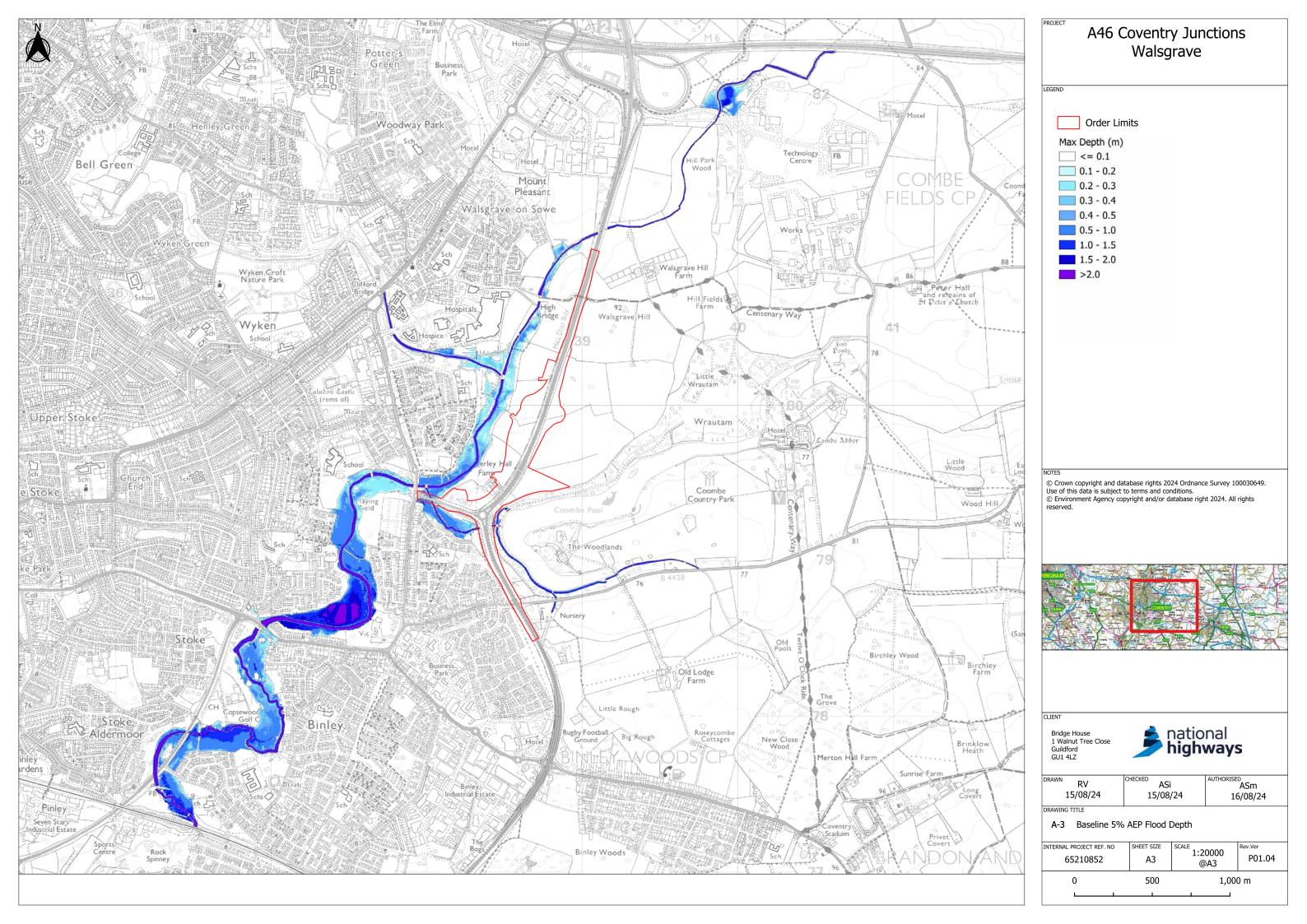
Figure A13: 1% AEP Depth Difference

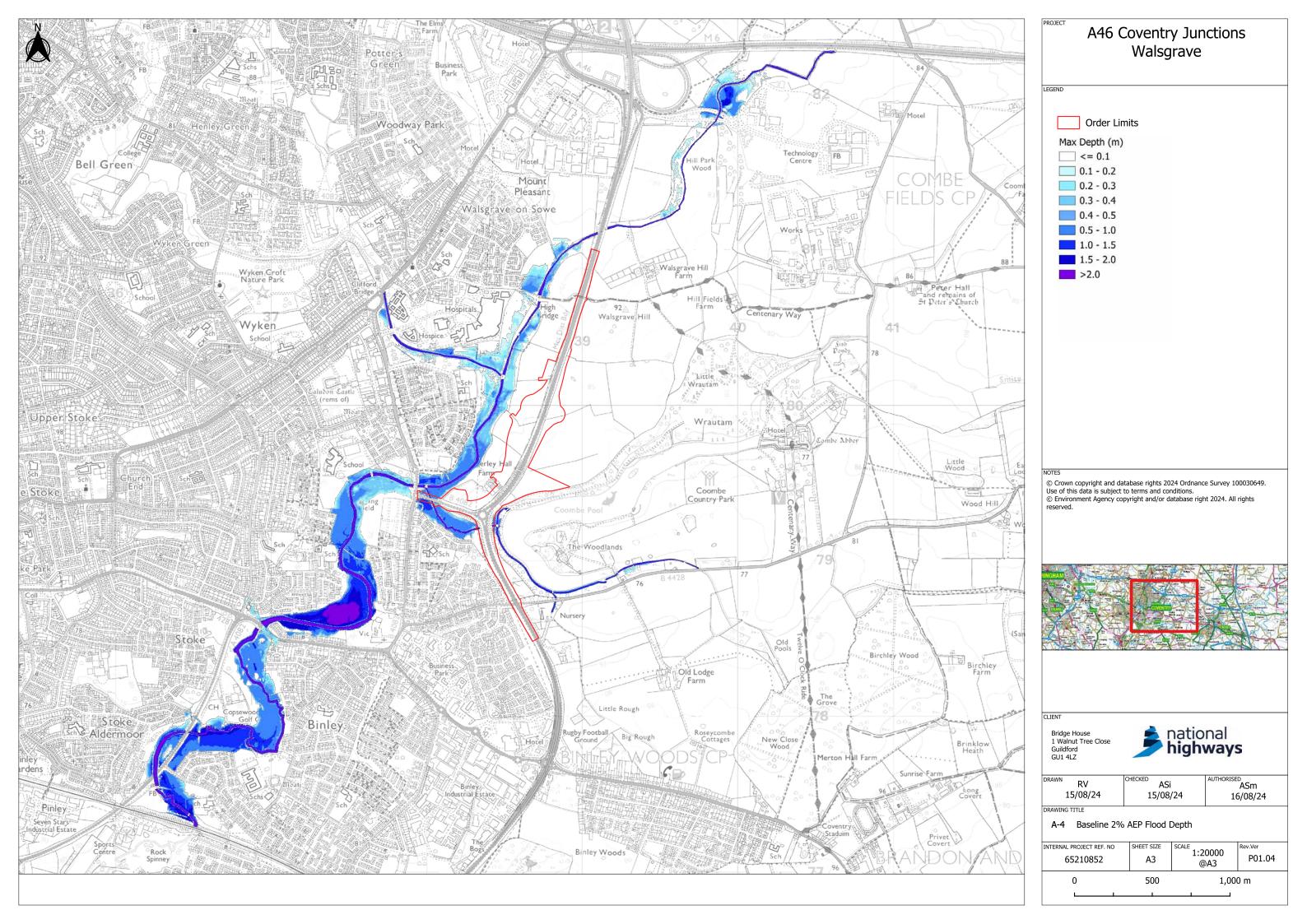
Figure A14: 1% AEP + 32% Depth Difference

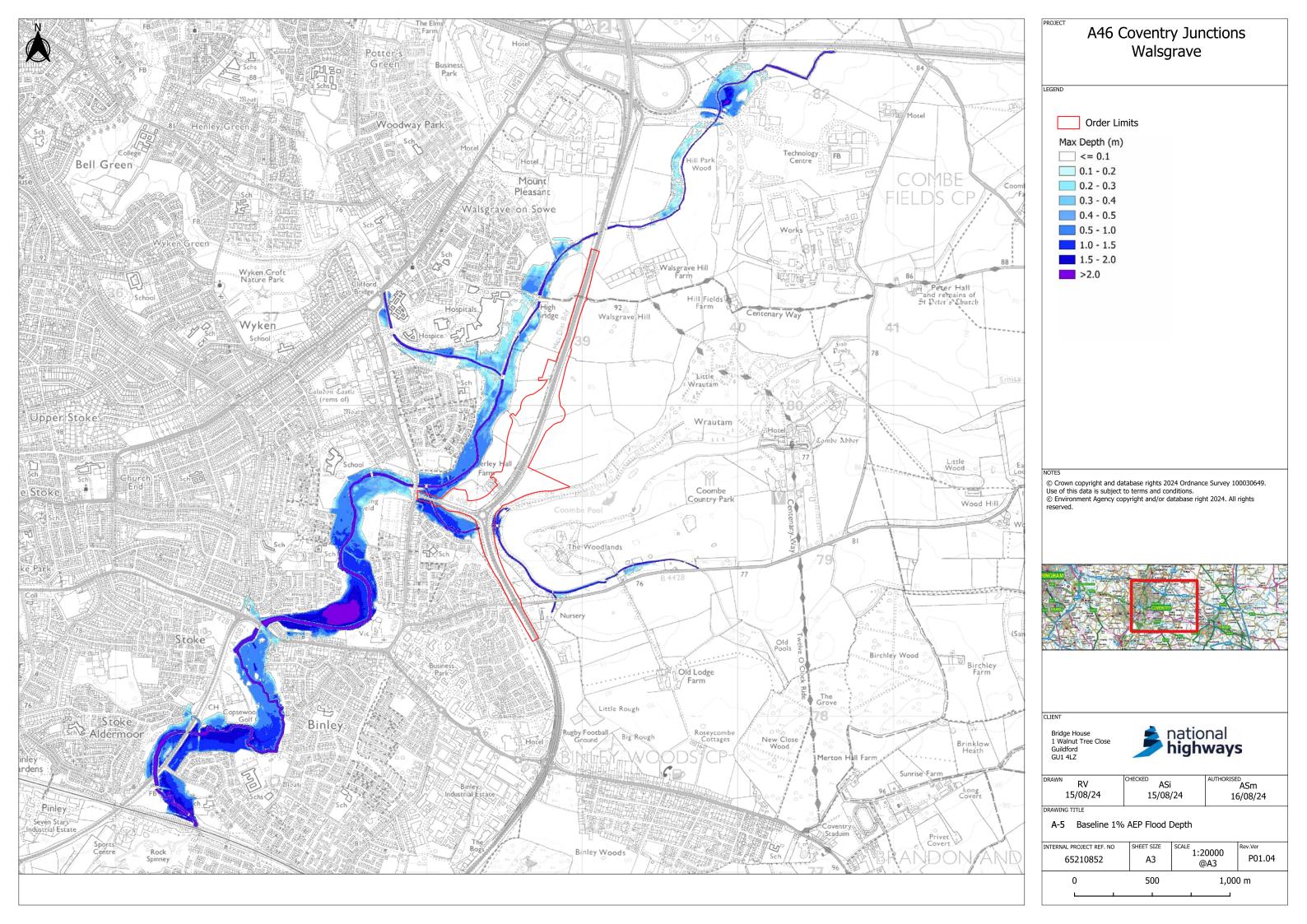
Figure A15: 1% AEP + 59% Depth Difference

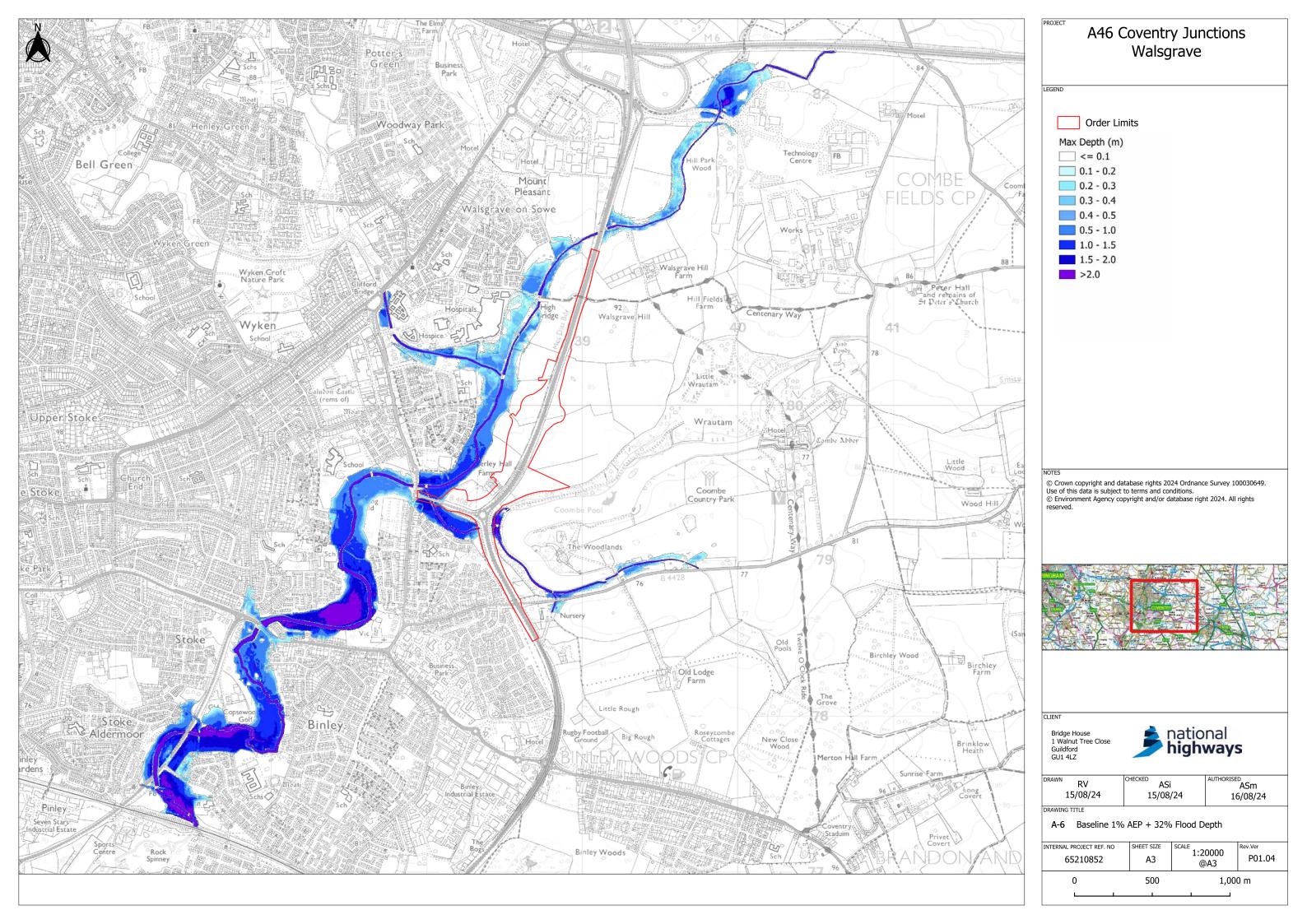


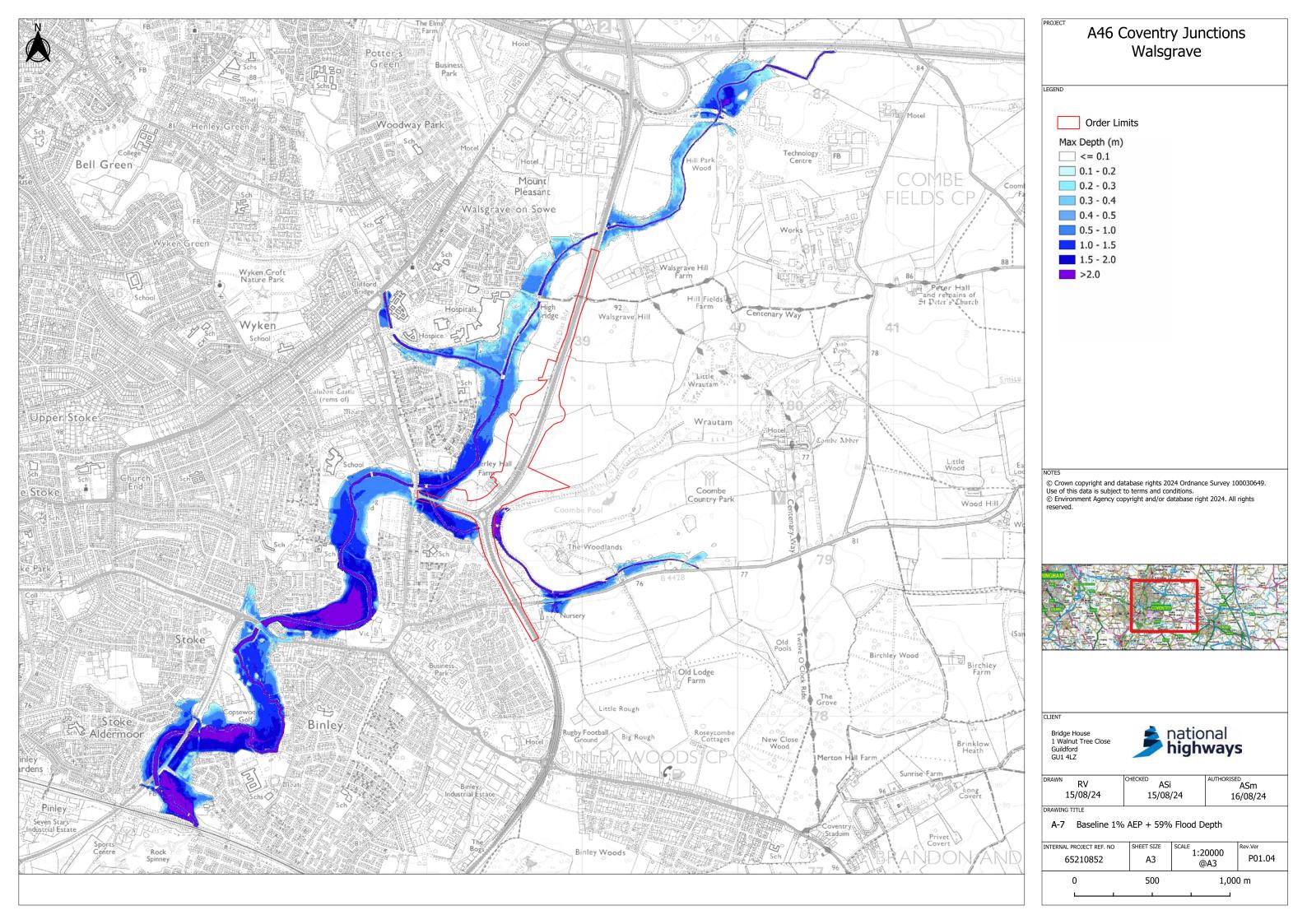


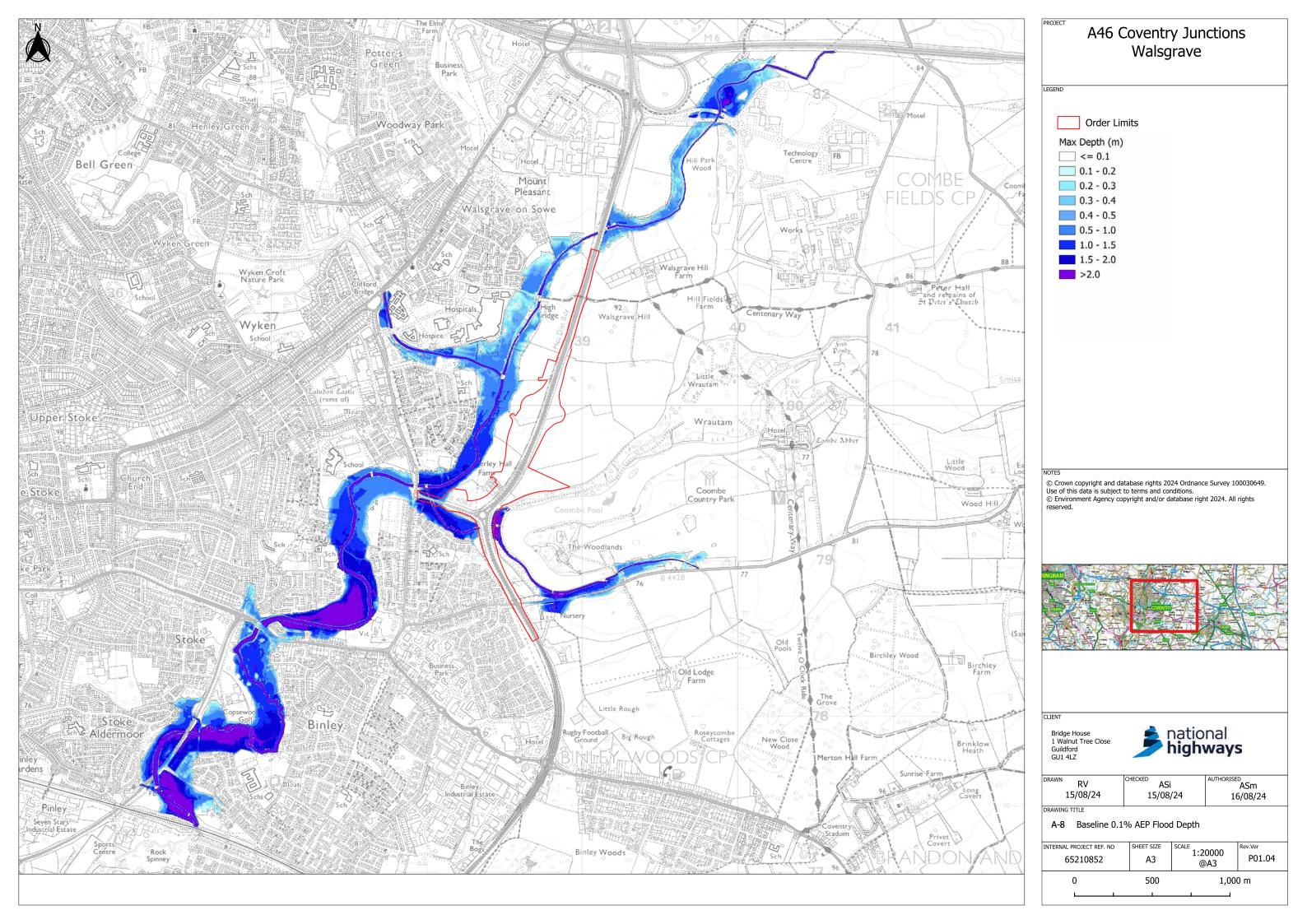


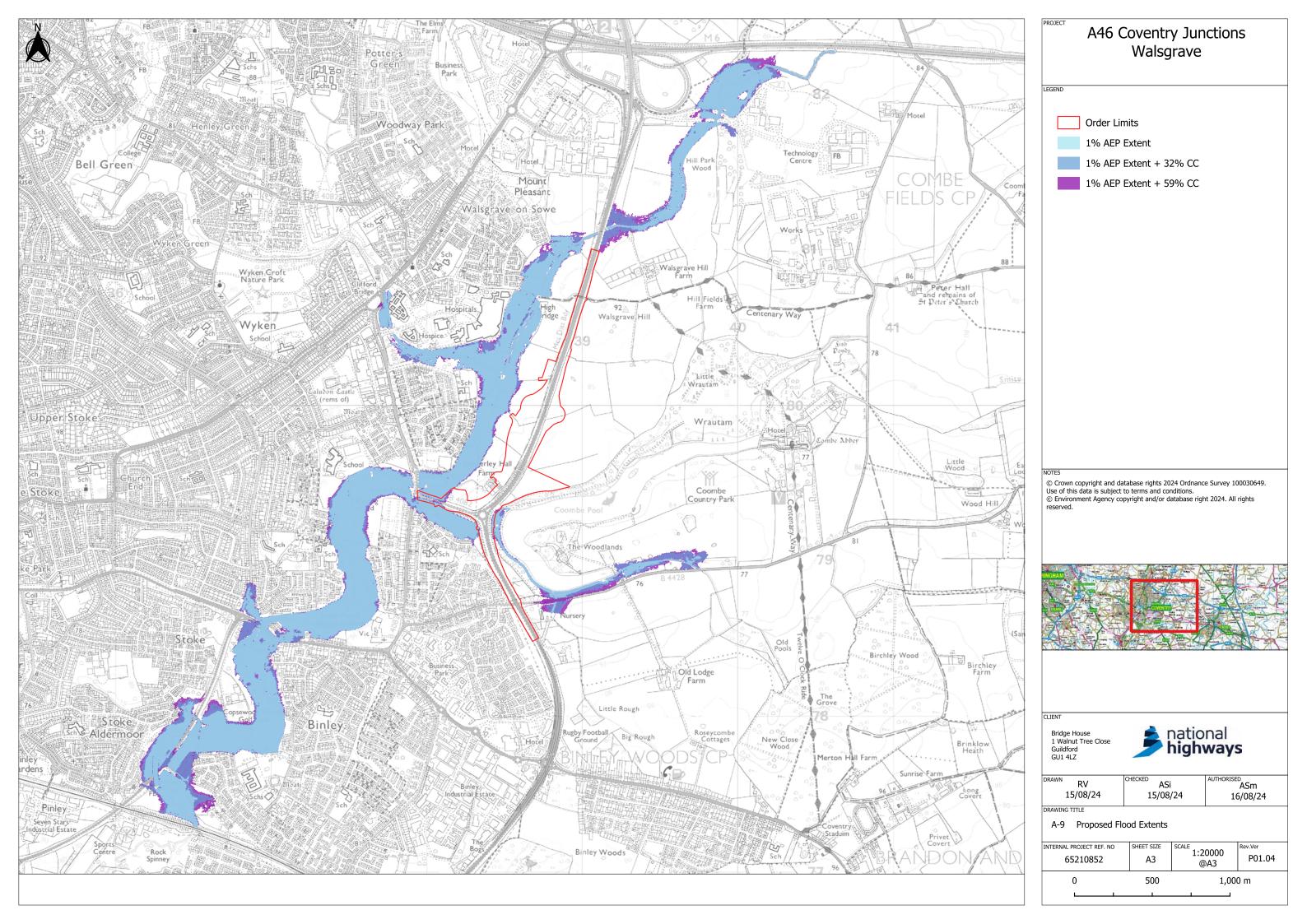


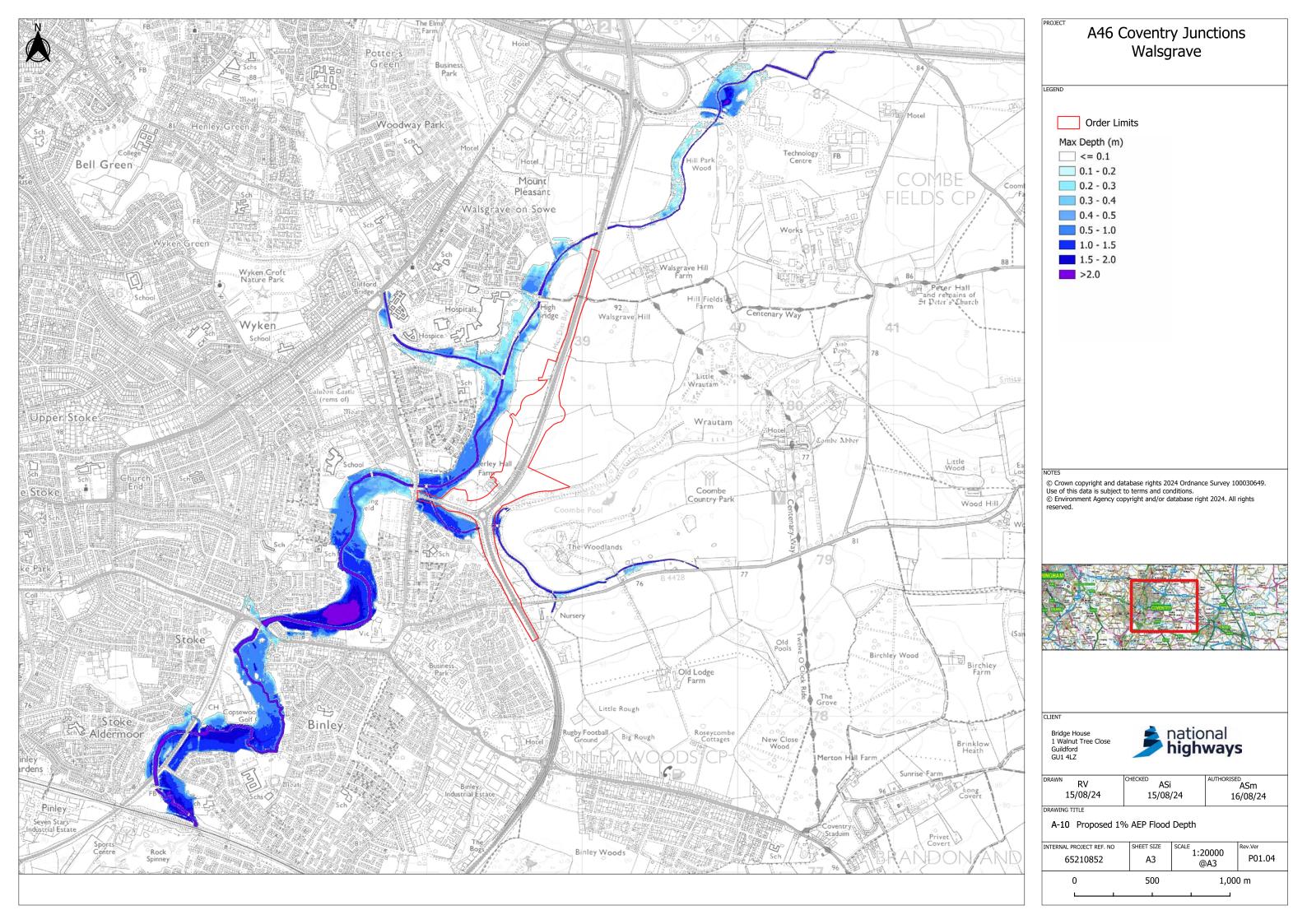


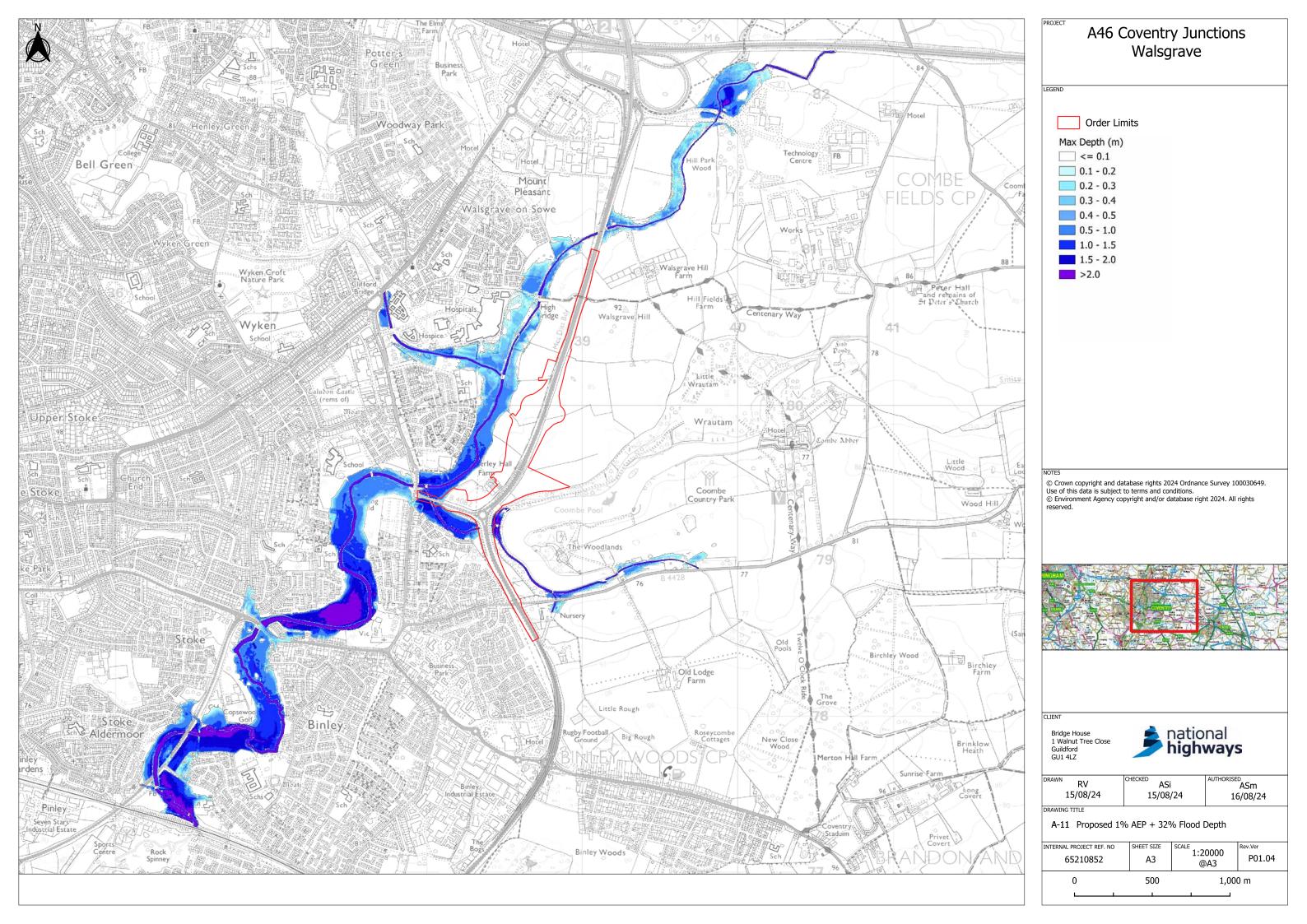


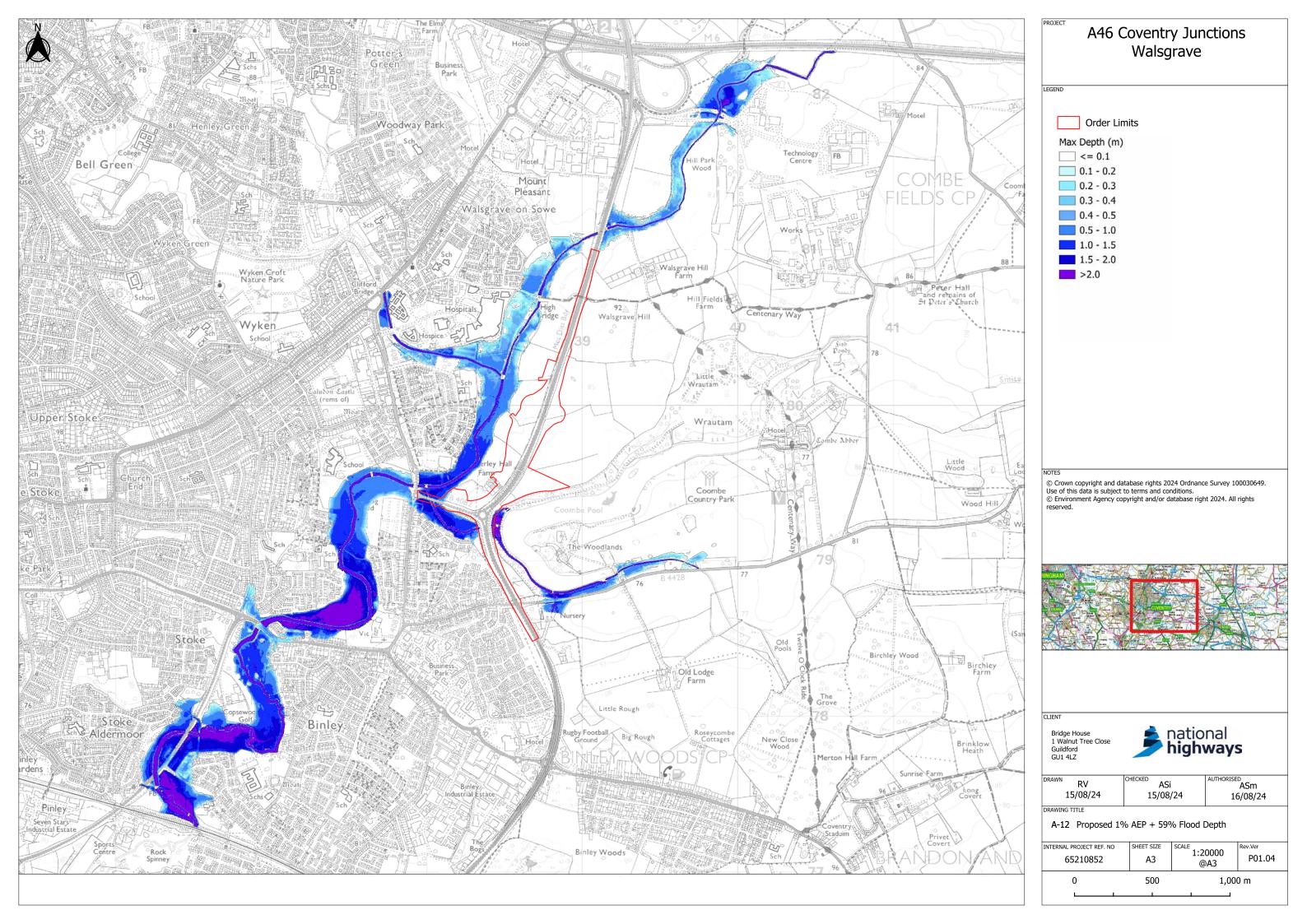


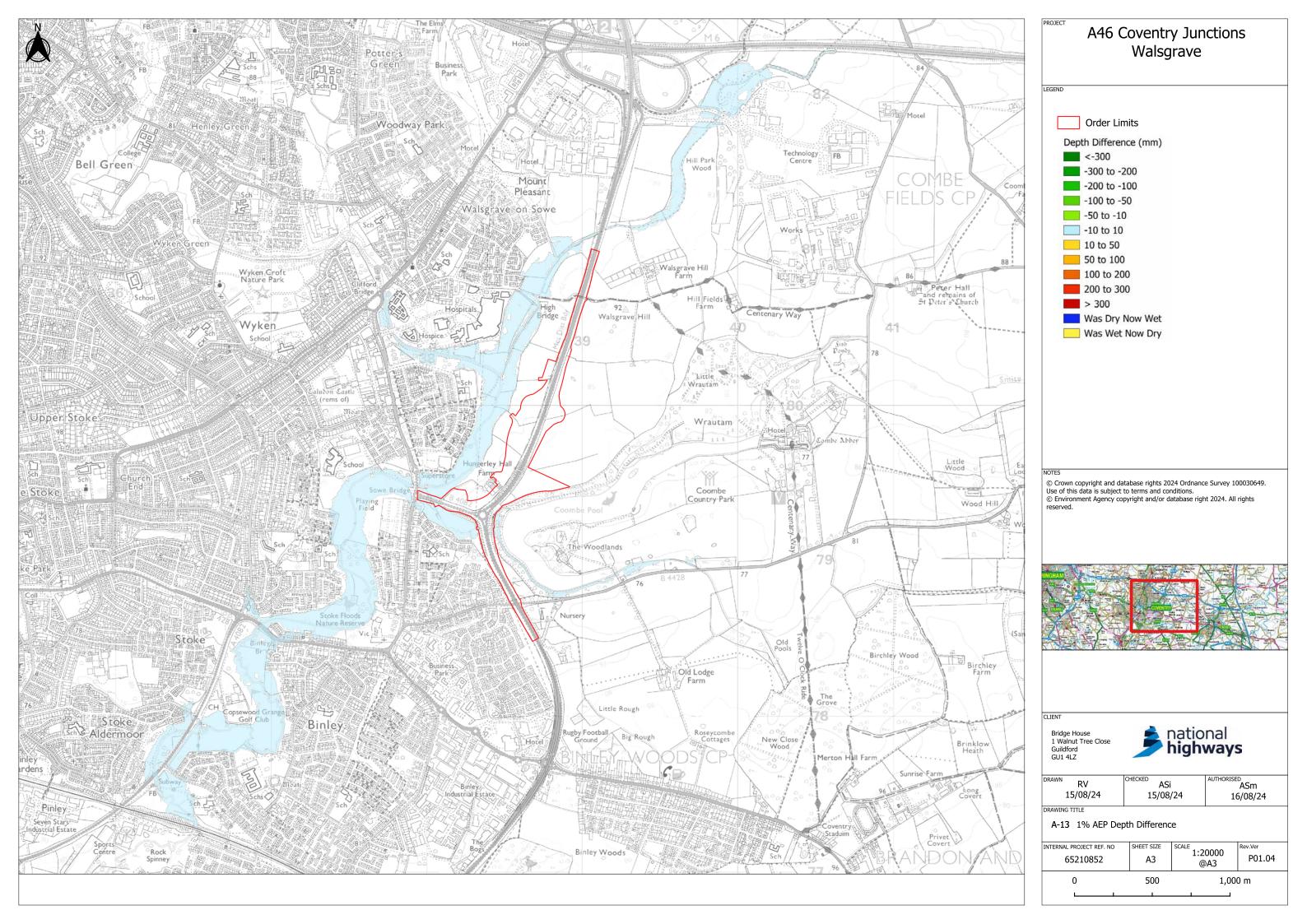


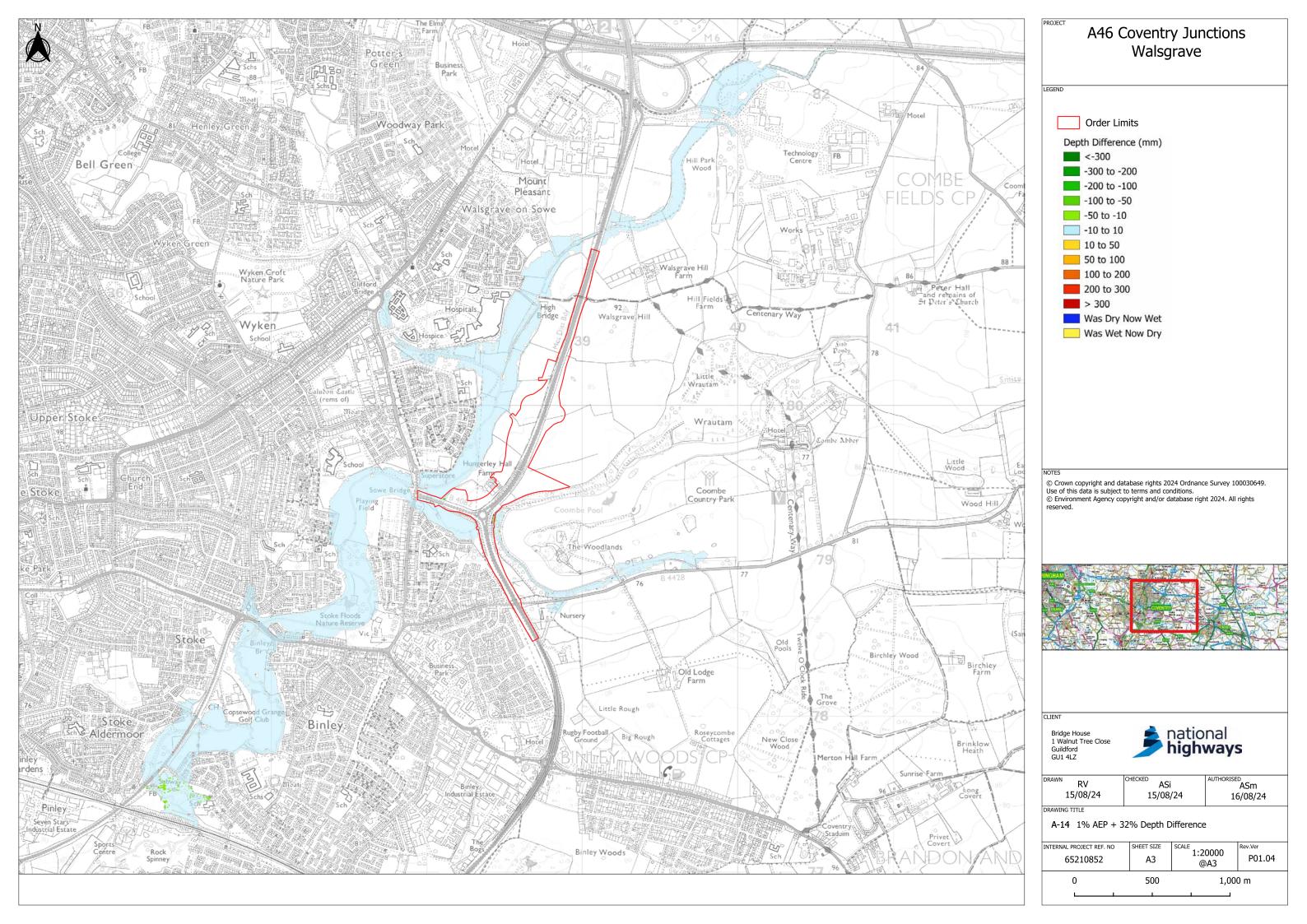


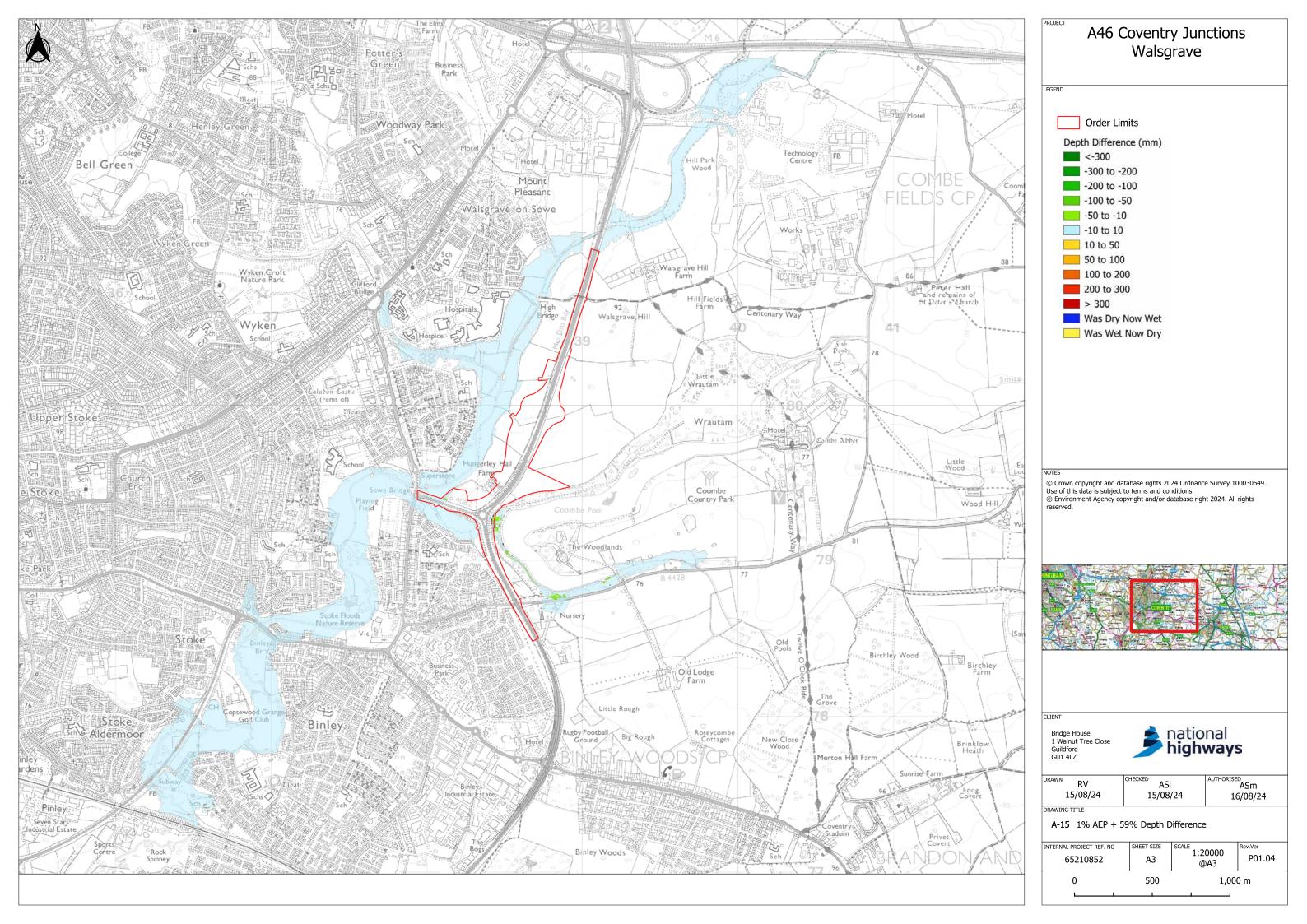














Annex B. Hydraulic Mmodelling Rreport



A46 COVENTRY JUNCTIONS (WALSGRAVE)

Annex B - Hydraulic Modelling Report

PCF STAGE 3 FOR REVIEW AND AUTHORIZATION | S4 HE604820-OIL-EWE-00-RP-LW-30002 | P08 06/11/24

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National Highways Project Manager:

Octavius Delivery Integration Partner, Project Manager:

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1. Introduction

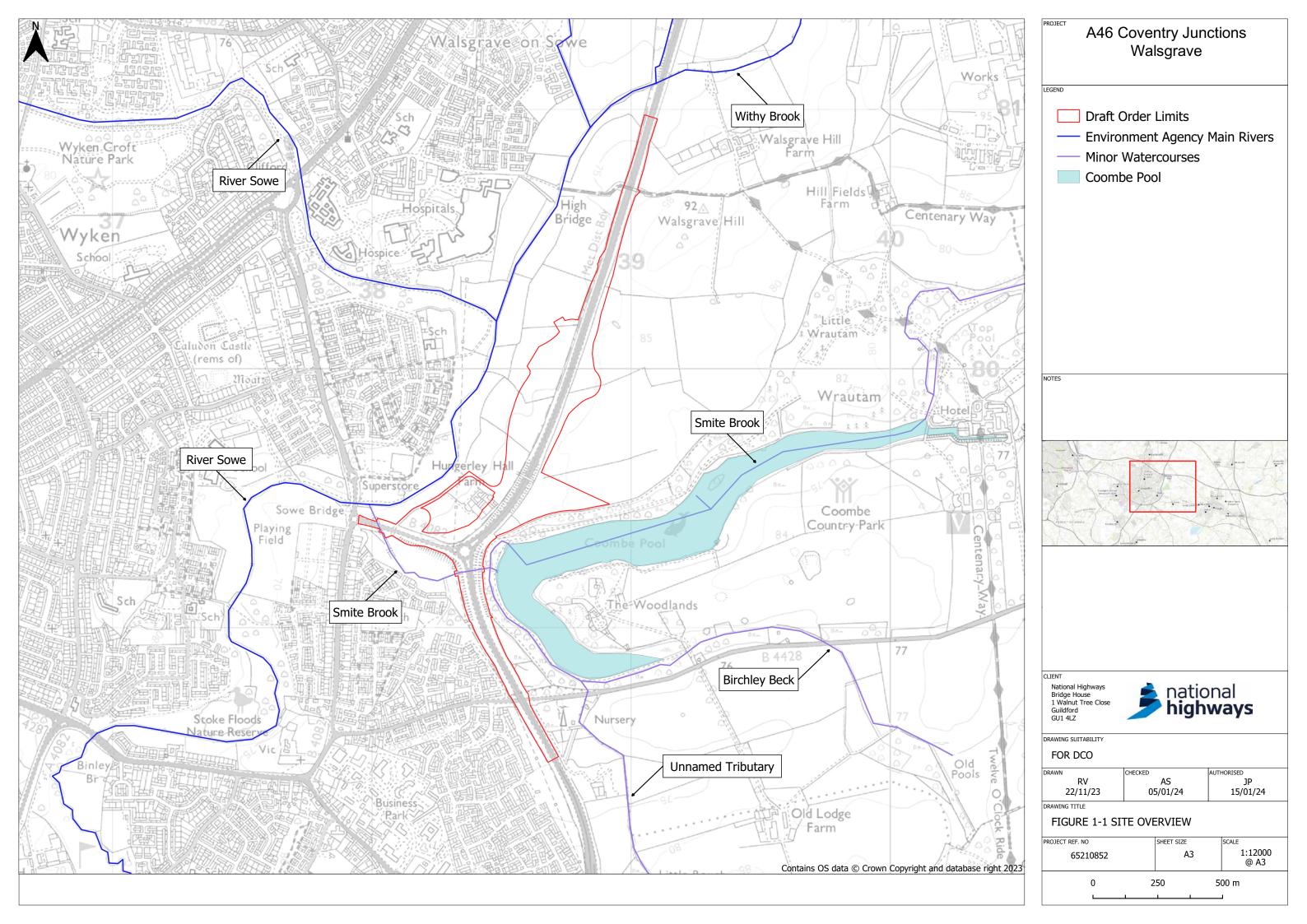
- 1.1.1. Sweco UK Ltd (Sweco) have been commissioned by National Highways to provide a flood risk assessment and associated hydraulic modelling for the A46 Walsgrave Junction upgrade project (referred to herein as 'the Scheme'). The existing A46 Walsgrave Junction comprises a dual carriageway roundabout that links the B4082 with the Coventry Eastern bypass. The junction is located 5km east of Coventry city centre.
- 1.1.2. The Scheme comprises of an upgrade to the junction of the A46 Coventry Eastern bypass and the B4082, east of Walsgrave. The Scheme is being progressed by National Highways to ease congestion and reduce queuing along the A46 corridor, east of Coventry.
- 1.1.3. The design includes realignment of existing highways embankments in the vicinity of the A46 Walsgrave Junction and the construction of new slip roads. A hydraulic model was developed to characterise the baseline and proposed flooding conditions. This report summarises the modelling procedures, outputs and results analyses.

1.2. Hydrological study area

1.2.1. The A46 Walsgrave Junction is located within the wider River Sowe catchment. The Smite Brook flows east-west through Coombe Pool located within Coombe Abbey Park (Figure 1-1). Coombe Pool discharges back into Smite Brook via a bell mouth spillway, spillway and sluice. Birchley Beck originates within Birchley Wood located south-east of Coombe Pool. It flows west adjacent to Coombe Pool before it confluences with an unnamed tributary, termed the 'Unnamed tributary'. The Unnamed tributary discharges into Smite Brook immediately downstream of the Coombe Pool outfall structures. Smite Brook flows beneath the existing A46 highway and embankment via a 5.0m x 1.7m rectangular culvert and the B4082 via a 7.0m x 3.0m rectangular culvert before it joins with the River Sowe, which flows in a north south direction west of the Scheme. The River Sowe and Withy Brook reaches in the vicinity of the Scheme are classified by the Environment Agency as main rivers.

1.3. Data Sources

- 1.3.1. The following data sources have been used to inform this assessment:
 - A46 Walsgrave Junction FRA and appendices (AECOM, 2021).
 - Revitalised Flood Hydrograph rainfall-runoff method (ReFH) Version 2.4





2. Legacy model

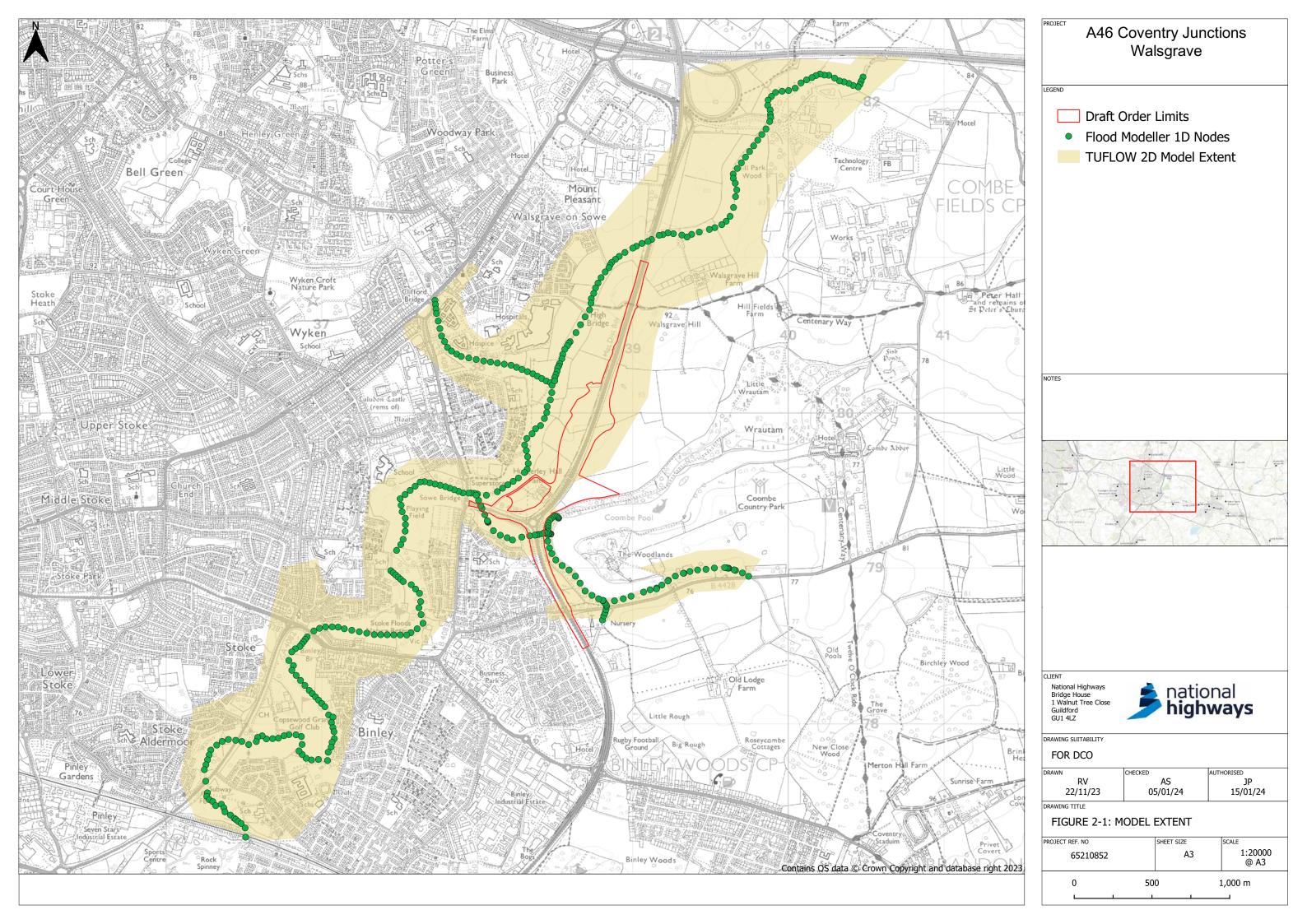
- 2.1.1. A baseline legacy model was developed by AECOM during National Highways Project Control Framework (PCF) Stage 2 to define the existing flooding conditions across the Scheme area. The legacy model is a 1D/2D linked Flood Modeller/TUFLOW model of the River Sowe, Smite Brook and tributaries.
- 2.1.2. The model was developed from the 2011 ISIS (now known as Flood Modeller) /TUFLOW Environment Agency hydraulic model of the River Sowe and Withy Brook. The extent of the 2D model domain and 1D nodes are shown in Figure 2-1. The Environment Agency's 2011 model was truncated at the West Coast Main Line (i.e. the new downstream boundary) to reduce run times and extended in the east to include the Smite Brook, Coombe Pool structures, Unnamed tributary and Birchley Beck. Note that no changes have been made as part of this assessment to the 1D node locations / cross sections or 2D boundary.
- 2.1.3. The following sections provide a brief outline as to the construction of the legacy model by AECOM, further detail is provided in the PCF Stage 2 A46 Walsgrave FRA (AECOM, 2021).

2.2. Channel survey

2.2.1. Channel survey data was procured by AECOM in 2021 for the Smite Brook and the Unnamed tributary. The survey captured the key features in the Smite Brook/Coombe Pool system that directly influenced flooding around the A46 Walsgrave Junction. It is understood that the model reaches of Smite Brook, Unnamed tributary and Birchley Beck were built directly from the survey outputs.

2.3. Hydrology

- 2.3.1. The hydrology was updated through the use of best practice flow estimation methods within Appendix B (HE604820-OIL-EWE-00-CA-LW-00002 A46 Walsgrave Junction FEH Record). The flow estimation points within the legacy model include:
 - The upstream truncation point at Ansty Road on the River Sowe;
 - Upstream of Withy Brook at the M6;
 - Lateral inflow for the intervening catchment areas on the River Sowe and Withy Brook;
 - Upstream extent of Smite Brook (flow applied to Coombe Pool reservoir unit)
 - Upstream extent of the Unnamed tributary; and
 - Upstream extent of Birchley Beck.





2.3.2. The downstream boundary of the model used the water surface from the 1% AEP model results from before the truncation was completed.

2.4. Sensitivity analysis

2.4.1. Sensitivity of the model to roughness, flow and Coombe Pool initial water level were assessed within the legacy model. The A46 Walsgrave PCF Stage 2 Flood Risk Assessment found the model responded to changes in roughness and flows as expected, however a reduction in the Coombe Pool initial water level had no effect on resultant levels or extents.

2.5. Climate change allowances

2.5.1. Climate changes allowances based on UKCP18 projections for peak river flows (Environment Agency, 2022) were made for the 1% AEP event. The Scheme is located in the Avon Warwickshire Management catchment. As the Scheme is classed as essential infrastructure, the relevant percentile for the Scheme is 'Higher Central' and the epoch is '2080s'. This equates to a climate change uplift of 32% for peak river flows and flood compensation calculations.

2.6. Roughness

2.6.1. The Manning's 'n' roughness coefficients were updated as part of the legacy model build and informed by standard values from Chow (1959). The adopted coefficients are shown in Table 2-1 below.

Table 2-1: Summary of legacy model Manning's 'n' roughness coefficients

Material Number	Manning's 'n' Value	Description	OS MM Feature Codes
1	0.04	Manmade surface	10056, 10096
2	0.04	Garden	10053
3	0.025	Path or track	10123, 10119
4	0.08	Railway	10167
5	0.025	Road	10172
6	1.0	Buildings	10021
7	0.1	Glasshouses	10062
8	0.075	Tree	10111
9	0.25	Stability	N/A
10	0.03	Water	10089
11	0.05	Embankments	10183
12	0.05	Structures	10185
13	0.05	Others	10054



99	0.04	Fields and natural land	10217
		(default value)	

2.6.2. A list of the simulation parameters used in the legacy model are given in Table 2-2 below.

Table 2-2: Legacy model simulation parameters

Parameter	Value	
2D timestep	2s	
1D timestep	1s	
Grid size	6m	
Precision	Double	
TUFLOW Version	2020-01-AB-iDP-w64	
FMP Version	4.5.1.6163	

2.7. Calibration

2.7.1. As part of the legacy model build, model calibration was performed using three observed events on the Withy Brook. Adjustments to the representation of antecedent events were made in order to better match the baseflow seen in the recorded stage location within the model. Ultimately no adjustments to parameters were taken from the calibration exercise and carried forward to the estimation of design hydrographs. Critically, the calibration provided an indication of model results accuracy on Withy Brook and the River Sowe but did not provide confidence for Smite Brook due to the lack of gauged data on this tributary.

2.8. Model performance

2.8.1. The legacy model suggested that up to the 1% AEP event the convergence was good with short periods of non-convergence (Figure 2-2). Poor model convergence in the area of the Scheme were noted at unit SO69U and upstream of unit SMT1_0534Cl for the 1% AEP + 32% and 0.1% AEP events. These periods of non-convergence were localised and not considered to impact on model performance. The peak flood levels and extents within the vicinity of the A46 Walsgrave Junction were considered robust and the legacy model was deemed suitable for assessment of flood risk within the area of the Scheme.



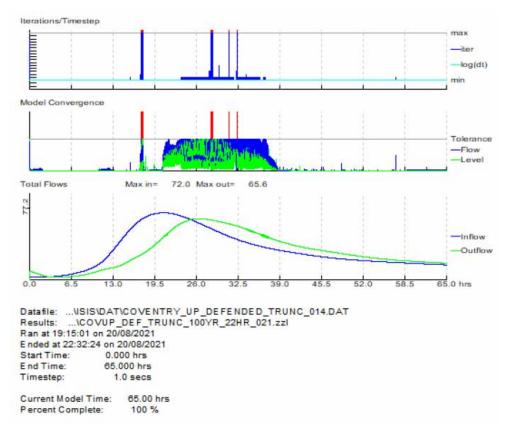


Figure 2-2: Legacy model 1% AEP FMP convergence plot

2.9. Environment Agency Review

2.9.1. The PCF Stage 2 hydraulic model was reviewed by the Environment Agency on 15th June 2021. The review flagged no issues to the model build or schematisation, only recommendations. The recommendations were addressed and incorporated into the updated baseline model by AECOM. The PCF Stage 2 hydraulic model was accepted by the Environment Agency for use in assessing the baseline flood risk in the area of the A46 Walsgrave Junction.



3. Stage 3 Baseline Model Updates

3.1.1. Updates to the PCF Stage 2 hydraulic model were required in line with modelling best practice and new data made available at PCF Stage 3.

3.2. Software selection

3.2.1. The hydraulic model was updated to the latest versions of Flood Modeller Pro and TUFLOW to improve model stability (Table 3-1). Updating the hydraulic model to the latest software version improved the accuracy of results and is in line with best practice. The key hydraulic modelling parameters used are found in Appendix A.

Table 3-1: Updated software versions

Software	Stage 2 (2021)	Stage 3 (2023)
TUFLOW	2020-01-AB-iDP-w64	2023-03-AA-iDP-w64
Flood Modeller Pro	4.5.1.6163	6.2.8578.25992

3.3. Consultation

- 3.3.1. The Environment Agency were consulted on 17th October 2023 by Sweco and COWI regarding the hydrological and hydraulic approach to the Scheme. The Environment Agency agreed to the following:
 - A full hydrological update would be made using FEH methods.
 - The 'Higher Central' peak river flow allowance (32%) for the Avon Warwickshire Management Catchment with a design life of 2080s would be used for the design of any structures.
 - There would be no changes to the suite of flood event simulations from PCF Stage 2.
 - The 1% AEP 17-hour duration event will be run as a sensitivity test.

3.4. Hydrology

- 3.4.1. The PCF Stage 2 hydrological assessment, completed in 2021, used FEH methods to estimate design flows for input to the hydraulic model. The assessment made use of the latest available data at the time. The FEH Statistical method used the National River Flow Archive (NRFA) peak flow dataset, Version 9, to estimate peak flows and the ReFH (Revitalised rainfall-runoff) method used the FEH13 rainfall DDF model to build design hydrographs.
- 3.4.2. At PCF Stage 3, the NRFA peak flow dataset had been updated to Version 12 and ReFH had been recalibrated using the FEH22 rainfall DDF model.



- 3.4.3. A full hydrological assessment was therefore carried out to make use of the latest data to improve the accuracy of the inflow hydrology to the hydraulic model. Further information can be found in Appendix B.
- 3.4.4. Updating the hydrology to the latest datasets and rainfall models resulted in a reduction in peak flows and volumes across the wider Sowe catchment. Larger reductions in peak flow are predicted for the western, urban sub-catchments than the eastern, rural sub-catchments.
- 3.4.5. The final updated hydrographs were applied to the 1D flow-time boundary units within the model.
- 3.4.6. No updates to climate change allowances were required.
- 3.4.7. The modelled flood events remained unchanged from the legacy model and are given below:
 - 50% AEP (1 in 2-year event)
 - 5% AEP (1 in 20-year event)
 - 2% AEP (1 in 50-year event)
 - 1% AEP (1 in 100-year event)
 - 1% AEP + 32% CC (1 in 100-year plus 32% climate change event)
 - 0.1% AEP (1 in 1000-year event)
- 3.4.8. The 1% AEP + 32% climate change event is termed the 'design event'.
- 3.4.9. PCF Stage 2 assessed the design event only for option modelling. It was agreed with the Environment Agency that PCF Stage 3 would only assess the design event for option modelling as baseline modelling demonstrates the Scheme lies outside the flood extents for lower order events.
- 3.4.10. Following further consultation with the Environment Agency as part of the model review, the 1% AEP event was also included.
- 3.4.11. Sensitivity of the model was investigated for changes in roughness and flows.

3.5. Topography

3.5.1. A scheme wide topographic survey was commissioned at PCF Stage 3. The survey consisted of survey points taken along the existing highway and the adjacent land. The topographic survey was received in DWG format as a series of 3D points and lines (Figure 3-1). A Triangulated Irregular Network (TIN) was built from the DWG to form a surface. The surface was then converted to raster and ultimately ASCII to be read into the TUFLOW engine (Figure 3-2).



Consistency in joins between the LiDAR ground model and topographic survey was reviewed and deemed to be acceptable.



Figure 3-1: Stage 3 DWG topographic survey

3.5.2. The legacy model ground model was built using 1m and 2m Light Detecting and Ranging (LiDAR) data (National LiDAR Programme, 2020) alone. Incorporation of the PCF Stage 3 topographic survey in the ground model resulted in increased accuracy and confidence in flood depths surrounding the junction.



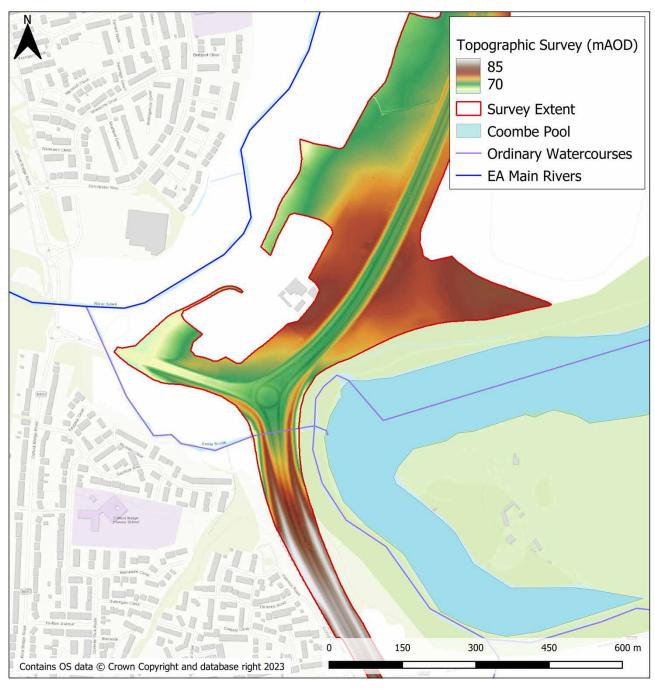


Figure 3-2: Stage 3 topographic survey coverage around Walsgrave Junction

3.6. Initial conditions

3.6.1. Initial conditions were generated for all 1D nodes using the 1% AEP plus 32% climate change event. The conditions defined a stage for every 1D node for a given time within the simulation. This ensured all cross-sections were wet at the beginning of each simulation.



3.7. Structures verification

3.7.1. A site walkover was carried out in October 2023 to verify the modelled reaches of Smite Brook, Birchley Beck and the Unnamed tributary to inspect the condition of modelled structures. All modelled 1D structures were present during the site walkover and there were no significant changes to channel geometries of note. No modifications were made to the baseline 1D FMP model.

3.8. Environment Agency Review

3.8.1. The Stage 3 A46 hydraulic model was reviewed by the Environment Agency on 30th January 2024. The review flagged two key changes to be made within the model prior to suitability for use in assessing flood risk impacts of the Scheme.

Chainage review

3.8.2. The modelled chainage on the Withy Brook had been overestimated by approximately 200m. A chainage review was carried out and the modelled chainage reduced to that estimated from Google Earth satellite imagery.

Bank Elevations

- 3.8.3. Bank elevations between cross-sections within the legacy model were largely derived from now superseded LiDAR. In certain areas, 2D bank elevations inbetween surveyed cross-sections were greater than 0.5m than the latest (2022) composite LiDAR. Where this was the case, the bank elevations were updated in line with the latest LiDAR.
- 3.8.4. The hydraulic model was approved by the Environment Agency on 1st October 2024.



4. Model calibration

- 4.1.1. As part of the development of the legacy model, the hydrological model was calibrated. As part of the development of the Stage 3 model the calibration exercise was repeated.
- 4.1.2. The ReFH2 model was used to create hydrographs using data from the Finham rain gauge. Checks were made within the model using observed levels at High Bridge Level gauge against derived levels from the hydrographs at the gauge location. The legacy 2021 hydrology study noted the uncertainty in the modelled representation of the gauge location and the accuracy of calibration with one rainfall gauge. Therefore, the default ReFH2 parameters were retained for the 2021 hydrology study. Further information can be found in Appendix B.
- 4.1.3. Inflow hydrographs were developed in the 2021 hydrology study for three events using rainfall data from the Finham rain gauge- 3rd March 2007, 25th November 2012 and 16th February 2020. The legacy model was calibrated against the observed events to confirm the model was behaving as expected at the high Bridge gauge location.
- 4.1.4. The observed events were also used to verify the hydraulic model in this study. However, given the uncertainty surrounding the high Bridge gauge representation within the model, the observed events were used to check timing and response of the modelled stage curve only. No other gauges were located within the modelled extents nor suitable for model verification. Figure 4-1 shows a comparison between the modelled and recorded levels at High Bridge gauge.



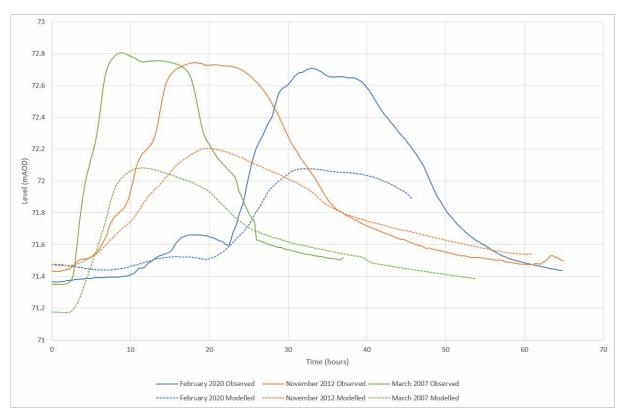


Figure 4-1: Modelled and observed levels at Withy Brook High Bridge Gauge

- 4.1.5. The observed events confirmed that the hydraulic model behaved well regarding timing and response of the modelled stage at the gauged location. There is a notable difference in stage of between 400mm 600mm between observed and modelled events. This discrepancy is likely due to the representation of the gauge within the model and using rainfall data from a gauge significantly downstream of the modelled catchment.
- 4.1.6. This is a recognised limitation in the rainfall calibration data. If additional rainfall data is available for future calibration, then it may be possible for the volume of recorded rainfall at the Finham rain gauge to be scaled to the equivalent volume of rainfall for the High Bridge gauge by a ratio of catchment areas. The sensitivity of rainfall volume to predicted stage at High Bridge gauge could then be assessed.



5. Stage 3 Baseline Model Results

5.1.1. Flood maps for the full suite of flood events including the 1% AEP and 1% AEP + 32% climate change events are provided in the A46 Walsgrave Junction Flood Risk Assessment- Appendix A.

5.2. Flood depths

5.2.1. Flood waters for the 1% AEP event are generally contained within bank along the Smite Brook, Birchley Beck and Unnamed tributary reaches (Figure 5-1). Out of bank flooding occurs upstream of hydraulic controls such as footbridges and stream confluences. Flow is throttled by the A46 culvert causing flood waters to pond within the floodplain up to depths of 130mm. Downstream of the A46 culvert flood waters spill into the Smite Brook floodplain causing ponding water up to 162mm. Floodplain and channel depths increase on the River Sowe and Withy Brook reaches. This is due to wider channels, larger model inflows and increased conveyance moving downstream to the downstream model extent.

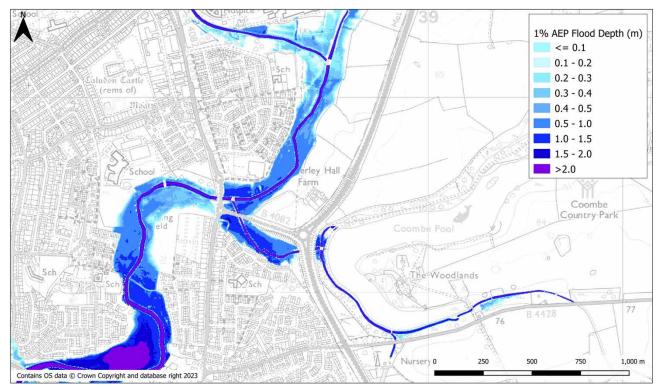


Figure 5-1: 1% AEP maximum flood depth

5.3. Stage 3 and legacy model comparison

5.3.1. Due to changes in the hydrology and minor changes to the ground model, the Stage 3 results predicted differences in flood depths and extents to the legacy model results. Figure 5-2 shows an extent comparison between the two assessments. The updated hydrology reduced the peak inflows within the



hydraulic model. The greatest reduction in peak flows was within the eastern catchments of the Smite Brook and tributaries. These reductions in flows combined with smaller catchments and flatter floodplains resulted in this being the area with the largest reduction in flood extents between the two results. Predicted flood extents along the Withy Brook and River Sowe remained generally unchanged between the two model results.

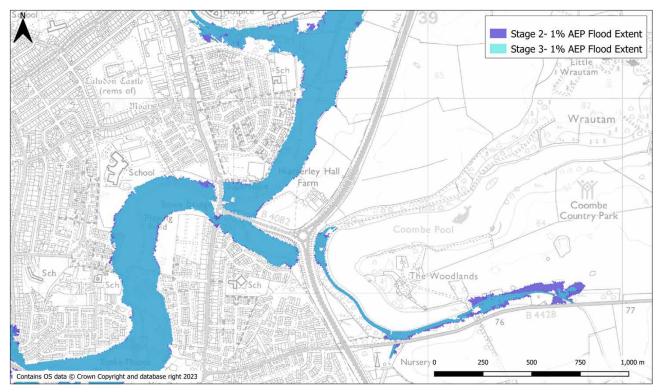


Figure 5-2: 1% AEP extent comparison

- 5.3.2. The reduction in peak flows resulted in a predicted reduction in peak depths within the updated hydraulic model. Depths are generally predicted to reduce by up to 300mm over the flooded extent (Figure 5-3). Depth reductions greater than 300mm are predicted in the model; however, these are localised to the Smite Brook, its floodplain and its tributaries.
- 5.3.3. There is one localised area of predicted increase depths downstream of Clifford Bridge. This is due to changes to bank elevations and 1D chainage following the Environment Agency review.



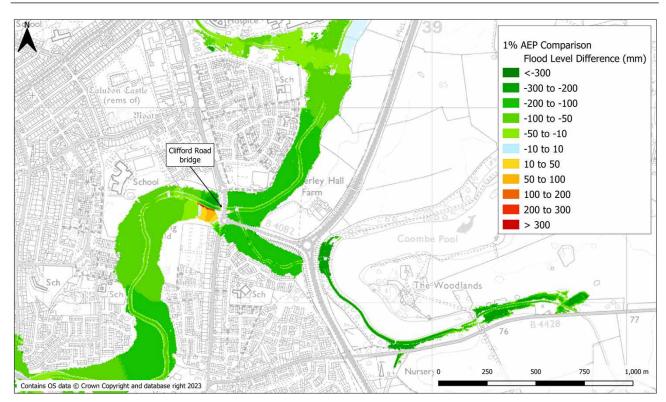


Figure 5-3: 1% AEP depth comparison

5.3.4. The updated 1% AEP model results were considered reasonable when compared to the legacy model results. Changes to depths and extents behaved as expected given the reduction in inflows and the model gave confidence in predicted results for the remaining flood events.

5.4. Model performance

1D domain

5.4.1. The results for the updated model indicate that model performance is good. Short periods of non-convergence remain within the model; however, these are not present through the peak of the event. The locations of non-convergence were further investigated to confirm their impact on results (Table 5-1). Similarly, to the legacy model, non-convergence occurs at the location of High Bridge Gauge on the Withy Brook during model run T = 18 hours and T = 27 hours. Attempts were made during the legacy model build to reduce instabilities associated with the modelled representation of the gauge, however, were limited by a lack of survey data. Fluctuations in water levels are experienced at the High Bridge gauge 1D nodes; however, these effects are diminished moving to the next downstream node. Critically, the location of these nodes are significantly upstream from the A46 Walsgrave Junction.



Table 5-1: Locations of 1% AEP non-convergence

1D Flood Modeller Node	# of Non-convergences	Location	
WB10	233		
WB11	192	High Bridge Gauge	
WB11OD	3		
SMT1_0534C2	6	A46 Culvert	
SMT1_0534C1	208	A46 Culvert	

5.4.2. Periods of non-convergence occur at T = 28 hours (after the peak) at the location of the A46 culvert (Figure 5-4). This is likely due to the large volumes of impounding water accumulating downstream of Coombe Pool before being throttled by the culvert. The stage and flow plots for node SMT1_0534C1 behave as expected and the non-convergence does not impact on results (Figure 5-5).

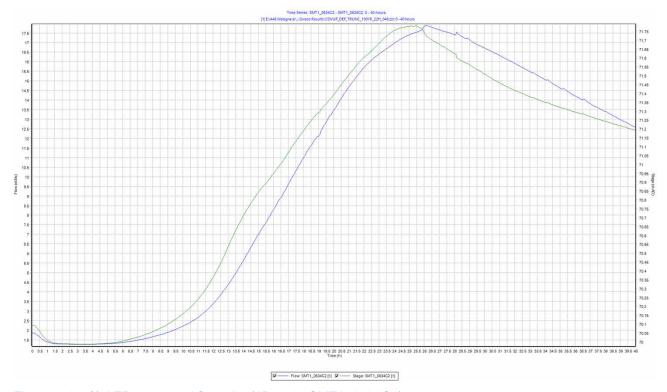


Figure 5-4: 1% AEP stage and flow plot (1D node SMT1_0534C1)



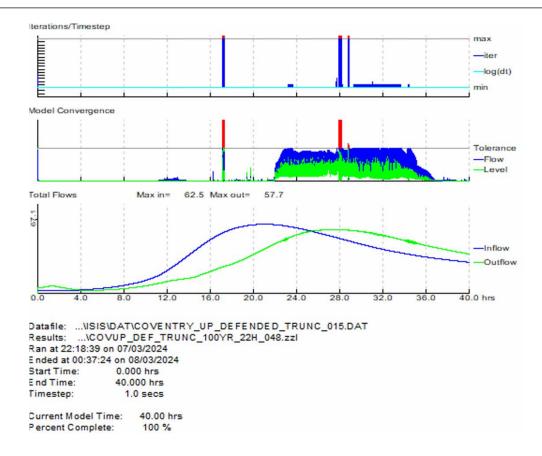


Figure 5-5: 1% AEP Flood Modeller non-convergence plot

5.4.3. The number of non-convergences increase as flows are increased to the 1% AEP + 32% event, notably at 1D node SO69U. This is the upstream cross-section of the Binley Road bridge crossing on the River Sowe. The non-convergence occurs during model T = 24 – 27 hours through the peak of the event. During this time, large volumes of water spill out of the 1D domain and over Binley Road via the 2D spill. Non-convergence associated with node SO69U is noted within the legacy model and is a known existing issue within the 2011 ISIS/TUFLOW Environment Agency hydraulic model. Although a significant number of non-convergences occur through the 1% AEP + 32% event peak, they are mostly attributed to a location significantly downstream of the A46 Walsgrave Junction (Table 5-2) and thus unlikely to impact the model findings at / as a result of the Scheme.



Table 5-2: Locations of 1% AEP + 32% non-convergence

1D Flood Modeller Node	# of Non-convergences	Location		
WB10	216	High Pridge Cours		
WB11	190	High Bridge Gauge		
SO69U	17756	Binley Road spill into 2D		
SMT1_0534C2	17	A46 Culvert		
SMT1_0534C1	320	A40 Cuivert		

2D domain

- 5.4.4. Mass balance remains within the acceptable model range of +/- 1.0% for the 1% AEP event (Figure 5-6) except for a spike after T = 10 hours. This spike increases to -3.09% for the 1% AEP + 32% event. Investigation suggests the spike occurs at the first timestep that flow rapidly spills out into the 2D domain at two locations, one of which is a pond at Stoke Floods Green. Both locations are on the River Sowe and significantly downstream from the A46 Walsgrave Junction. The spike does not occur during the peak of the event.
- 5.4.5. Periods of non-convergence and spikes in mass balance are present within the baseline model; however, these are localised and are not considered to impact on model performance. There is confidence in the modelled peak flood levels and extents surrounding the A46 Walsgrave Junction and the model is suitable for the Stage 3 option assessment.



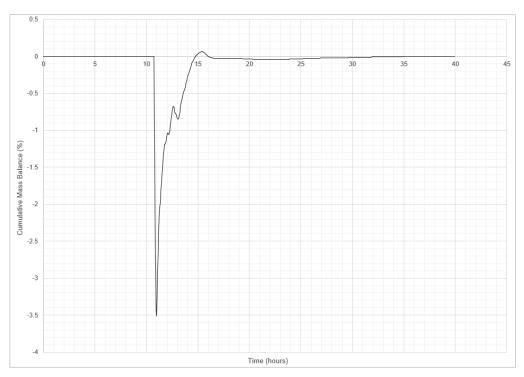


Figure 5-6: 1% AEP cumulative mass balance

5.5. Sensitivity analysis

- 5.5.1. Sensitivity testing was undertaken to assess the influence on the 1% AEP event results with changes to the following elements:
 - +/- 20% to Manning's 'n' channel and floodplain roughness values; and
 - +/- 20% to inflows for the 1% AEP event.
- 5.5.2. The influence of a 100mm reduction in initial Coombe Pool water level was assessed within the legacy model and was found to have no impact upon results. As no changes have been made to the model build in the area of Coombe Pool since the legacy model, no further investigations to initial water level sensitivity were made.

Roughness

- 5.5.3. An increase in 20% to Manning's 'n' roughness values resulted in an increase to flood depths across all modelled reaches (Figure 5-7). Increases in flood depths were generally predicted by up to 100mm with three areas local to the A46 Walsgrave Junction predicting up to 300mm.
- 5.5.4. Increased ponding of flood waters occurred upstream of the Unnamed tributary and Smite Brook confluence, north of the B4428. Flow is throttled at this location under the 1% AEP event. An increase in roughness increased the time occupied



- by flood waters within the floodplain, causing an increase in flood depths by up to 114mm.
- 5.5.5. Further ponding is predicted upstream of the A46 culvert where the Unnamed tributary meets the Coombe Pool overflow chute. This complex area is modelled in both 1D/2D, resulting in numerous flow reversals over the HX lines. Flood depths in this area are predicted to increase by up to 300mm. This is a 25% increase on existing 1% AEP flood depths of 1200m.
- 5.5.6. Increased depths are predicted on the left bank of the River Sowe, downstream of Clifford Road Bridge. Flood waters overtop Clifford Road via the 2D spill in this location and rapidly flow down the steep bank. The increased 2D roughness causes additional ponding before flood waters join the River Sowe.

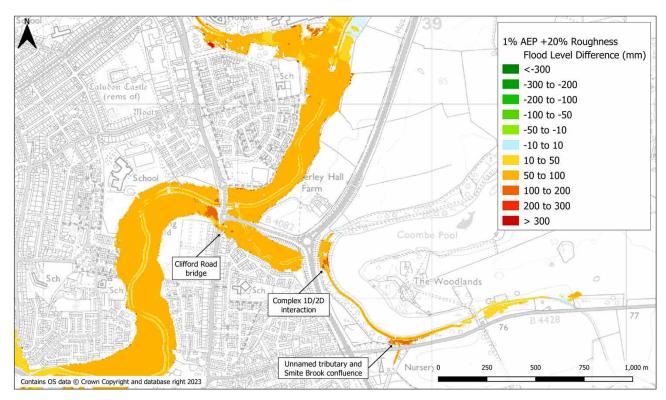


Figure 5-7: 1% AEP +20% roughness flood level difference

5.5.7. Conversely, reductions in roughness result in decreases to flood depths across the entire model domain (Figure 5-8). The largest reduction in flood depths are generally predicted in areas of the model local to the A46 Walsgrave Junction. The largest reduction in flood depths upstream of the A46 culvert (214mm) are an 18% reduction of predicted 1% AEP baseline flood depths (1200mm). Decreasing roughness allows flood waters to pass through key structures, such as the A46 and B4082 culverts with increased velocities resulting in decreased predicted depths. The model is less sensitive to decreased roughness in areas further away from the A46 Walsgrave Junction where fewer structures act as hydraulic controls that influence floodplain volumes and depths.



- 5.5.8. Changes to Manning's 'n' appears to make no significant difference to the flood extents around the A46 Walsgrave Junction and within the model domain. Changes to roughness do have an impact on depths, however this is relative to the percentage change in Manning's 'n' coefficient.
- 5.5.9. The results suggest the model shows a reasonable response to changes in Manning's 'n' coefficients.

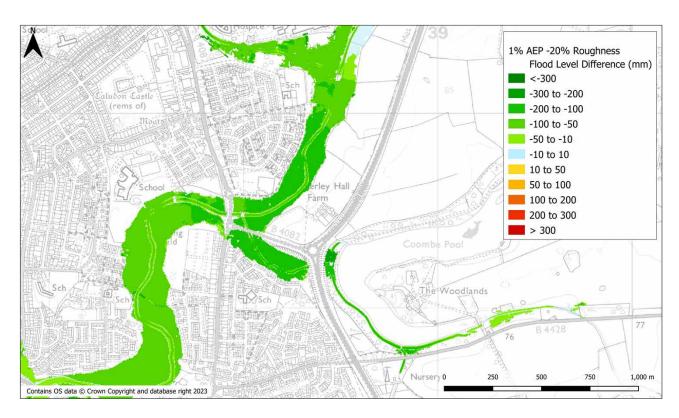


Figure 5-8: 1% AEP -20% roughness flood level difference

Flow

5.5.10. An increase in 20% flow to the 1% AEP event resulted in an increase in flood depths across all modelled reaches (Figure 5-9). The largest increases in flood depths are predicted along the Unnamed tributary where the channel is narrow and approximately 3m wide. Flow remains largely in bank under the 1% AEP event in this area. Flood waters directly upstream of the A46 Walsgrave Junction are predicted to increase by 601mm in areas that predict flood depths of 1330mm in the 1% AEP event. Increases in flood depths downstream of the A46 Walsgrave Junction are less significant (216mm) due to the wide Smite Brook floodplain.



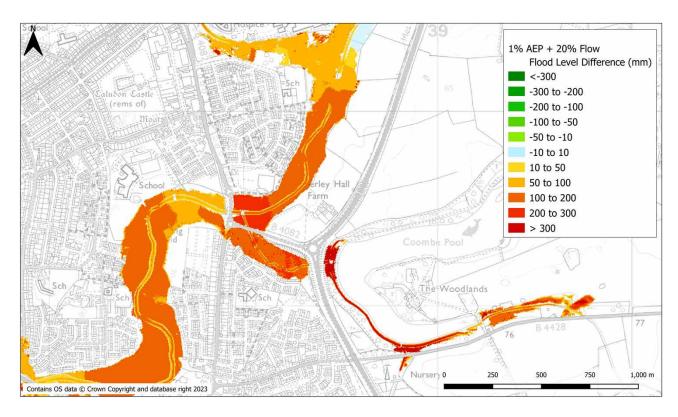


Figure 5-9: 1% AEP +20% flow flood level difference

- 5.5.11. A reduction in flow by 20% is generally comparable to the inflows derived from the 2021 hydrology study that informed the legacy model. This suggests that using the new FEH22 DDF hydrological model has had the greatest impact on flood depths along the smaller sub-catchments of the Smite Brook and its tributaries.
- 5.5.12. A reduction of flow by 20% resulted in a decrease in flood depths across all modelled reaches (Figure 5-10). The greatest reduction in flood depths are predicted along the Unnamed tributary (477mm) and around the A46 Walsgrave Junction (513mm). The model is less sensitive to flow around the Withy Brook and River Sowe confluence where the floodplain is much wider.
- 5.5.13. Changes to flows appear to make no significant difference to the flood extents around the A46 Walsgrave Junction. The results show that the model is more sensitive to variations in applied flow where the flood level is driven by storage such as the area upstream of the A46.
- 5.5.14. The results suggest the model shows a reasonable response to changes in flow.



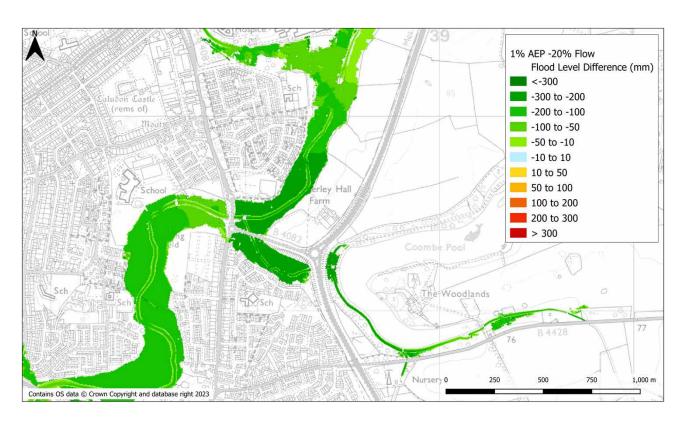


Figure 5-10: 1% AEP -20% flow flood level difference



6. Option Model Build

6.1. Description of scheme

- 6.1.1. The Scheme comprises of an upgrade to the junction of the A46 Coventry Eastern bypass and the B4082, east of Walsgrave. The Scheme is being progressed by National Highways to ease congestion and reduce queuing along the A46 corridor, east of Coventry.
- 6.1.2. The proposed full grade separated dumb-bell junction is approximately 800m north of the existing A46 Walsgrave Junction roundabout and consists of north and southbound diverge and merge slip roads connecting to an overbridge with roundabouts to the east and west (Figure 6-1). The proposed Walsgrave overbridge spans across the A46 between the two roundabouts and carries a two-lane single carriageway.
- 6.1.3. The Scheme proposes to reduce the existing eastern A46 embankment south of the existing A46 Walsgrave Junction. The eastern embankment currently provides protection to fluvial flood waters from flooding the A46 carriageway. Protection is maintained along the southbound carriageway to prevent fluvial flood waters entering the highway, by maintaining the embankment level to the design event level (74.0mAOD) with an allowance of 600mm freeboard. Ensuring the design of the highway is protected against flood waters.
- 6.1.4. The Scheme includes two proposed basins to attenuate surface water runoff from the highway. The northern basin is contained between the A46 and the proposed slip road and sits entirely outside the floodplain. The B4082 basin is located in the south of the scheme, north of the B4082 and will be accessed from a private road off the B4082. The B4082 basin lies outside of the floodplain except for the western edge of the access track.



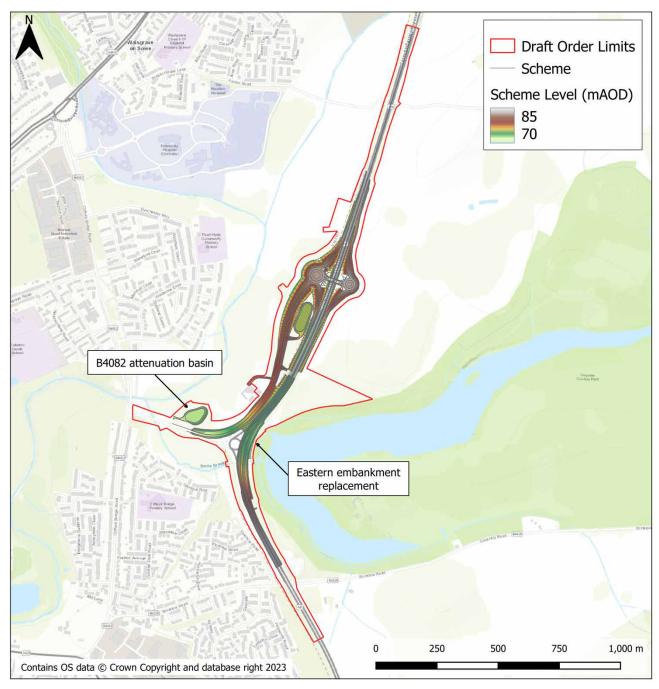


Figure 6-1: Scheme design

- 6.1.5. The existing eastern embankment earthworks are to be removed and replaced with a layer of clay to prevent seepage and potential undermining of the proposed highway (Figure 6-2). The proposed embankment will be graded to existing slope (1 in 2.5) or slacker to ensure no net gain in material within the floodplain.
- 6.1.6. There will be no earthwork volume loss between the existing and proposed embankments below the design event plus 600mm freeboard level.



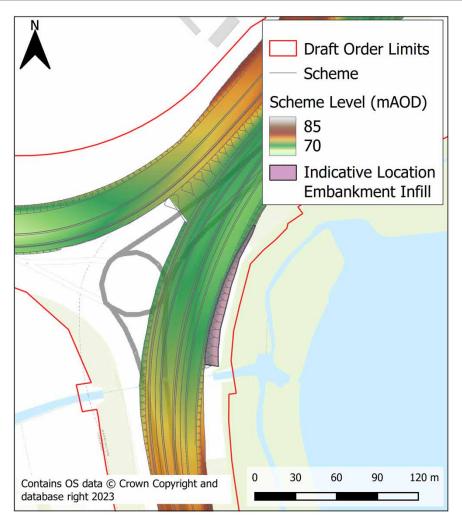


Figure 6-2: Eastern A46 embankment replacement

6.2. Topographic updates

- 6.2.1. The Scheme 3D model was exported to an ASCII grid file and superimposed onto the baseline ground model. The 3D model includes the highways design, together with drainage basins and access tracks.
- 6.2.2. No further changes to topography were made within the option model.

6.3. Roughness values

6.3.1. The proposed B4082 drainage basin access track will be constructed using gravel fill at existing grade. The access track Manning's 'n' value in this area was adjusted from 0.040 to 0.025 to account for the change in roughness (Figure 6-3). This was the only adjustment to Manning's 'n' values within the Option scenario as the remainder of the Scheme lay outside of the design flood extent.



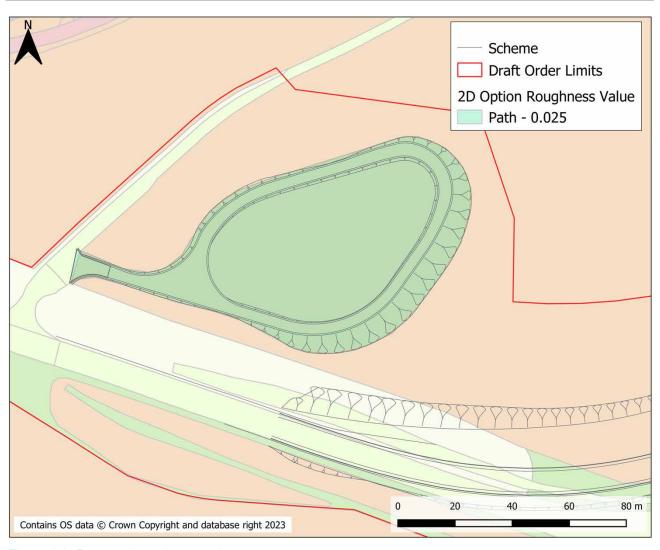


Figure 6-3: Proposed roughness values



7. Option Results

- 7.1.1. The design event flood maps are provided in the A46 Walsgrave Junction Flood Risk Assessment Appendix A.
- 7.1.2. The majority of the Scheme lies outside of the design event flood extent. The inclusion of the scheme within the model resulted in changes to flood depths local to the A46 Walsgrave Junction virtually all within the model tolerance of +/- 10mm (Figure 7-1). A flood depth comparison for the 1% AEP is provided in Appendix A of the A46 Walsgrave Junction Flood Risk Assessment. The changes in flood depths of the 1% AEP event are virtually all within the model tolerance of +/- 10mm.
- 7.1.3. The proposed finished level of the southbound carriageway of 74.0mAOD is maintained the full length of the Scheme design and ensures no flooding of the carriageway itself.
- 7.1.4. The proposed attenuation ponds sit outside the design flood extents. They remain dry during a fluvial event and have full capacity to attenuate highways drainage.

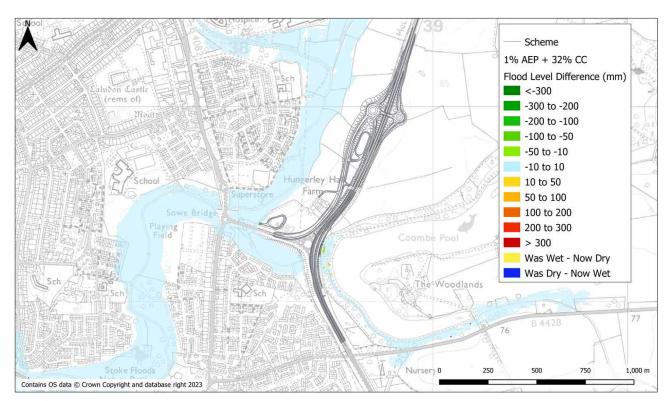


Figure 7-1: 1% AEP + 32% Scheme flood level difference

7.1.5. Figure 7-2 indicates small areas of both betterment and detriment in the Smite Brook floodplain east of the A46 Walsgrave Junction. These changes are in an area that already floods up to a depth of 2.2m in the design event. As detailed in



Section 6.1, the proposed embankment will be graded to the existing slope or slacker to ensure there is no net gain in material within the floodplain.

Slackening of the embankment within the ground model created marginal floodplain storage and resulted in increased depths along the embankment and additional model cells receiving flood waters. This has resulted in minor localised fluctuations in a limited number of cells in close proximity to the culvert, which are attributed to the model calculations.

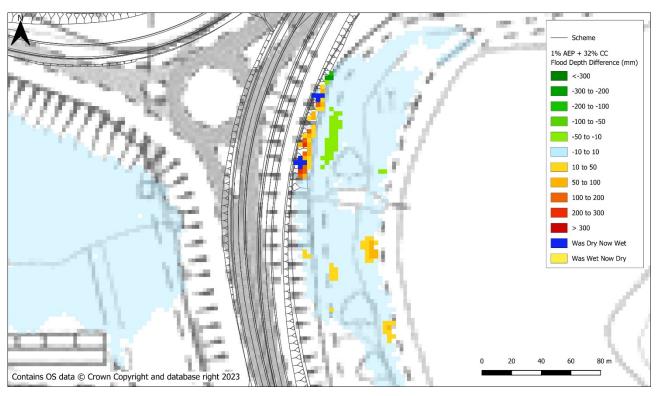


Figure 7-2: Variations in flood level difference

7.1.6. Figure 7-3 shows a flow comparison between the baseline and proposed design event taken from the cross-section immediately downstream of the A46 culvert (SMT1_0451). Any variations in flood depths upstream of the A46 culvert result in no impacts to downstream flows, flood levels or receptors. The design is therefore considered acceptable in terms of flood risk and no flood compensation is required.



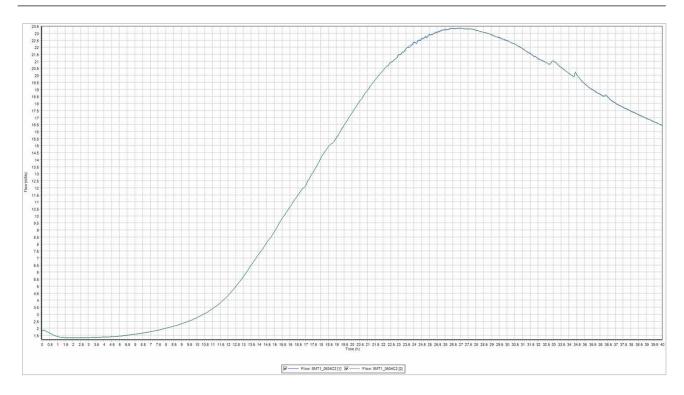


Figure 7-3: Flow comparison downstream of A46 culvert



8. Conclusion

- 8.1.1. Sweco have been commissioned by National Highways to provide a flood risk assessment and associated hydraulic modelling for the A46 Walsgrave Junction upgrade project. A hydraulic model was developed to characterise the baseline and proposed flooding conditions. A baseline legacy model was developed by AECOM during National Highways PCF Stage 2 to define the existing flooding conditions of the area. Updates were made to the legacy model which included use of the newest software versions, updated hydrological inflows and a new topographical survey.
- 8.1.2. Model updates resulted in a reduction to the 1% AEP flood extents and depths compared to the legacy model, most notably in areas upstream of the A46 Walsgrave Junction. This can be attributed to the larger reduction in peak flows for the eastern, rural sub-catchments compared to the western urban sub-catchments. There are notable decreases to flood depths along the Unnamed tributary and the ponding water upstream of the A46 culvert where flood levels are driven by storage. Furthermore, minor changes to bank elevations downstream of Clifford Bridge resulted in increased flood depths compared to the legacy model.
- 8.1.3. A high-level calibration was undertaken using observed data from the High Bridge gauge against modelled outputs. The observed data was used to check timing and response of the modelled stage curve only. A lack of detailed survey data is noted in the area of High Bridge gauge. Similarly to the 2021 legacy model findings it was considered inappropriate to calibrate the model using one gauge significantly upstream of the Scheme and located on a different reach to the Smite Brook.
- 8.1.4. Investigations were made into non-convergences within the model which could be an indicator of underlying instabilities. These non-convergences were however, associated with isolated areas along the existing Environment Agency ISIS model of the River Sowe and Withy Brook. The mass balance of the model was considered acceptable, and confidence was given in the model suitability for option assessment.
- 8.1.5. Sensitivity testing was undertaken to assess the influence on the 1% AEP event results with changes to Manning's 'n' roughness coefficients and variations of inflows. The results suggested the model showed a reasonable response in flood depth difference with changes to roughness and flow. Changes to roughness and flow appeared to make no significant difference to the flood extents around the A46 Walsgrave Junction.



8.1.6. The Scheme was tested under the 1% and 1% AEP + 32% climate change events. Protection of the carriageway was provided up to the design event level plus an allowance of 600mm freeboard. The Scheme design ensures no flooding of the carriageway under the design event. Slackening of the embankment within the ground model created marginal floodplain storage along the embankment. Further assessment is provided within the FRA.



9. References

AECOM (2021). A46 Walsgrave Junction Flood Risk Assessment

Chow, V.T. (1959). Open Channel Hydraulics

Design Manual for Roads and Bridges (2020). CD 356, Design of highway structures for hydraulic action, Revision 1.

Environment Agency (2022). Flood risk assessments: climate change allowances. Available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances. Accessed: 7 August 2024

National LiDAR Programme (2020). DEFRA Survey data download.

Flood Estimation Handbook. Revitalised Flood Hydrograph rainfall-runoff method (ReFH) Version 2.4



Appendix A. Hydraulic Modelling Files

Default Flood Modeller Pro 1D simulation parameters were used for all events except for those given in Table A-1.

Table A-1: 1D ief simulation parameters

1D ief Simulation Parameter	Value
Dflood	10 (1000-year event only)
Maxitr	19 (adjusted to increase stability and reduce non-convergence)

Table A-2: Baseline 1D model files

Baselir	ne 1D Model Files	Comment
dat	Coventry_up_defended_Trunc_015.dat	1 Flood Modeller Pro network used for all simulations
ied	2yr_22hr_Summer.ied 20yr_22hr_Summer.ied 50yr_22hr_Summer.ied 100yr_22hr_Summer.ied 100yrsCC32_22hrs_Summer.ied 100yrsCC59_22hrs_Summer.ied 1000yr_22hr_Summer.ied 100yrs_22hrs_Q+20_Summer 100yrs_22hrs_Q-20_Summer 100yr_17hr_Summer.ied 100yr_22hr_Winter.ied 100yr_22hr_Winter.ied March2007 Calibration Event.ied Nov2012 Validation Event.ied Feb2020 Calibration Event.ied	 Flood events Flow sensitivity 17-hour event duration analysis Seasonality analysis Model calibration
ief	CovUp_DEF_Trunc_2yr_22hr_048.ief CovUp_DEF_Trunc_50yr_22hr_048.ief CovUp_DEF_Trunc_50yr_22hr_048.ief CovUp_DEF_Trunc_100yr_22hr_048.ief CovUp_DEF_Trunc_100yrCC32_22hr_048.ief CovUp_DEF_Trunc_100yrCC59_22hr_048.ief CovUp_DEF_Trunc_1000yr_22h_048.ief CovUp_DEF_Trunc_100yr_22h_048.ief CovUp_DEF_Trunc_100yr_22h_Q+20_044.ief CovUp_DEF_Trunc_100yr_22h_Q-20_044.ief CovUp_DEF_Trunc_100yr_22h_N+20_044.ief CovUp_DEF_Trunc_100yr_22h_N-20_044.ief CovUp_DEF_Trunc_100yr_17hr_044.ief CovUp_DEF_Trunc_100yr_22hr_WINTER_044.ief CovUp_DEF_Trunc_100yr_22hr_WINTER_044.ief CovUp_DEF_Trunc_Mar_2007_Calibration_Event.ief CovUp_DEF_Trunc_Nov_2012_Calibration_Event.ief	 Flood events Flow / roughness sensitivity 17-hour event duration analysis Seasonality analysis Model calibration

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	CovUp_DEF_Trunc_Feb_2020_Calibration_Event.ief	
iic	SWECO_COVUP_DEF_TRUNC_100YRCC32_22HR _025_IC_v3.iic	1 initial conditions file used for all simulations captured at T = 8 hours



Table A-3: Baseline 2D model files

Baseline 2	2D Model Files	Comment
tcf	SWECO_Coventry_Up_Trunc_~s~_~e1~_~e2~_048	Design events
tbc	SWECO_Coventry_up_Trunc_010.tbc	Design events
tgc	SWECO_Coventry_up_Trunc_025.tgc	Design events
tmf	Coventry_up_002	Design events

Table A-4: Option 1D model files

Option 1D	Model Files	Comment
dat	Coventry_up_defended_Trunc_015.dat	
ied	100yr_22hr_Summer.ied 100yrsCC32_22hrs_Summer.ied 100yrsCC59_22hrs_Summer.ied	
ief	CovUp_DEF_Trunc_100yr_22hr_052.ief CovUp_DEF_Trunc_100yrCC32_22hr_052.ief CovUp_DEF_Trunc_100yrCC59_22hr_052.ief	
iic	SWECO_COVUP_DEF_TRUNC_100YRCC32_22H R_025_IC_v3.iic	

Table A-5: Option 2D model files

Option 2D	Model Files	Comment		
tcf	SWECO_Coventry_Up_Trunc_~s~_~e1~_~e2~_052.tcf	New TCF for Option run		
tbc	SWECO_Coventry_up_Trunc_010.tbc			
tgc	SWECO_Coventry_up_Trunc_028.tgc	New TGC writes in Option ASC and Option materials layer		
tmf	Coventry_up_002.tmf			



Appendix B. A46 Walsgrave Junction Hydrological Assessment

Title

Project title: Stage 3 A46 Walsgrave Junction

Date: 06/11/2023

Introduction

Sweco UK has been appointed by National Highways (NH) to undertake a Flood Risk Assessment (FRA) to support the redevelopment of the A46 Walsgrave Junction. A hydrological study was carried out at NH PCF Stage 2 in 2021. This assessment is an update to the original hydrology. The assessment site borders the Coventry City and Rugby Borough councils where the proposed works to upgrade the Walsgrave Junction in order to improve the congestion and reduce queuing along the A46 will be undertaken. This report utilises FEH methods to assess the potential effects of fluvial flooding upon the development.

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	Method StatementLocations where flood estimates are required

Approval

Name	Signature	Date
		06/11/23
		13/11/23
		21/11/23
	Name	Name Signature

Abbreviations

AM Annual Maximum
AREA Catchment area (km2)
BFI Base Flow Index

BFIHOST Base Flow Index derived using the HOST soil classification

CFMP Catchment Flood Management Plan
CPRE Council for the Protection of Rural England

FARL FEH index of flood attenuation due to reservoirs and lakes

FEH Flood Estimation Handbook
FSR Flood Studies Report
HOST Hydrology of Soil Types
NRFA National River Flow Archive
POT Peaks Over a Threshold

QMED Median Annual Flood (with return period 2 years)

ReFH Revitalised Flood Hydrograph method SAAR Standard Average Annual Rainfall (mm)

SPR Standard percentage runoff

SPRHOST Standard percentage runoff derived using the HOST soil classification

Tp(0) Time to peak of the instantaneous unit hydrograph URBAN Flood Studies Report index of fractional urban extent

URBEXT1990 FEH index of fractional urban extent

URBEXT2000 Revised index of urban extent, measured differently from URBEXT1990 WINFAP-FEH Windows Frequency Analysis Package – used for FEH statistical method

1 Summary of assessment

1.1 Summary

Item	Comments
Catchment location:	River Sowe, Coventry
Purpose of study and complexity:	Provide updated inflows to the River Sowe model to assess flood risk for the A46 Walsgrave Junction project. The site lies within the River Sowe catchment. Within the River Sowe catchment, there are multiple waterbodies of interest, the River Sowe, Smite Brook, and Coombe Pool, as well as minor tributaries. The main area of interest concerns the Smite Brook which is culverted beneath the embanked A46.
Key catchment features:	The catchment is a mixture of urban land use to the west of the proposed development (towards Coventry city centre) and more rural environments to the east. Coombe Pool is a large reservoir situated to the east of Coventry in close proximity to the proposed development.
Flooding mechanisms:	Fluvial flooding is the main mechanism of flooding at the development site which is located within Flood zone 3.
Gauged / ungauged:	There are no flow gauges located within the modelled reach; however, a level gauge is present on Withy Brook and a level and flow gauge are present on the River Sowe.
Final choice of method:	ReFH2
Key limitations / uncertainties in results:	Lack of data for calibration on the modelled watercourses.

1.2 Flood frequencies

The frequency of a flood can be quoted in terms of a return period, which is defined as the average time between years with at least one larger flood, or as an annual exceedance probability (AEP), which is the inverse of the return period. Return periods are output by the Flood Estimation Handbook (FEH)¹ software and can be expressed more succinctly than AEP. However, AEP can be helpful when presenting results to members of the public who may associate the concept of return period with a regular occurrence rather than an average recurrence interval. The table below is provided to enable quick conversion between return periods and annual exceedance probabilities.

AEP (%)	50	20	10	5	3.33	2	1.33	1	0.5	0.1
AEP	0.5	0.2	0.1	0.05	0.033	0.02	0.013	0.01	0.005	0.001
Return Period (yrs)	2	5	10	20	30	50	75	100	200	1,000

¹ https://www.hydrosolutions.co.uk/software/flood_estimation_handbook/

Method Statement

Requirements for flood estimates 2.1

Item	Comments
Overview and Project Scope:	A full hydrological assessment was completed by AECOM in 2021 at National Highways (NH) Project Control Framework (PCF) Stage 2. The hydrology was accepted by the EA and used to form the inflows to the hydraulic model of the River Sowe and tributaries.
	The purpose of this assessment is to update the hydrology with the latest NRFA peak flow dataset ² and to make use of the recently released FEH22 DDF model. Hydrographs are required as updated inflows to the hydraulic model.
	This study makes reference to the Stage 2 hydrological record (A46 Coventry Junctions Upgrade- Walsgrave Flood Estimation Calculation Record, 2021). This study is hereby referred to as the '2021 hydrology study'

2.2 **The Catchment**

Item	Comments
Catchment Description:	The River Sowe rises in the north-west of Coventry and flows south-east towards the eastern suburbs of Coventry (Figure 2.1). It is joined by the Withy Brook which drains a predominantly rural area, to the north-east of Coventry (Figure 2.1). The River Sowe flows under the B4082 where it is joined by the Smite Brook which drains a rural area east of Coventry (Figure 2.1). It flows through Coombe Pool, an ornamental manmade lake. Two unnamed tributaries flow around the toe of the Coombe Pool dam and into Smite Brook downstream of the pool.
	The A46 Walsgrave Junction is shown in Figure 2.1. The junction joins the B4082 to the A46. Within the Sowe catchment are two level gauges: the River Sowe @ Hall Green Road, and the Withy Brook @ High Bridge (Figure 2.1). Downstream of the catchment along the River Sowe lies a rainfall gauge: Finham rainfall gauge and a flow gauge: the River Sowe @ Stoneleigh (Figure 2.1). Figure 2.1 shows the upstream model limits for the five identified watercourses in the Sowe catchment.
	Google Earth³, BGS Viewer⁴, and QGIS⁵ were utilised to analyse the potential change in topography, geology, soils, and land use since the 2021 hydrology study. The analysis showed no significant changes in these characteristics. The Sowe catchment is underlain by sandstone and siltstone of mixed permeability. The eastern part of the catchment is overlain by superficial deposits of till/glacial sand/gravels. The River Sowe, Withy Brook and Smite Brook are underlain by Alluvium.
	The Coventry Canal and Oxford Canal run through the Sowe catchment. These canals could impact on flood risk; however, this is outside the scope of this assessment.

² https://nrfa.ceh.ac.uk/peak-flow-dataset

³ https://earth.google.com/web/@49.19629861,-2.09326651,51.73781099a,437.69046818d,35y,0h,0t,0r/data=OgMKATA
⁴ https://geologyviewer.bgs.ac.uk/?_ga=2.98031199.1714669816.1699609380-349121520.1699609380
⁵ QGIS version 3.28.4

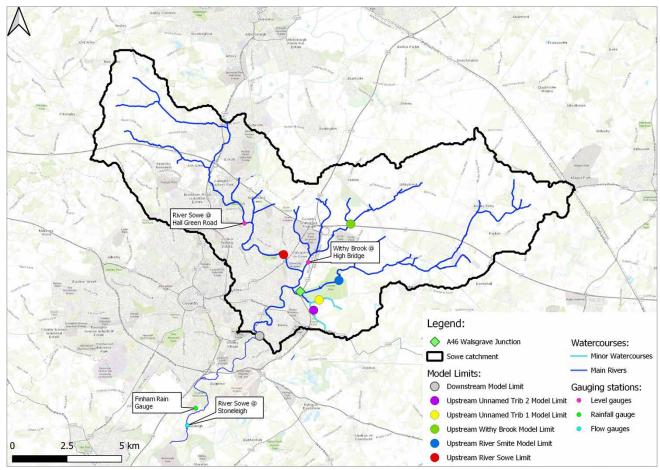


Figure 2.1: Study area, watercourses, and gauging stations.

2.3 Hydrometric Data

Item	Comments
Source of flood peak data:	NRFA Peak Flow Dataset, Version 12.0.2, released September 2023 was used for this assessment. This contains data up to the end of September 2022. Issues regarding certain catchments were identified and an updated Version 12.1 was released to fix these issues. The catchments affected were not included in this assessment. A sensitivity check was undertaken for the Sowe US catchment using the Version 12.1 dataset. No changes to peak flows were noted.
	Note the 2021 study made use of NRFA Peak Flow Dataset, Version 9, released September 2020. This contained data up to water year 2018-19 and 2019-20 for stations that set new records.

Gauging stations (flow and level):

Four gauges were identified within the 2021 Study that area located within the study area. However, only the Rover Sowe flow gauge will be used to inform this study.

Water- course	Station name	Gauging authority number	NRFA number (used in FEH)	Grid reference	Catchment area (km²)	Туре	Period of available data
Withy Brook	High Bridge	26303	N/A	N/A	28.2	Level	1996 to present

River Sowe	Hall Green Road	2207	N/A	N/A	35.5	Level	2008 to present
River Sowe	Stoneleigh	N/A	54004	433155, 273096	262.0	Flow	1951 to present
N/A	Finham Rain	449957	N/A	N/A	N/A	Rainfall	1996 to present
River Sowe	Longford	2209	N/A	434930 , 283310	N/A	Level	2009 to present

Data available at each flow gauging station:

There are no flow gauging stations present within the catchment site; however, there is a flow gauging station 8.2km downstream along the same watercourse (River Sowe). The River Sowe at Stoneleigh flow gauge has obtained AMAX data, which will be used as a QMED donor for the study catchments in the statistical method.

Rating Equations:

Item	Comments
Rating reviews:	The River Sowe at Stoneleigh (NRFA gauge number- 54004) will be used for QMED estimation due to its locality to the study area. Three peak flow ratings have been applied over a 72-year peak flow dataset history. The ratings are a good fit to the gaugings. No rating review required.

Type of data	Data relevant to this study	Data available	Source of data	Details
Check flow gaugings (if planned)	No	No		
Rating equations	No	No		
Historic flood data	No	Yes	2021 hydrology study	Section 3.5 of hydrology record
Flood or level data for events	No	Yes	2021 hydrology study	
Results from previous studies	Yes	Yes	2021 hydrology study	Flood estimation record
Other information e.g. groundwater, tides, etc	No	No		

2.4 Hydrological understanding of the catchment

Item	Comments
Conceptual model:	The main area of interest surrounds the A46 Walsgrave Junction. Flooding in this location is likely from the River Sowe and Smite Brook.
	Coombe Pool routes flow from Smite Brook, which may attenuate water levels. Unnamed Tributary 1 drains rural land east of Coombe Pool and joins Smite Brook downstream.
	Unnamed Tributary 2 flows north from Binley Woods housing estate to join Unnamed Tributary 1 immediately upstream of Coombe Pool.

Unusual catchment features:

No catchments are considered highly permeable (BFIHOST19 > 0.65).

The River Sowe catchment is highly urbanised. Withy Brook and Smite Brook are mainly rural. Tributary 1 catchment is rural and tributary 2 catchment is partly urbanised.

Coombe Pool is represented within the model so is not considered in the hydrological representation.

Coventry and Oxford Canals run through the study catchments. The canals have the potential to impact on flood flows. An assessment of this risk was made in the 2021 study which deduced that the risk of canals intercepting significant flows and conveying it across the catchment boundaries is considered to be low.

2.5 Initial choice of approach

Item	Comments
Are FEH methods appropriate?	Yes
Initial choice of method(s) and reasons:	FEH statistical and ReFH2.4 ⁶ methods are appropriate as the catchment is ungauged and contains both rural and urban inflows. The final decision for the appropriate method will be made following the analysis of the results.
How will hydrograph shapes be derived if needed?	Hydrographs are required and will be obtained from ReFH2.4. Peak flows will be compared to the 2021 hydrology study.
Will the catchment be split into sub-catchments? If so, how?	The catchment will be split into seven sub-catchments utilising a distributed modelling approach. This allows for the consideration of the timing of flows within the main three sub-catchments: the River Sowe, Withy Brook, and Smite Brook. The catchment sizes and geology have not changed since the 2021 hydrology study; therefore, the same methods of splitting the sub-catchments will be applied.
Software to be used:	FEH Web Service ⁷ / NRFA / WINFAP v5 ⁸ / ReFH2.4 / Flood Modeller Pro ⁹

⁶ https://www.hydrosolutions.co.uk/software/refh-2/

⁷ https://fehweb.ceh.ac.uk/

⁸ WINFAP V5

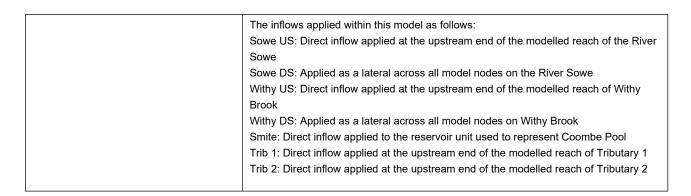
⁹ Flood Modeller Pro v5.1

3 Locations where flood estimates are required

3.1 Summary of subject sites

Item	Comments
Summary of subject sites:	The locations of the 2021 hydrology study subject sites were assessed and deemed appropriate for this study. The subject sites have remained unchanged between the studies.

Site code	Type of estimate:	Water- course	Site name / description	Easting	Northing	AREA on FEH Web Service (km²)	Revised AREA (if altered) (km²)
Sowe US	Lumped	River Sowe	At A4600	437700	280800	52.3	51.8
Sowe DS	Sub- catchment	River Sowe	Sub-catchment from SoweUS to model downstream boundary at railway line	437700- 436500	280800- 277300	N/A	12.7
Withy US	Lumped	Withy Brook	Downstream of M6 crossing	440600	282300	15.5	15.5
Withy DS	Sub- catchment	Withy Brook	Sub-catchment from WithyUS to confluence with River Sowe	440600- 438500	282300- 280200	N/A	9.93
Smite	Lumped	Smite Brook	Downstream of Coombe Pool	438550	279150	33.2	34.9
Trib 1	Lumped	Tributary 1	Downstream of unnamed Tributary 1 (excluding unnamed Tributary 2 catchment area)	439750	278950	4.41	4.76
Trib 2	Lumped	Tributary 2	Downstream of unnamed Tributary 2	438850	278800	1.11	1.78
Reasons for choosing above locations					pints for the hydrauli comparison betwee		



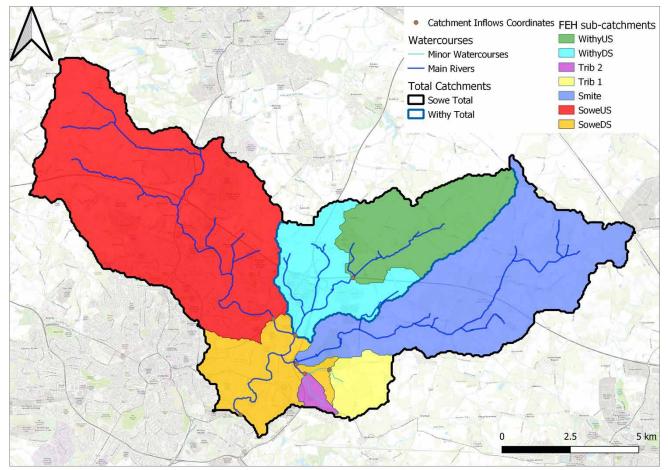


Figure 3.1 – Map of the original FEH catchments.

3.2 Catchment Descriptors

Item	Comments
Catchment boundary checks and revisions:	Catchment boundaries were checked via the NRFA web service and Ordnance Survey mapping ¹⁰ , which indicated no significant changes in catchment boundary characteristics since the previous report in the 2021 hydrology study.
	Figure 3.1 shows the original FEH catchment boundaries.
	The catchment boundaries were adjusted to match the same catchment boundary areas as the 2021 hydrology study. Figure 3.2 is an extract from the 2021 study which shows the final catchment boundaries.
URBEXT source and method for updating:	URBEXT2000 values were derived from the original catchment descriptors with a visual analysis of each sub-catchment's urban extent. The sub-catchments that showed minimal change in urban development were kept the same. The sub-catchment that remained unchanged was Tributary 1. Sub-catchments with small to medium sized areas of new urban development not captured within the FEH web service calculation of URBEXT2000 were recalculated, adding 5% to the URBEXT2000 value. The sub-catchments that were increased by 5% were Withy US, Smite, Sowe US, and Trib 2. Sub-catchments showing large areas of new urban development not considered in the FEH web service calculation of URBEXT2000 were recalculated, adding 10% to the URBEXT2000 value. The URBEXT2000 values for the Sowe DS and Withy DS were edited in the 2021 hydrology study using calculations to adjust the respective Sowe Total and Withy Total URBEXT2000 values. This assessment agrees with the changes and were made for this study.
BFIHOST source, checks and updates:	Defra MAGIC Maps ¹¹ and BGS Viewer were used to compare current BFIHOST19 and SPRHOST catchment descriptors against the values found in the 2021 hydrology study.
	BFIHOST19 values were checked and kept the same as the original catchment descriptors for the sub-catchments apart from the Tributary 2 value. The 2021 hydrology study noted that Tributary 2 had an unusually high BFIHOST19 value with no justification for this value. The BFIHOST19 and SPRHOST were edited in the 2021 hydrology study. This assessment agrees with the changes and were made for this study.

¹⁰ https://www.bing.com/maps?cp=52.413658%7E-1.420818&lvl=12.2&style=s https://magic.defra.gov.uk/MagicMap.aspx

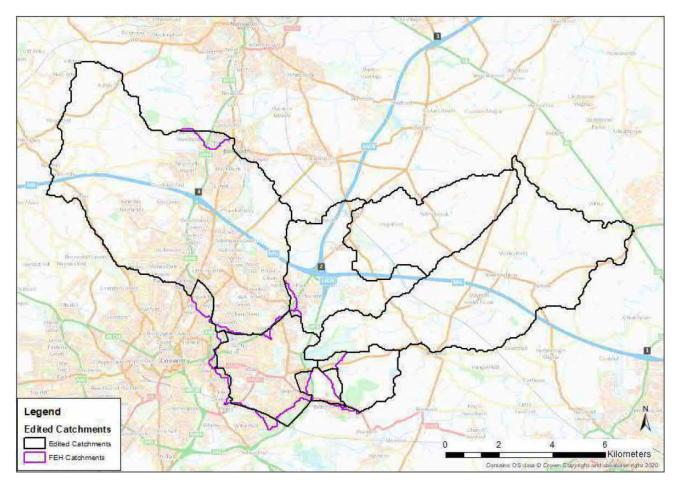


Figure 3.2 – Extract from the 2021 hydrology study record of the adjusted catchment boundaries

The adjusted catchment descriptors are given below. The adjusted values are shown in red. The only discrepancies in catchment descriptor values between the two studies are the URBEXT2000 values. This is because the change in URBEXT2000 was visually estimated as opposed to using the UEF equation.

Site code	FARL	PROP WET	BFIH OST	BFIHOS T (19)	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	SPRHOST (%)	URBEXT 2000	FPEXT
Sowe US	0.989	0.300	0.550	0.519	9.5	26.0	667	33.7	0.2421	0.111
Sowe Total	0.957	0.300	0.497	0.487	14.0	25.5	657	36.67	0.1359	0.112
Withy US	1.00	0.300	0.347	0.354	4.11	30.2	651	41.5	0.0025	0.0816
Withy Total	1.00	0.300	0.374	0.379	6.02	25.5	648	41.5	0.01206	0.110
Smite	0.960	0.300	0.459	0.464	10.1	27.4	652	38.9	0.0096	0.0940
Trib1	1.00	0.300	0.477	0.478	1.91	15.6	645	40.8	0.0060	0.135
Trib 2	1.00	0.300	0.536	0.478	1.37	14.6	645	40.8	0.0808	0.120

The catchment descriptors from the edited intervening Sowe DS and Withy DS catchments were reviewed from the 2021 hydrology study. This study agrees with the changes made. The adjusted catchment descriptors for the Sowe DS and Withy DS are shown below.

Site code	FARL	PROPW ET	BFIHOS T	BFIHOST (19)	DPLBA R (km)	DPSBAR (m/km)	SAAR (mm)	SPRHOST	URBEX T2000	FPEX T
Sowe DS	1.000	0.300	0.497	0.710	3.55	22.9	656	27.6	0.4722	0.180
Withy DS	1.000	0.300	0.374	0.410	4.02	19.8	644	41.5	0.0398	0.144

4 Stationary statistical methods

4.1 Method overview

Item	Comments
What is the purpose of applying these methods?	To estimate peak flood flows for each of the subject catchments to be used in a hydraulic model of the study area.
What methods will be used to estimate QMED and growth curves?	The wider Sowe catchment in the study area is ungauged; however, the River Sowe is gauged at Stoneleigh (54004), which is approximately located 8.2km downstream of the study catchment. This station is suitable for use as a QMED donor within WINFAP v5. The growth curves will be estimated using a pooled analysis.

Site code	Methods used for QMED	Methods used for growth curves
Sowe US	Single donor (54004)	Pooled analysis
Sowe DS	Single donor (54004)	Pooled analysis
Withy US	Single donor (54004)	Pooled analysis
Withy DS	Single donor (54004)	Pooled analysis
Smite	Single donor (54004)	Pooled analysis
Trib 1	Single donor (54004)	Pooled analysis
Trib 2	Single donor (54004)	Pooled analysis

4.2 Estimating QMED

Item	Comments
QMED at ungauged subject sites:	Donor transfer using a single donor station (Sowe @ Stoneleigh) was used within WINFAP v5 to estimate QMED for the subject sites. The station was selected due to its locality to the study area. Sowe @ Stoneleigh is considered urban. As such, the de-urbanisation function within WINFAP v5 was applied within the donor window. This generated the adjusted 'rural' QMED.
	The bankfull channel width approach to estimate QMED is not applicable due to the size of the watercourses, as well as the impact of urban factors.
Urban adjustment of QMED:	The urban adjustment factor of QMED was applied within WINFAP v5 to all subject sites as per current guidance.

Donor sites chosen and QMED adjustment factors:

The table below shows the Sowe @ Stoneleigh catchment. The station was selected for donor transfer due to locality to the study area. The 2021 hydrology study observed QMED and QMED from CDs are shown for comparison.

Notably, the observed QMED at the gauge has reduced from 31.0m³/s to 30.67m³/s. Use of BFIHOST19 when estimating QMED from CDs was introduced in WINFAP v5. The 2021 hydrology study used WINFAP v4 and estimated QMED using BFIHOST. This has resulted in a reduction in the estimation of QMED from CDs from 28.88m³/s to 25.73m³/s.

NRFA no.	Method (AM/ POT/LF)	Adjustment for climatic variation?	QMED from flow data (m³/s)	2021 QMED from flow data	De- urbanised QMED from flow data (m³/s) (A)	QMED from catchment descriptors (m³/s) (B)	2021 QMED from catchment descriptors (m³/s) (B)	Adjustment ratio (A/B)
54004	AM	No	30.7	(m³/s) 31.0	25.5	25.7	28.9	0.99

The table below shows the original and adjusted QMED values for each sub-catchment. A comparison to the final QMED values in the 2021 hydrology study is also included. The largest discrepancy in QMED estimation for the subject catchments is for Sowe US. This is due to the largest variation between the BFIHOST and BFIHOST19 CD value.

Site code	QMED (from CDs) (m³s-¹)	Methods used for QMED	QMED with single donor (rural) (from CDs) (m³s-¹)	Final estimate of QMED urban (m³s-1)	2021 hydrology study Final adjusted QMED
Sowe US	6.05	Single donor (54004)	6.03	7.94	7.55
Sowe DS	0.88	Single donor (54004)	0.88	1.87	1.93
Withy US	3.28	Single donor (54004)	3.27	3.28	3.43
Withy DS	1.90	Single donor (54004)	1.90	1.97	1.96
Smite	4.32	Single donor (54004)	4.31	4.35	4.50
Trib 1	0.85	Single donor (54004)	0.85	0.85	0.88
Trib 2	0.37	Single donor (54004)	0.37	0.40	0.38

Item	Comments
Uncertainty in QMED	Estimating QMED from CDs alone is not advised. The influence on using a donor site reduces the factorial Standard Error (FSE) compared to using CDs alone. Using a donor site reduces the uncertainty to between 1.380 to 1.396. Down from 1.431 when using CDs alone.

4.3 Estimating growth curves

Derivation of growth curves at subject sites:

The subject sites were split up into two pooling groups. One to represent the urbanised, permeable western catchments of the Sowe US, Sowe DS, and Withy DS. And one to represent the less permeable, rural eastern catchments of Withy US, Smite, Trib 1, and Trib 2. In line with the 2021 hydrology study, the URBEXT2000 threshold was relaxed 0.3 when creating the pooling groups to maximise the use of local data.

The Environment Agency's guidelines state that modifications to pooling groups tend to have a relatively minor effect on the final design flow. The review of the pooling group has initially focused on the first five stations. Stations outside the first five stations were removed for the following reasons, moving up into the first five stations, highly permeable catchments, short records/inaccuracies of flow data, outliers on L-plots and skewed data, and unrepresentative growth curves. No adjustments were made for non-flood years.

The table below summarises the pooling groups. Further information on the derivation of pooling groups can be found in Annex A.

Site code	Method (SS, P, ESS, H.)	Site code from whose descripto rs group was derived	If P or ESS, name of pooling group	Distribution used and reason for choice	Any urban or non-flood years adjustments	Parameters of distribution (location, scale and shape after adjustments)	Growth factor for 100-year return period
Sowe US, Sowe DS, Withy DS	Р	SoweUS	Western	GL selected as agreed well with 1% and 0.1% distributions and produced most conservative 1% peak.	Adjusted for urbanisation within WINFAP v5	Location: 1.00 Scale: 0.253 Shape: -0.208	2.95
Withy US, Smite, Trib 1, Trib 2	Р	Smite	Eastern	GL selected as agreed well with 1% and 0.1% distributions and produced most conservative 1% peak.	No adjustments made	Location: 1.00 Scale: 0.309 Shape: -0.154	3.07

Methods: SS - Single Site; P - Pooled; ESS - Enhanced Single Site; H - Historical. Pooled and ESS growth curves were derived using the procedures from Science Report SC050050 (2008). Urban adjustments are carried out using the method of Kjeldsen (2010).

Derivation of pooling groups:

Name of group	Site code from whose descriptors group was derived	Subject site treated as gauged? (ESS)	URBEXT2000 threshold applied to pooling group selection?	Default L-moments deurbanised
Western	Sowe US	No	0.300	L-CV: 0.286
				L-Skew: 0.146
Eastern	Smite	No	0.300	L-CV: 0.279
				L-Skew: 0.193

Methods: Unless otherwise stated, pooling groups were derived using the procedures from Science Report SC050050 (2008). The small catchment pooling procedure is given in the report on Phase 2 of project SC090031 (2021) and implemented in WINFAP v5.

Name of group	Initial Pooling Group H2 value	Recommendation for initial pooling group	Final Pooling Group H2 value	Recommendation for final pooling group review
Western	4.01	Review essential	0.232	Review not required
Eastern	0.980	Review not required	0.339	Review not required

Pooling group composition:

Name of group	Changes made to default pooling group, with reasons	Weighted average L- moments	Growth factor for 100-year return period
Western	Stations within highly permeable catchments that did not align with the subject site were removed, as well as sites with short record lengths. Additional stations were added to increase the record length.	L-CV: 0.249 L-Skew: 0.208	2.95
Eastern	Gauging stations with evident issues such as poor flow data/flat or significant growth curves/short record length were removed. Stations within highly permeable catchments were also removed. Additional stations were added to increase the record length.	L-CV: 0.298 L-Skew: 0.154	3.08

4.4 Final choice of QMED and growth curves

Item	Comments
Method choice and reasons:	The donor method was used to estimate QMED. Due to the Sowe @ Stoneleigh gauging station present 8.2km downstream of the study area, a single donor method was used. Changes between WINFAP v4 and WINFAP v5 establish a change in QMED calculation from using BFIHOST to BFIHOST19 values. This, along with a reduction in observed QMED by 0.59m3/s at the gauge and a difference in how URBEXT2000 has been updated, has led to a minor disparity between QMED values in this report and the 2021 hydrology study.
	Given the reduction in FEH Statistical peak compared to the 2021 hydrology assessment and in the interest of not underestimating flood volumes at the Walsgrave Junction, GL was selected as the preferred distribution.

Growth Curve Factors for the following return periods for GL, GEV and KAP3 distributions for the Western Catchment Pooling Group:

	2	5	10	20	30	50	100	200	1000
GL	1	1.41	1.71	2.03	2.23	2.52	2.95	3.44	4.90
GEV	1	1.45	1.76	2.07	2.26	2.50	2.83	3.18	4.04
KAP3	1	1.42	1.73	2.05	2.25	2.52	2.91	3.33	4.50

Growth Curve Factors for the following return periods for GL, GEV and KAP3 distributions for the Eastern Catchment Pooling Group:

	2	5	10	20	30	50	100	200	1000
GL	1	1.48	1.81	2.15	2.37	2.65	3.07	3.53	4.81
GEV	1	1.53	1.87	2.20	2.38	2.61	2.91	3.20	3.86
KAP3	1	1.50	1.84	2.18	2.38	2.64	3.01	3.39	4.35

Final flood estimates from stationary statistical methods:

Site		Flood peak (m³/s) for the following return periods (in years)								
code	2	5	10	20	30	50	100	200	1000	
Sowe US	7.94	11.2	13.5	16.1	17.7	20.0	23.4	27.3	38.9	
Sowe DS	1.87	2.53	3.04	3.61	3.98	4.50	5.31	6.27	9.26	
Withy US	3.28	4.80	5.87	6.99	7.69	8.63	10.0	11.6	16.0	
Withy DS	1.90	2.81	3.44	4.09	4.50	5.04	5.83	6.71	9.15	
Smite	4.31	6.37	7.79	9.27	10.2	11.4	13.2	15.2	20.7	
Trib 1	0.85	1.25	1.53	1.82	2.00	2.25	2.60	2.99	4.08	
Trib 2	0.37	0.54	0.66	0.79	0.87	0.97	1.13	1.30	1.76	

Flood peak in m3/s for the return periods in years or AEP (%) events.

Comparison of final flood estimates from stationary statistical methods vs the 2021 hydrology study:

Site code	e Flood peak (m³/s) for the following return periods (in years)						
	100-year return	2021 hydrology study 100-year return					
Sowe US	23.4	21.2					
Sowe DS	5.31	5.42					
Withy US	10.0	10.2					
Withy DS	5.83	5.73					
Smite	13.2	13.5					
Trib 1	2.60	2.63					

5 Revitalised Flood Hydrograph 2 Method

5.1 Method Overview

Item	Comments
What is the purpose of applying this method?	The ReFH2 model has been used to calculate peak flood flows for various return periods which can be compared to the results of the FEH Statistical Method as well as the findings from the 2021 hydrology study. The results will be reviewed and the most appropriate method of calculating peak flood flows will be used in the modelling. The ReFH2 model will derive inflow hydrographs for the hydraulic model.
Rural and urban catchment sub-divisions:	The western catchments (Sowe US, Sowe DS, Withy DS) have been urbanised. The URBEXT2000 was calculated using a percentage adjustment using the URBEXT200 layer in the FEH Web Service map.
Version of ReFH2 applied:	ReFH2.4 – FEH22

5.2 Model Parameters

A summary of the default ReFH2.4 model parameters are given below.

Site code	Method	Event Duration (hours)	Tp (hours) rural	Cmax (mm)	BL (hours)	TP urban scaling factor	IF	IRF	DS
Sowe US	CD	17:00	9.74	441	59.0	0.750	0.400	0.700	0.500
Sowe DS	CD	09:00	5.77	724	57.7	0.750	0.400	0.700	0.500
Withy US	CD	09:00	5.75	287	39.0	0.750	0.400	0.700	0.500
Withy DS	CD	11:00	6.49	332	42.4	0.750	N/A	N/A	N/A
Smite	CD	17:00	9.88	382	55.8	0.750	N/A	N/A	N/A
Trib 1	CD	07:30	4.57	396	39.6	0.750	N/A	N/A	N/A
Trib 2	CD	06:30	3.86	396	36.8	0.750	N/A	N/A	N/A

Methods: OPT: Optimisation from event analysis, BR: Baseflow recession fitting, LAG: TP from lag analysis, CD: Catchment descriptors, DT: Data transfer, CAL: model calibration.

5.3 Calibration

The ReFH2 model was calibrated during the 2021 hydrology study. Checks were made on the Withy Brook using observed levels at the High Bridge Level gauge. The ReFH2 model was used to create flow hydrographs using data from the Finham rain gauge, located 8-18km south of the Withy Brook catchment. The results showed the ReFH default parameters underestimated peak water levels at the High Bridge gauge

location by approximately 400-600mm. The 2021 hydrology study noted that there is uncertainty in the modelled representation of the gauge location and the detail surrounding the model build in this area. Given the uncertainty in the model build at High Bridge and the location of the rain gauge from Withy Brook catchment, the 2021 hydrology study concluded it was not justified to calibrate the ReFH2 hydrological model using data from this gauge.

A further check was made in the 2021 hydrology study which used the modelled flood levels during the QMED event with the LMED water level derived from the level data at High Bridge Gauge. Critically, the model produced a level that was 32mm higher than that recorded at the gauge. This suggested the model properly reproduced peak water levels during the flood event using default ReFH2 parameters. The default ReFH2 parameters were retained for the 2021 hydrology study.

Recalibrating the ReFH DDF model with the FEH22 rainfall has generally resulted in a slight decrease in peak flow compared to using the ReFH FEH13 DDF model (2021 hydrology study). No further data has been made available for calibration since the 2021 hydrology study. It was assumed that calibration of the hydrological model in this study would draw the same conclusions as those from the 2021 hydrology study. Therefore, no calibration was undertaken.

5.4 Model inputs for design events

Item	Comments				
Storm duration testing:	Storm duration testing was undertaken during the 2021 hydrology study. The hydraulic model was tested for the 9, 17, 22 and 30 hour durations. The flood extents were almost identical for all durations. The 17 hour event was found to cause the greatest flood depths on the River Sowe on the west side of Walsgrave junction and the 22-hour event caused the greatest flood depths on the Smite Brook on the east side of the junction. The scheme is extended more to the east than the west of the junction and so a 22 hour duration was used for modelling.				
	The 17 and 22 hour storm durations were compared within this study. The 22 hour duration gave the highest flood depths along the Smite Brook in the area of the Walsgrave Junction. The 17 hour duration generally gave the highest flood depths on the River Sowe and Withy Brook. Flood levels upstream of the A46 culvert directly inform the Scheme design. As such, the 22 hour storm duration was selected for this study. This can be seen in Figure 7.1 of the Appendix.				
Seasonality:	Winter hydrograph profiles should be used for rural catchments and summer profiles used for urban (URBEXT2000>0.3 or >0.15 with BFIHOST19>0.65). It is not recommended to use different storm profiles within the same event. The model was run with the 1% AEP for both summer and winter storm profiles. The results showed the summer event produced the greatest event of flooding (Appendix- Figure 7.2). A summer storm profile was used in this study.				

The design ReFH model parameters are given below:

Site code(s)	Rainfall DDF model	Season of design event	Storm duration	Tp (hours) Time to Peak	Cmax (mm) Maximum storage capacity	BL (hours) Base flow lag
Sowe US	FEH22	Summer	22 hours 15 minutes	9.74	440	59.0
Sowe DS	FEH22	Summer	22 hours 15 minutes	5.77	724	57.6
Withy US	FEH22	Summer	22 hours 15 minutes	5.75	287	39.0
Withy DS	FEH22	Summer	22 hours 15 minutes	6.49	332	42.4
Smite	FEH22	Summer	22 hours 15	9.89	382	55.8

Trib 1	FEH22	Summer	minutes 22 hours 15 minutes	4.57	396	39.6
Trib 2	FEH22	Summer	22 hours 15 minutes	3.86	396	36.8

Final choice of ReFH2 flow estimates

The final urbanised peak flows from the ReFH method are given below.

Site code	Flood peak (m³/s) for the following return periods (in years)								
	2	5	10	20	30	50	100	200	1000
Sowe US	8.58	11.2	13.1	15.3	16.6	18.6	21.9	26.1	38.1
Sowe DS	2.61	3.43	4.02	4.66	5.07	5.65	6.62	7.82	11.3
Withy US	4.86	6.45	7.59	8.82	9.61	10.7	12.6	15.1	22.5
Withy DS	2.5	3.31	3.9	4.53	4.95	5.54	6.52	7.80	11.6
Smite	5.62	7.44	8.75	10.1	11.0	12.3	14.4	17.2	25.5
Trib 1	1.15	1.53	1.81	2.12	2.33	2.61	3.11	3.74	5.57
Trib 2	0.5	0.66	0.78	0.92	1.01	1.14	1.36	1.63	2.41

Flood peak in m³/s for the return periods in years or AEP (%) events.

A comparison of the final ReFH 1% AEP peak flows between the 2021 hydrology study and this study are given below.

Site code	Flood peak (m³/s) for the following return periods (in years)					
	100-year return	2021 hydrology study 100-year return				
Sowe US	21.9	24.5				
Sowe DS	6.62	7.52				
Withy US	12.6	14.5				
Withy DS	6.52	7.57				
Smite	14.4	16.9				
Trib 1	3.11	3.91				
Trib 2	1.36	1.77				

Peak flows for the 100-year return periods were consistently lower for this study compared to the 2021 hydrology study. The discrepancy between the sets of results is due to the DDF model being recalibrated to an additional ten years of rainfall data from 2013 to 2022.

6 Discussion and summary of results

6.1 Comparison of results from different methods

Item	Comments
Comparison of results	A comparison of the 100-year peak flows for all catchments are given below. The results from the 2021 hydrology study have also been provided for comparison.
from different methods:	The flood peak values from the Statistical Method results indicate an increase in peak flow for the Sowe US catchment compared to the previous 2021 hydrology study. However, changes in the calculation of QMED, which, as of WINFAP v5, uses BFIHOST19 instead of BFIHOST in WINFAP v4, create a disparity between the QMED values of the Sowe US from this report and the previous 2021 hydrology study. The Statistical Method results show similar peak flows to the 2021 hydrology study for the other catchments.
	The ReFH2 flood peak values generally show a decrease from the previous 2021 hydrology study for all catchments. This highlights the change between the use of FEH13 (previous study) and FEH22 (this study).
	The ReFH2 results show higher flood peak values than the Statistical Method values for all catchments except the Sowe US.

Site code:	2023 WINFAP 100- year return	2023 ReFH 100- year	Ratio of 2023 1% ReFH2 to FEH stat	2021 WINFAP 100 year return	2021 ReFH 100 year return
Sowe US	23.4	21.9	0.94	21.2	24.5
Sowe DS	5.31	6.62	1.25	5.42	7.52
Withy US	10.0	12.6	1.26	10.2	14.5
Withy DS	5.83	6.52	1.12	5.73	7.57
Smite	13.2	14.4	1.09	13.5	16.9
Trib 1	2.60	3.11	1.20	2.63	3.91
Trib 2	1.13	1.36	1.20	1.34	1.77

Site code:	2023 WINFAP 1000 year return	2023 ReFH 1000 year return	Ratio of 2023 0.5% ReFH2 to FEH stat	2021 WINFAP 1000 year return	2021 ReFH 1000 year return
Sowe US	38.9	38.1	0.980	31.5	41.4
Sowe DS	9.26	11.3	1.22	8.05	12.3
Withy US	/ 16.0 22.5		1.40	16.0	24.9
Withy DS	9.15 11.6		1.27	8.51	12.9
Smite	e 20.7 25.5		1.23	21.2	28.7
Trib 1	4.08	5.57	1.37	4.11	6.41
Trib 2	1.76	2.41	1.37	2.10	2.85

6.2 Final choice of method

Item	Comments
Choice of method and reasons:	Flows will be calculated using the ReFH2 method. This method ensures that peak flood flows are not underestimated for the catchment. Calibration using observed data from high Bridge gauge showed the model performed as expected in terms of timing and response of the modelled hydrograph at the gauge location.
How will the flows be applied to a hydraulic model?	 The model inflows will be applied to the hydraulic model at the same locations as in the 2021 hydrology study. The locations and type of inflow are given below: SoweUS: direct inflow applied at the upstream end of the modelled reach of the River Sowe SoweDS: applied as a lateral across all model nodes on the River Sowe WithyUS: direct inflow applied at the upstream end of the modelled reach of Withy Brook WithyDS: applied as a lateral across all model nodes on Withy Brook Smite: direct inflow applied to the reservoir unit used to represent Coombe Pool Trib1: direct inflow applied at the upstream end of the modelled reach of Tributary 1 Trib2: direct inflow applied at the upstream end of the modelled reach of Tributary 2

6.3 Final results

The final peak flows are given below.

Site code		Flood peak (m³/s) for the following return periods (in years)							
	2	5	10	20	30	50	100	200	1000
Sowe US	8.58	11.2	13.1	15.3	16.6	18.6	21.9	26.1	38.1
Sowe DS	2.61	3.43	4.02	4.66	5.07	5.65	6.62	7.82	11.3
Withy US	4.86	6.45	7.59	8.82	9.61	10.7	12.6	15.1	22.5
Withy DS	2.5	3.31	3.9	4.53	4.95	5.54	6.52	7.80	11.6
Smite	5.62	7.44	8.75	10.1	11.0	12.3	14.4	17.2	25.5
Trib 1	1.15	1.53	1.81	2.12	2.33	2.61	3.11	3.74	5.57
Trib 2	0.5	0.66	0.78	0.92	1.01	1.14	1.36	1.63	2.41

Flood peak in m^3/s for the return periods in years or AEP (%) events.

Site code(s)	Season of design event	Storm duration (hrs)	Storm area for ARF (km2)	Return period(s)
Sowe US	Summer	22 hours 15 minutes	51.8 km ²	2, 5, 10, 20, 30, 50, 100, 200,1000
Sowe DS	Summer	22 hours 15 minutes	12.7 km ²	2, 5, 10, 20, 30, 50, 100, 200,1000
Withy US	Summer	22 hours 15 minutes	15.54 km ²	2, 5, 10, 20, 30, 50, 100, 200,1000
Withy DS	Summer	22 hours 15 minutes	9.93 km ²	2, 5, 10, 20, 30, 50, 100, 200,1000
Smite	Summer	22 hours 15 minutes	34.90 km ²	2, 5, 10, 20, 30, 50, 100, 200,1000
Trib 1	Summer	22 hours 15 minutes	4.76 km ²	2, 5, 10, 20, 30, 50, 100, 200,1000
Trib 2	Summer	22 hours 15 minutes	1.78 km ²	2, 5, 10, 20, 30, 50, 100, 200,1000

Item	Comments
Climate change allowances:	Climate changes allowances ¹² were made for the 1% AEP event. The allowances use the UKCP19 projections for peak river flows based on management catchment. The development is located in the Avon Warwickshire Management Catchment. The relevant percentile for the development is 'Higher Central' and the epoch is '2080s'. This equated to a climate change uplift of 32% for peak river flows and flood compensation calculations.

6.4 Checks

Item	Comments
Growth factor checks:	The ReFH2 1% AEP growth factors are within the typical range of 2.1 - 4.0. The ReFH2 0.1% AEP over 1% AEP growth factors are within a typical range of 1.7-1.8.

Site code	1% AEP growth factor	0.1% AEP / 1% AEP ratio
Sowe US	2.55	1.74
Sowe DS	2.54	1.71
Withy US	2.60	1.78
Withy DS	2.61	1.78
Smite	2.57	1.77
Trib 1	2.70	1.79
Trib 2	2.72	1.77

 $^{^{12}\} https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances$

Item	Comments
Spatial consistency of results:	The increase in peak flows are consistent with the increase in sub- catchment area and downstream location on the watercourse.
Return periods for notable historic floods:	No return period analysis was carried out for this study.
Comparisons with previous studies:	Results have been compared with the 2021 hydrology study throughout this report.

6.5 Assumptions, limitations, and uncertainty

Item	Comments
Assumptions (specific to this study):	It is assumed the gauged flow data 8.2km downstream of the catchment site along the same watercourse is representative of the flow found within the catchment site. It is also assumed that the catchment descriptors provided for the study area are an accurate representation of the catchment characteristics. It is also assumed the treatment of urban areas within the ReFH2 calculations are appropriate.
Limitations:	The main limitation is reliable and accurate data for calibration. Further information surrounding the High Bridge gauge would be required before it can reliably be used for calibration. A further limitation is the lack of gauged data surrounding the subject area.
	The use of a single storm duration may over-estimate hydrograph volumes for watercourses where the recommended critical duration is significantly shorter, resulting in a conservative estimate of flood extents and/or depths within some modelled reaches.
Uncertainty:	Uncertainty cannot be quantified for highly urbanised catchments in the ReFH2 method. However, modelled flood extents were compared with the observed flood extents during the 2021 hydrology study and shown to be similar. Furthermore, the shape and timing of default ReFH2 inflow hydrographs compared well with observed data for the SoweUS and Withy Brook catchments. Considering the negligible change in peak flows between the assessments, this gives good confidence in the results.

Item	Comments
Suitability of results for future studies:	The design peak flow estimates and hydrographs have been derived for the purposes of the modelling study only. If peak flow estimates and/or hydrographs are required for the different purposes, then a review of the results are required.
Recommendations for future work:	Uncertainties in the results could be reduced with flow data along the Smite Brook, in the area of the Walsgrave Junction.

7 Appendix

7.1 Digital files

ltem	Comments
Digital files:	
 If you are submitting work commissioned by the Environment Agency or for review by the Environment Agency, you should be prepared to submit as digital files your input data, output data and project files (where these exist) from the software you have used in the flood estimation. Refer to Section 8.5 of the Flood Estimation Guidelines. Use this section to list the files you are submitting, if relevant. 	WINFAP v5 Projects ReFH2.4 Projects A46_Walsgrave_Junction_Calculation_Sheet

Initial pooling group composition – Eastern Catchments

Pool site code:	Name:	Distance	Years of data	QMED AM	L-CV	L-SKEW	Comment:
36011	Stour Brook @ Sturmer	0.490	52.0	6.77	0.290	0.180	Retained – rating reviewed and no reason to discard
39086	Gatwick Stream @ Gatwick Link	0.491	47.0	9.75	0.149	0.00	Removed - Outlier on L-moments plot and flat growth curve
38020	Cobbins Brook @: Sewardstone Road	0.500	51.0	7.47	0.328	0.329	Removed – due to flat growth curve
19017	Gogar Burn @ Turnhouse	0.550	30.0	12.8	0.190	0.220	Retained – rating reviewed and no reason to discard
33054	Babingley @ Castle Rising	0.553	46.0	1.13	0.229	0.189	Removed – highly permeable catchment (BFIHOST = 0.895)
30006	Slea @ Leasingham Mill	0.583	37.0	1.84	0.307	0.205	Removed – highly permeable catchment (BFIHOST = 0.786)
30013	Heighington @ Heighington Beck	0.615	46.0	0.648	0.363	0.438	Removed - Significant growth curve outlier
26013	Driffield Trout Stream @ Driffield	0.646	12.0	2.78	0.274	0.237	Removed – highly permeable catchment (BFIHOST = 0.837), outlier on L-moments plot and extremely short record length
36004	Chad Brook @ Long Melford	0.680	55.0	4.81	0.300	0.180	Retained – rating reviewed and no reason to discard
36010	Bumpstead Brook @ Broad Green	0.720	55.0	7.59	0.350	0.110	Retained – rating reviewed and no reason to discard
27081	Oulten Beck @ Oulton Farrer Lane	0.730	36.0	2.55	0.250	0.240	Retained – rating reviewed and no reason to discard

Final pooling group composition – Eastern Catchments

Pool site code:	Name:	Distance	Years of data	QMED AM	L-CV	L-SKEW	Comment:
36011	Stour Brook @ Sturmer	0.490	52.0	6.77	0.290	0.180	Retained – rating reviewed and no reason to discard
19017	Gogar Burn @ Turnhouse	0.550	30.0	12.8	0.190	0.220	Retained – rating reviewed and no reason to discard
36004	Chad Brook @ Long Melford	0.680	55.0	4.81	0.300	0.180	Retained – rating reviewed and no reason to discard
36010	Bumpstead Brook @ Broad Green	0.720	55.0	7.59	0.350	0.110	Retained – rating reviewed and no reason to discard
27081	Oulten Beck @ Oulton Farrer Lane	0.730	36.0	2.55	0.250	0.240	Retained – rating reviewed and no reason to discard
36003	Box @ Polstead	0.760	62.0	3.88	0.310	0.0800	Added to increase record length
36007	Belchamp Brook @ Bardfield Bridge	0.820	57.0	4.63	0.380	0.110	Added to increase record length
23017	Team @ Team Valley	0.900	43.0	12.1	0.230	0.200	Added to increase record length
37016	Pant @ Copford Hall	0.940	57.0	7.47	0.290	0.110	Added to increase record length
34005	Tud @ Costessey Park	1.24	60.0	3.13	0.290	0.240	Added to increase record length

Initial pooling group composition – Western Catchments

Pool site code:	Name:	Distance	Years of data	QMED AM	L-CV	L-SKEW	Comment:
33032	Heacham @ Heacham	0.137	54.0	0.442	0.296	0.134	Removed – highly permeable catchment (BFIHOST = 0.932)
26003	Foston Beck @ Foston Mill	0.209	61.0	1.76	0.248	-0.00400	Removed – highly permeable catchment (BFIHOST = 0.894)
26013	Driffield Trout Stream @ Driffield	0.211	12.0	2.78	0.274	0.237	Removed – highly permeable catchment (BFIHOST = 0.837), and extremely short
30006	Slea @ Leasingham Mill	0.260	37.0	1.84	0.307	0.205	Removed – highly permeable catchment (BFIHOST = 0.786)
33054	Babingley @ Castle Rising	0.320	46.0	1.13	0.229	0.189	Removed – highly permeable catchment (BFIHOST = 0.895)
33050	Snail @ Fordham	0.334	48.0	1.41	0.240	0.0590	Removed – highly permeable catchment (BFIHOST = 0.792)
36003	Box @ Polstead	0.390	62.0	3.88	0.310	0.0800	Retained – rating reviewed and no reason to discard
37009	Brain @ Guithavon Valley	0.467	60.0	3.90	0.374	0.357	Removed -
19017	Gogar Burn @ Turnhouse	0.480	30.0	12.8	0.190	0.220	Retained – rating reviewed and no reason to discard
36007	Belchamp Brook @ Bardfield Bridge	0.510	57.0	4.63	0.380	0.110	Retained – rating reviewed and no reason to discard
23017	Team @ Team Valley	0.560	43.0	12.1	0.230	0.200	Retained – rating reviewed and no reason to discard

Final pooling group composition – Western Catchment

Pool site code:	Name:	Distance	Years of data	QMED AM	L-CV	L-SKEW	Comment:
36003	Box @ Polstead	0.390	62.0	3.88	0.310	0.0800	Retained – rating reviewed and no reason to discard
19017	Gogar Burn @ Turnhouse	0.480	30.0	12.8	0.190	0.220	Retained – rating reviewed and no reason to discard
36007	Belchamp Brook @ Bardfield Bridge	0.510	57.0	4.63	0.380	0.110	Retained – rating reviewed and no reason to discard
23017	Team @ Team Valley	0.560	43.0	12.1	0.230	0.200	Retained – rating reviewed and no reason to discard
36004	Chad Brook @ Long Melford	0.570	55.0	4.81	0.300	0.180	Added to increase record length
37016	Pant @ Copford Hall	0.590	57.0	7.47	0.290	0.110	Added to increase record length
53029	Biss @ Trowbridge	0.630	39.0	12.1	0.230	0.280	Added to increase record length
34005	Tud @ Costessey Park	0.700	60.0	3.13	0.290	0.240	Added to increase record length
41022	Lod @ Halfway Bridge	0.770	52.0	16.3	0.290	0.180	Added to increase record length
36011	Stour Brook @ Sturmer	0.850	52.0	6.77	0.290	0.180	Added to increase record length

Critical Duration Flood Extents

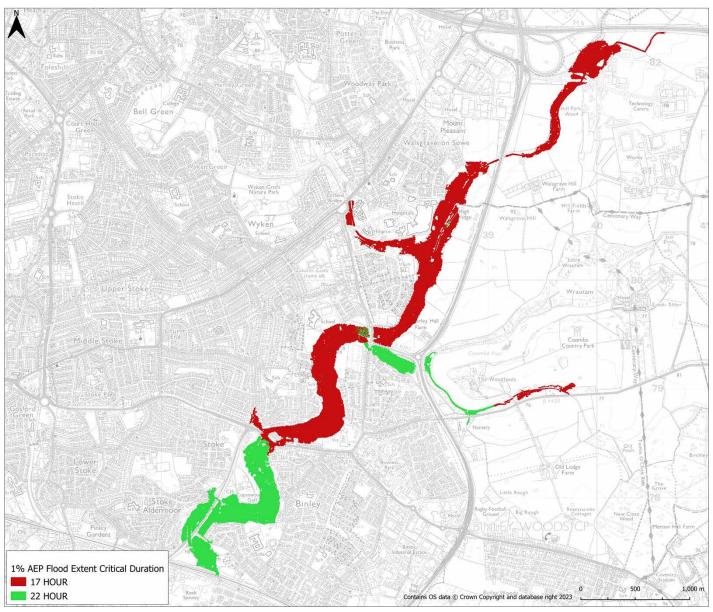


Figure 7.1: 1% AEP critical duration analysis - Duration that gives the highest flood level per 2D cell

Seasonality Flood Extents

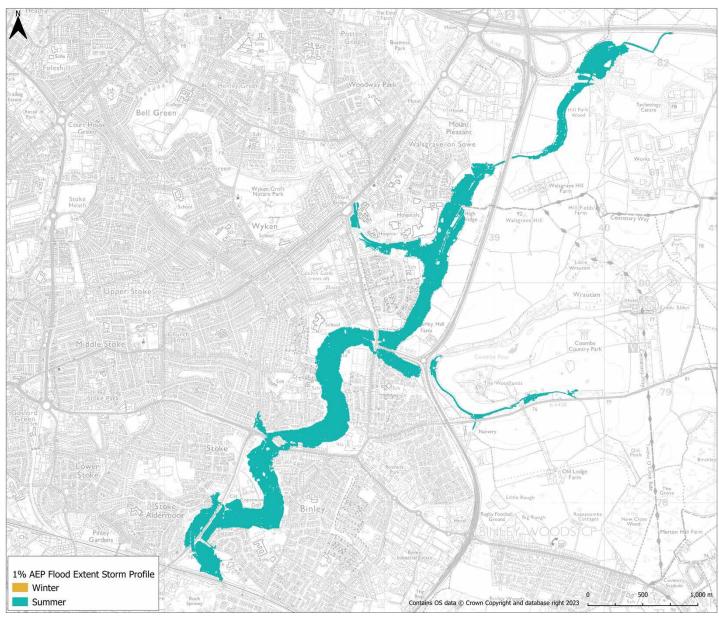


Figure 7.2: 1% AEP seasonality analysis- Season that gives the highest flood level per 2D cell

ReFH2 inflow hydrographs

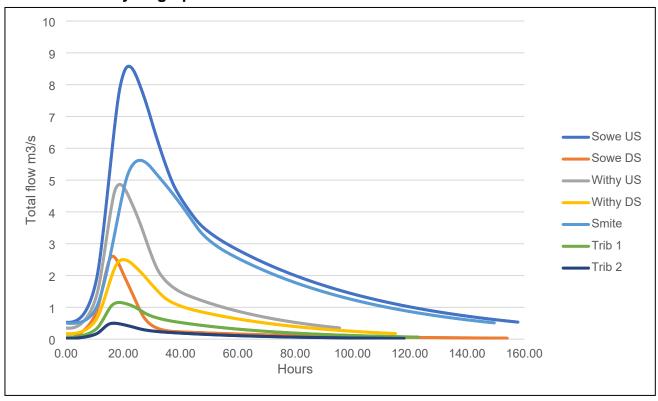


Figure 7.3: Hydraulic model inflow hydrographs of all catchments for the 2-year event

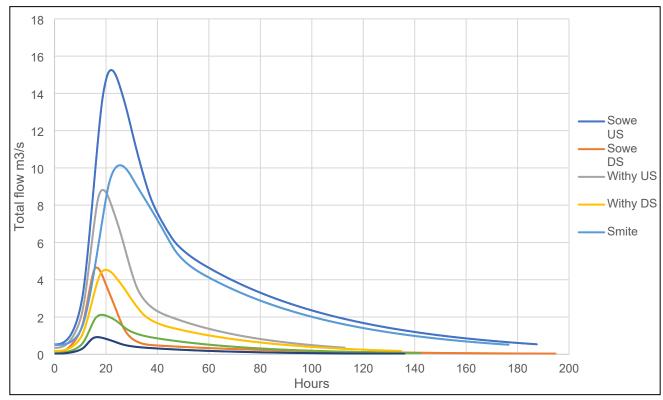


Figure 7.4: Hydraulic model inflow hydrographs of all catchments for the 20-year event

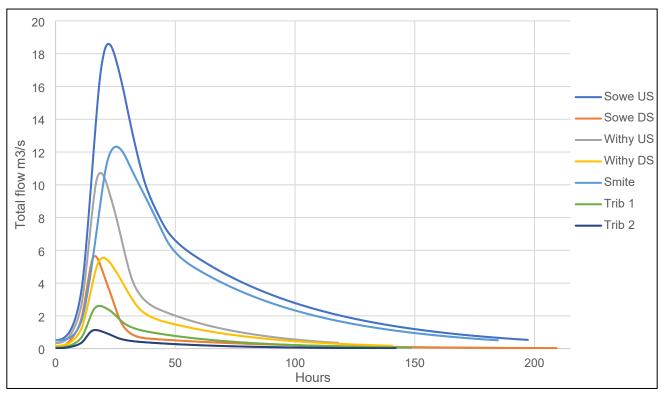


Figure 7.5: Hydraulic model inflow hydrographs of all catchments for the 50-year event

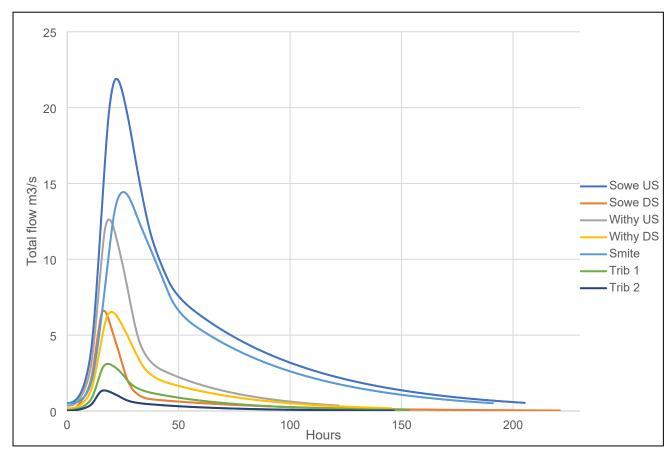


Figure 7.6: Hydraulic model inflow hydrographs of all catchments for the 100-year event

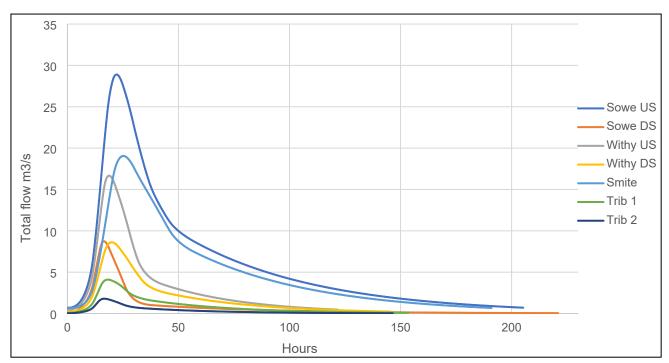


Figure 7.7: Hydraulic model inflow hydrographs of all catchments for the 100-year +CC event

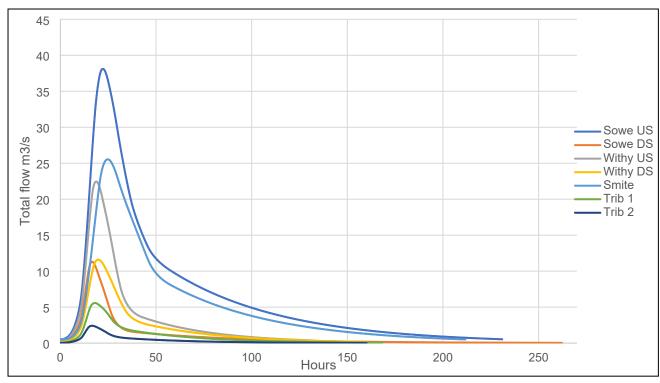


Figure 7.8: Hydraulic model inflow hydrographs of all catchments for the 1000-year event



Annex C. Environment Agency Approval Letter



Our ref: XA/2024/100155/02-L01 Your ref: TR010066-000003

Date: 18 October 2024

Dear Sir,

PRE-APPLICATION- A46 COVENTRY JUNCTION UPGRADE (WALSGRAVE) FLOOD RISK ASSESSMENT - ENVPAC/1/NIT/00010

Further to our meeting dated: 09 October 2024 and the updated information.

The applicant has confirmed that there will be no earthwork volume gain within the design flood extent. On this basis, we do not require Flood plain compensation work to be undertaken.

We have reviewed the submitted hydraulic flood model. We have found that this model is an acceptable representation of flood risk.

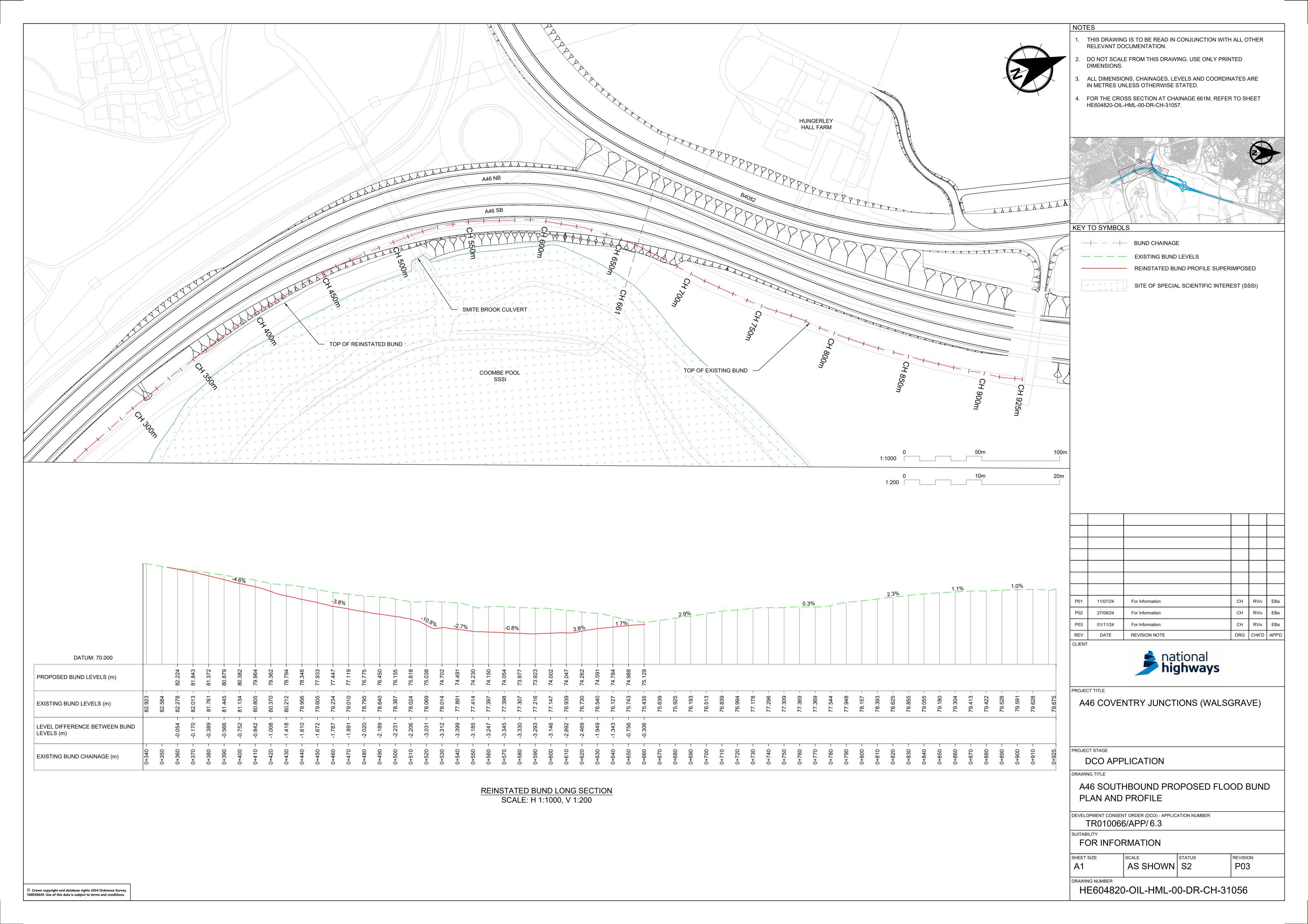
A Flood Risk Activity Permit is required for any activities conducted on the floodplain of a main river if planning permission is not in place. In the context of Flood Risk Activity Permitting, a Nationally Significant Infrastructure Project (NSIP) does not meet the definition of planning permission. Consequently, a Flood Risk Activity Permit is necessary for activities within the 1% Annual Exceedance Probability (AEP) flood extent.

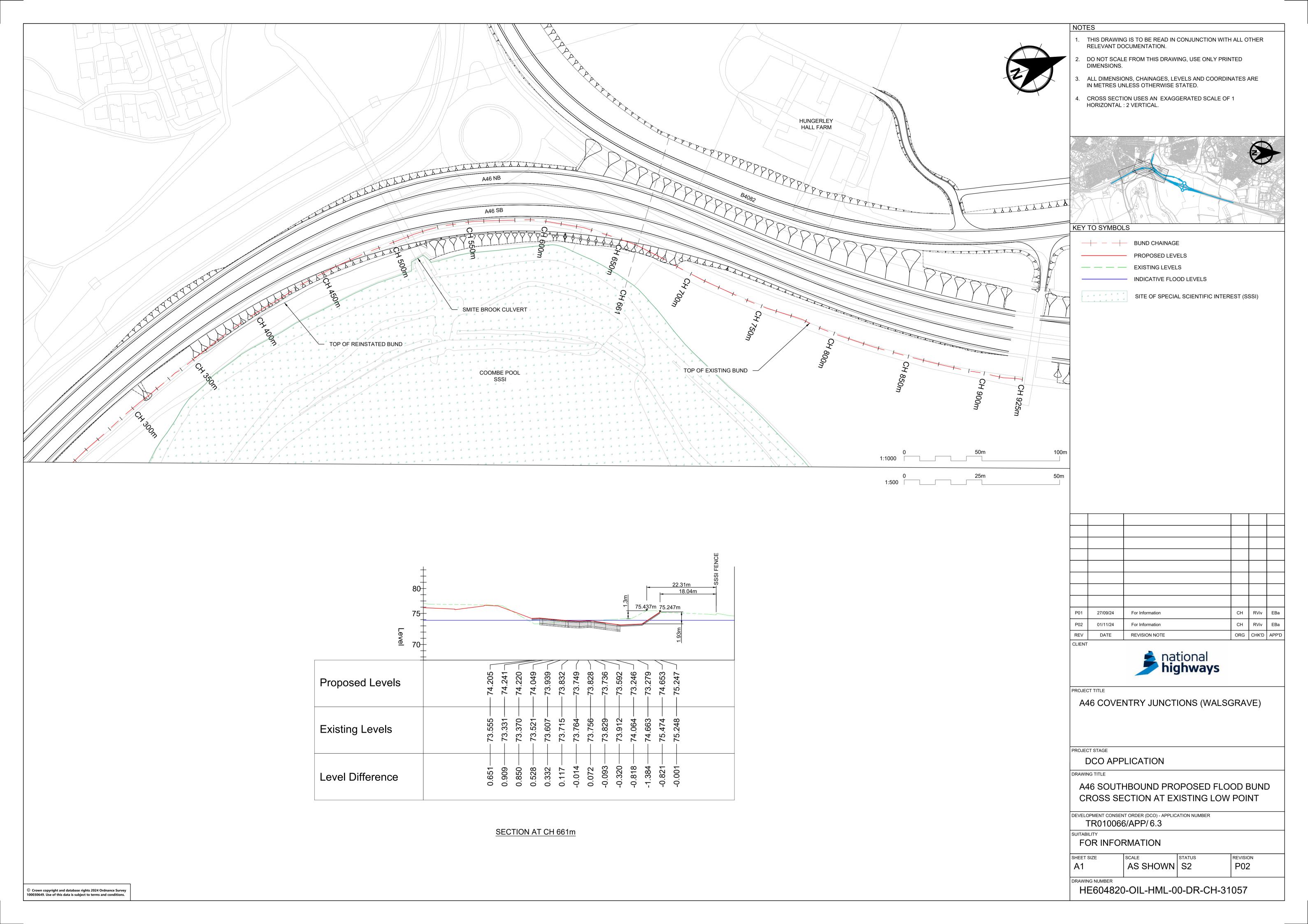
Yours sincerely





Annex D. A46 Southbound Embankment Flood Bund Drawing







Annex E. Environment Agency Coombe Pool Reservoir Correspondence

From: Enquiries_Westmids < Enquiries_Westmids@environment-agency.gov.uk > Sent: 10 April 2024 13:10

Sent: 10 April 2024 13: **To:**

Subject: 351878 - Reservoir inundation model for Coombe Pool, Coventry.

Enquiry regarding reservoir inundation model for Coombe Pool, Coventry.

Thank you for your enquiry which was received on 13 March, request for a copy of the reservoir inundation model for Coombe Pool, Coventry.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

Please refer to Open Government Licence which explains the permitted use of this information.

National Reservoir Safety - information withheld.

We are unable to provide the requested information as it is classed as Official Sensitive. We have on occasion released similar information to emergency responders under the Civil Contingencies Act. We are withholding the information as we consider that release would adversely affect National Security and Public Safety. Information contained within the inundation model has been withheld on the basis that disclosure of this information to the world at large would endanger national security and public safety. This is because this information can be used as the basis for a terrorist attack, which would put the public in danger. The EIR provides public authorities with exceptions to the duty to disclose environmental information and we consider EIR Regulation 12(5)(a) to apply to the withheld information.

You say that you are working on behalf of National Highways who are a Category 2 Emergency Responder. There is information available to Emergency Responders via Resilience Direct such as GIS data that maybe of use to them. This information is classed as official sensitive.

As a public body under FOI/EIR, we must provide reasons for this refusal. We also share how we have considered the Public Interest for refusal and disclosure. You can find details in the appendix.

If you are not satisfied you can contact us within 2 calendar months to ask for our decision to be reviewed. We shall review our response to your request and give you our decision in writing within 40 working days.

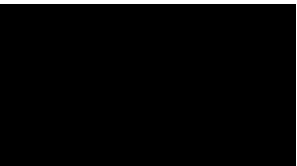
Information Commissioner Office

If you are not satisfied following this, you can then make an appeal to the Information Commissioner Office (ICO), the statutory regulator for EIR/FOI. The address is: ICO, Wycliffe House, Water Lane, Wilmslow, Cheshire. SK9 5AF. Tel: 0303 123 1113 (local rate) or 01625 545

745 (national rate) | Fax: 01625 524 510 | Email: casework@ico.org.uk | Website: http://www.ico.org.uk

Please send your replies to: Enquiries westmids@environment-agency.gov.uk

Kind Regards



Enquiries Westmids@environment-agency.gov.uk

Environment Agency, 9 Wellington Crescent, Fradley Park, Lichfield, Staffordshire, WS13 8RR

From:

Sent: Wednesday, March 13, 2024 11:20 AM

To: Enquiries, Unit < enquiries@environment-agency.gov.uk >

Cc:

Subject: 240314/OC02 Reservoir inundation model for Coombe Pool Coventry

Hello,

I would like to request a copy of the reservoir inundation model for Coombe Pool, Coventry please. As we are currently undertaking a flood risk assessment on behalf of National Highways for the upgrade of the A47 which is immediately downstream of Coombe Pool (NGR 438556, 279211). As part of this Coventry City Council (CCC) have raised a few questions relating to the approach of the modelling and associated mapping. We are aware that the Environment Agency have released this model to JBA to undertake refined modelling on behalf of CCC, however, we require our own version of the model to confirm assumptions and approaches.

Regards

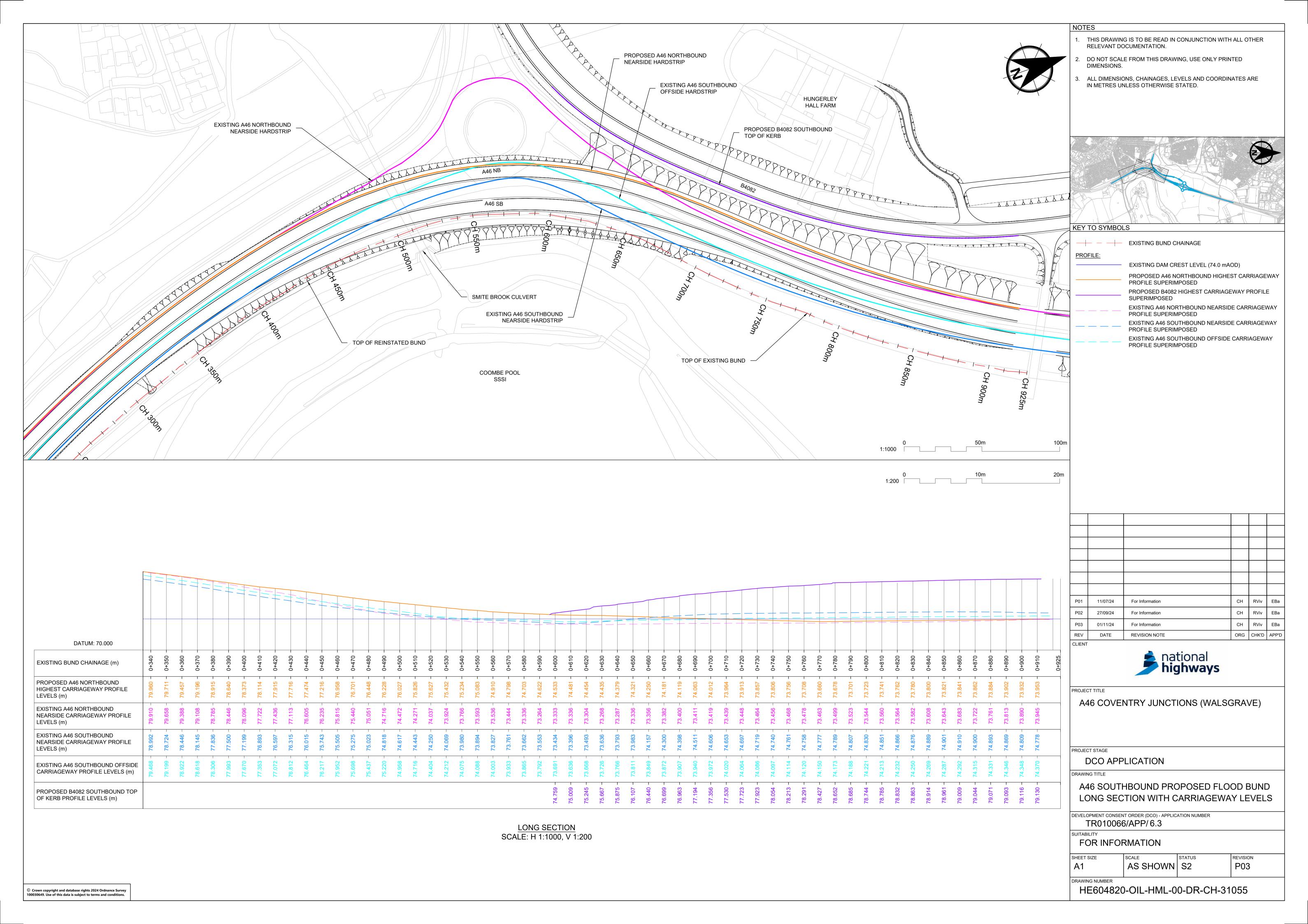


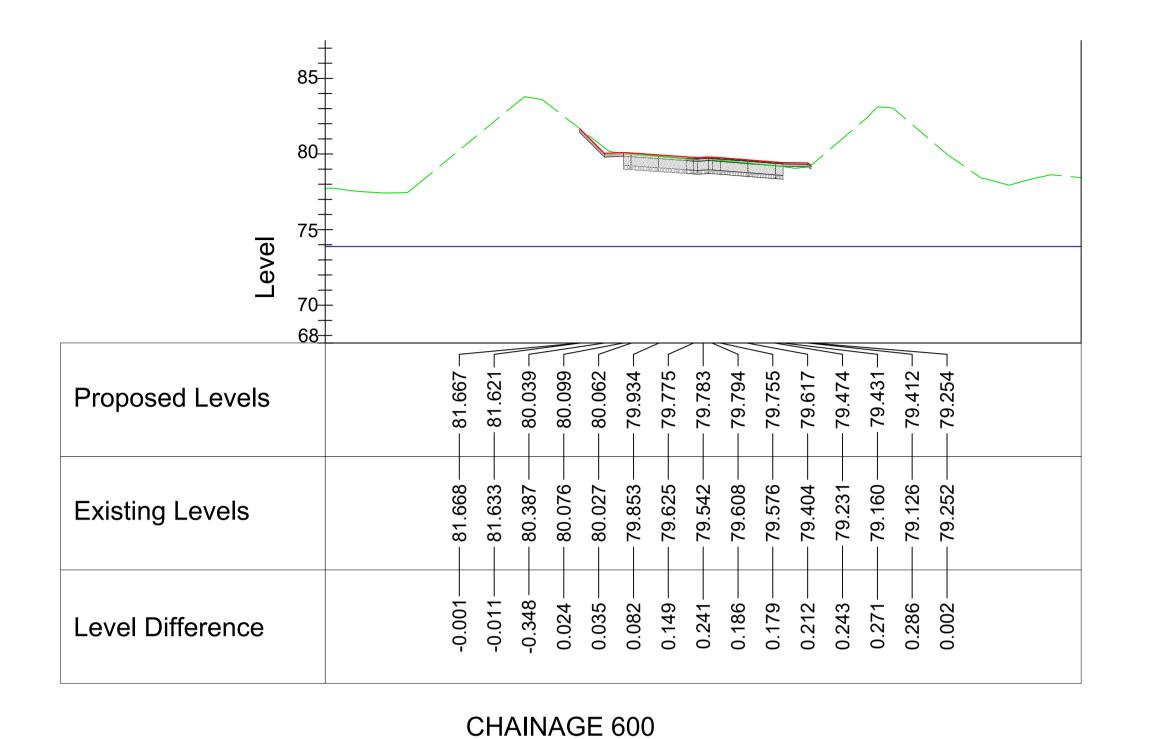
Information in this message may be confidential and may be legally privileged. If you have received this message by mistake, please notify the sender immediately, delete it and do not copy it to anyone else. We have checked this email and its attachments for viruses. But you should still check any attachment before opening it. We may have to

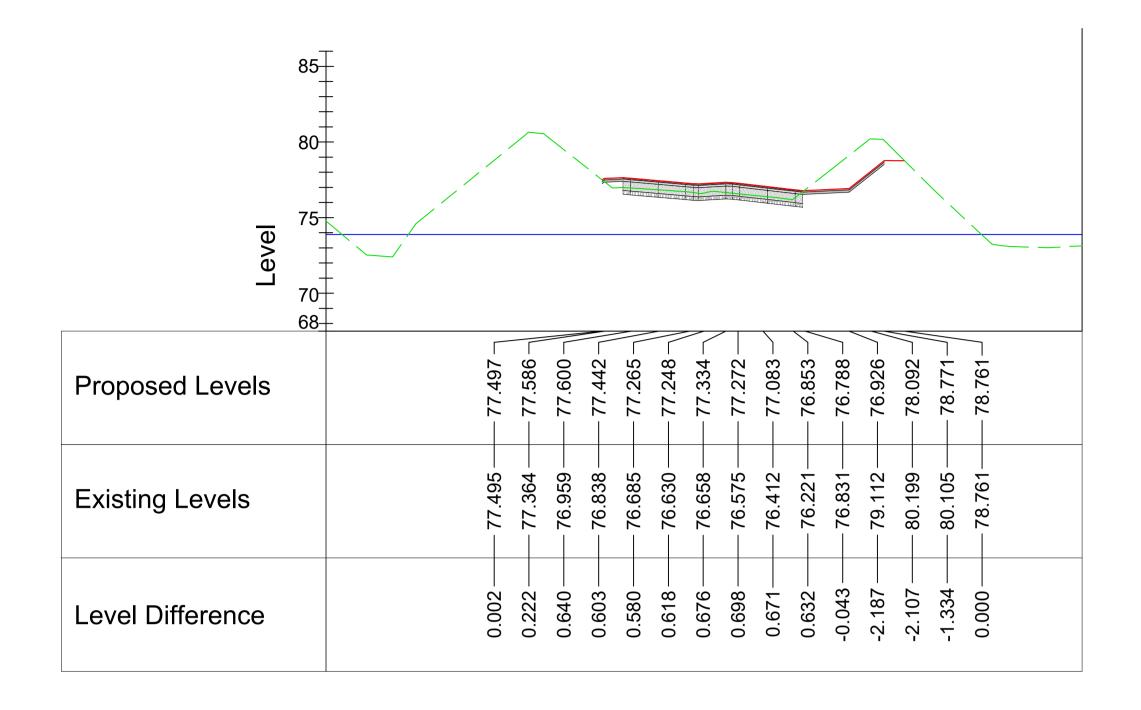
make this message and any reply to it public if asked to under the Freedom of Information Act, Data Protection Act or for litigation. Email messages and attachments sent to or from any Environment Agency address may also be accessed by someone other than the sender or recipient, for business purposes.



Annex F. A46 Southbound Highway Drawing

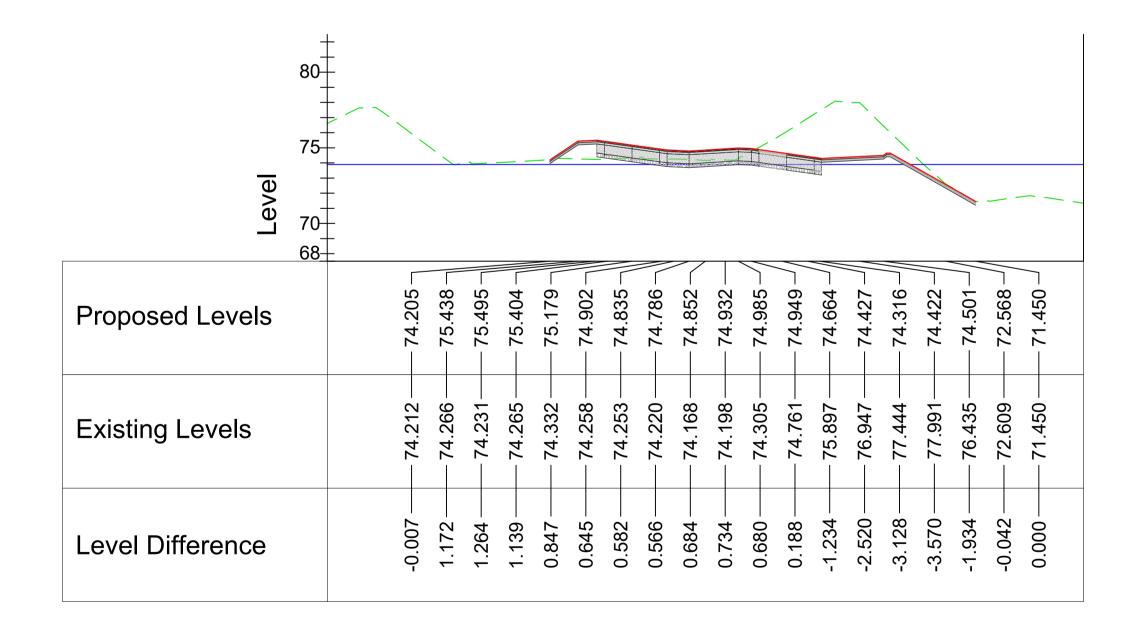




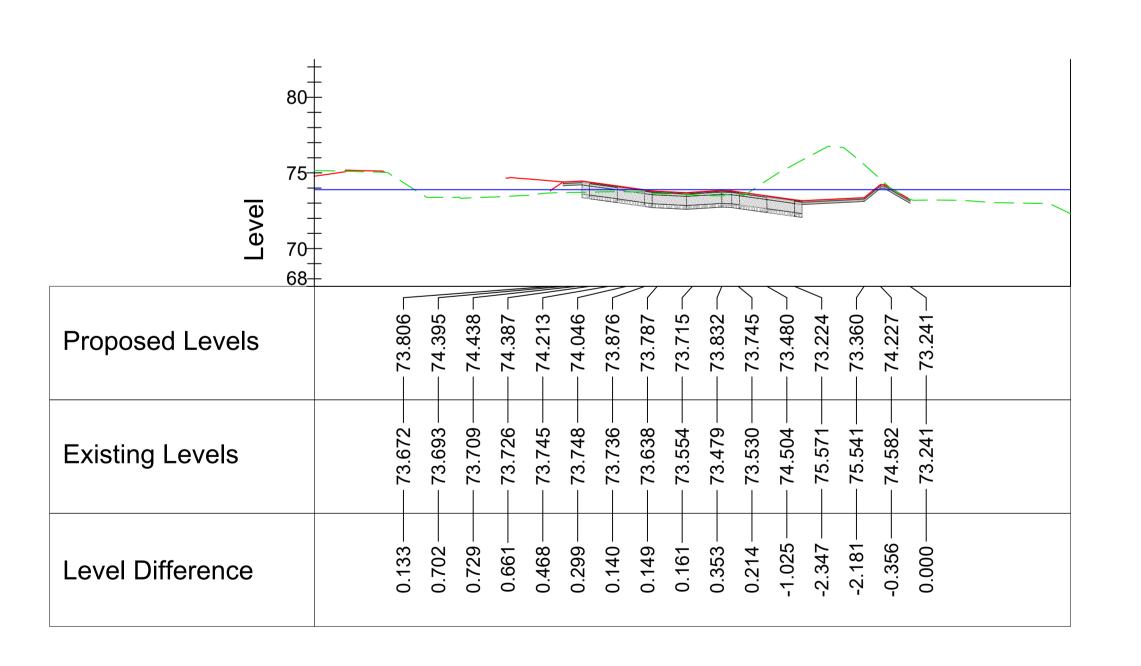


CHAINAGE 700





CHAINAGE 800



CHAINAGE 900

NOTES THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DOCUMENTATION. 2. DO NOT SCALE FROM THIS DRAWING, USE ONLY PRINTED DIMENSIONS. 3. ALL DIMENSIONS, CHAINAGES, LEVELS AND COORDINATES ARE IN METRES UNLESS OTHERWISE STATED. 4. CROSS SECTIONS USE AN EXAGGERATED SCALE OF 1 HORIZONTAL: 2 VERTICAL. KEY TO SYMBOLS PROPOSED LEVELS EXISTING LEVELS DESIGN FLOOD LEVEL + 600MM FREEBOARD

P01	11/07/24	For Information	СН	RViv	EBa
P02	27/09/24	For Information	СН	RViv	EBa
P03	01/11/24	For Information	СН	RViv	EBa
REV	DATE	REVISION NOTE	ORG	CHK'D	APP'D

CLIENT



A46 COVENTRY JUNCTIONS (WALSGRAVE)

PROJECT STAGE

DCO APPLICATION

DRAWING TITLE

A46 SOUTHBOUND FLOOD BUND **CROSS SECTIONS**

DEVELOPMENT CONSENT ORDER (DCO) - APPLICATION NUMBER

TR010066/APP/ 6.3

FOR INFORMATION

S2 P03 1:500 **A**1

HE604820-OIL-HML-00-DR-CH-31060

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Annex G. Part b of the Exception Test



A46 COVENTRY JUNCTIONS (WALSGRAVE)

Document number: HE604820-OIL-EWE-00-RP-LW-30012

Date: 16/12/24

Revision number: 01

Prepared By: RV



1. Introduction

1.1.1. This technical note supports the A46 Coventry Junctions (Walsgrave) Scheme Flood Risk Assessment (FRA). The technical note has been prepared to aid the Planning Inspectorate in their understanding and interpretation of the FRA in response to the Planning Inspectorate letter dated 12 December 2024 reference TR010066, which states:

"Whilst it is noted that the exception test appears to consider the requirements of Flood Zone 3b, the FRA does not provide specific information to differentiate between land within Flood Zones 3a and 3b. It is also unclear from the information presented whether the Proposed Development would result in no net loss of floodplain storage. The Applicant should respond to the Inspectorate as soon as practicable to confirm the location and extent of Flood Zones 3a and 3b and how this corresponds to the application of the exception test and the proposed flood mitigation/ compensation. If components would be located within Flood Zone 3b, the Applicant should provide confirmation that there would be no net loss of floodplain storage, in line with the principles of the exception test."

- 1.1.2. As explained in what follows, Appendix A defines the extent of Flood Zones 3a and 3b and it is confirmed that the Scheme would result in no net loss of floodplain storage in line with the principles of the Exception Test.
- 1.1.3. The Flood Risk and Coastal Change PPG (Table 1) defines:
 - Zone 3a High Probability as land having a 1% or greater annual probability of river flooding; or Land having a 0.5% or greater annual probability of sea. (Land shown in dark blue on the Flood Map)
 - Zone 3b The Functional Floodplain as this zone comprises land where water from rivers or the sea has to flow or be stored in times of flood. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Functional floodplain will normally comprise:
 - land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively; or
 - land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as 0.1% annual probability of flooding).
 - Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map).



- 1.1.4. The Coventry City Council (CCC) SFRA (2022) has used a variety of annual probabilities to map the functional floodplain (1 in 30-year (3.33% AEP), 1 in 50-year (2% AEP) or 1 in 100-year (1% AEP)), depending on Environment Agency model availability. Therefore, the site specific modelling presented in this technical note is considered to be a better representation of Flood Zone 3b for the Scheme extents than that in the SFRA mapping and meets the requirements of the functional floodplain as defined in the CCC SFRA. Additionally, the Scheme is not located in close proximity to an area which is designed to flood.
- 1.1.5. The Scheme specific hydraulic model has been run to define the extents and depths associated with FZ3b which is 3.33% AEP in accordance with Table 1 of the PPG.
- 1.1.6. Subsequent sections of this technical note address each of the key points in turn through providing references and information extracted from the FRA to demonstrate to the Planning Inspectorate, how and where these points are covered.



2. Works in the Floodplain

- 2.1.1. The Scheme Order Limit is a buffer around the existing highway as shown on Figure 4-1 of the FRA. The works proposed within the Order Limit are shown on the Works Plans (ref TR010066/2.3). A comparison of this against the 1 in 100-year plus climate change flood map (Annex A of the FRA) shows that the Scheme, proposes works adjacent to the floodplain in three distinct locations, the Smite Brook culvert (Work No 1K and Work No 3C), drainage attenuation pond access track (Work No 2G) and the pedestrian crossing (Work No 2I).
- 2.1.2. Schedule 1 of the draft Development Consent Order (DCO) describes these works as:
 - Work No. 1K Removal and reinstatement of existing environmental bund situated southeast of the realigned A46 (Work No. 1A), from south of the existing Smite Brook culvert for up to 150 metres in length, as shown on sheet 2 of the works plans.
 - Work No. 2I A new signalised pedestrian crossing situated 20 metres east of the existing Clifford Bridge Road roundabout, as shown on sheet 3 of the Works Plans and the extension of existing footway between points 2/7 and 2/10 and points 2/12 and 2/13, as shown on sheet 3 of the rights of way and access plans.
 - Work No. 2G A new southern detention basin access, 283 metres in length, commencing at a location approximately 140 metres from the existing Clifford Bridge Road roundabout and circulating around Work No. 2E, as shown on sheet 3 of the works plans.
 - Work No. 3C Reinstatement of existing timber fence where required and vegetation removal, as shown on sheet 2 of the works plans.



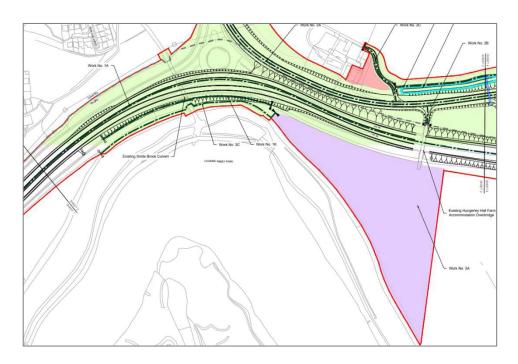


Figure 2-1: Extract of Works Plan Sheet 2





Figure 2-2: Extract of Works Plan Sheet 3

2.2. Work Number 1K

- 2.2.1. The FRA assesses the impacts of this element for the 1 in 100-year plus climate change flood event, which is more onerous than the 1 in 30-year plus climate change event which is used to define the functional floodplain / Flood Zone 3b. An extract from the FRA is shown below:
 - "8.3.17. The flood maps show that the Scheme does not result in changes in flood risk other than to some very limited areas of fluctuation around the upstream face of the A46 southbound embankment. This is due to a minor localised slackening of the embankment within the ground model which has created marginal additional floodplain storage. Slackening of the slope has resulted in increased depths along the embankment and a handful of additional model cells receiving flood waters.
 - 8.3.18 This slackening has occurred as a result of the top layer of the existing southbound embankment being removed and replaced with a layer of clay. This is to prevent seepage and potential undermining of the



proposed highway, during large magnitude flood events. The new top layer of the southbound embankment will be graded to match the existing slope (1 in 2.5) or shallower to ensure that the Scheme does not result in a loss / adverse change to the floodplain. There will be no earthwork volume gain (which would result in a loss of floodplain) between the existing and proposed southbound embankments below the design event plus 600mm freeboard level.

8.3.23. The proposed southbound embankment will be graded to existing slope or shallower and ensures no net gain in material below the design level. Therefore, there is no loss of floodplain and thus flood compensatory storage is not required for the Scheme."

2.3. Work Number 2I

- 2.3.1. This element is for a new signalised pedestrian crossing, this is located outside of the floodplain as shown by the 1 in 100-year plus climate change flood map (Annex A of the FRA). The other aspect is the extension of existing footway between points 2/7 and 2/10 and points 2/12 and 2/13, this is on existing high ground outside of the floodplain (Figure 2-4) and thus will not change the flood regime or result in a loss of floodplain storage.
- 2.3.2. The 1 in 30-year flood level is 71.02mAOD and the highway and the existing associated footpath is at a level of 71.95mAOD as shown in the Environment Agency's LiDAR.

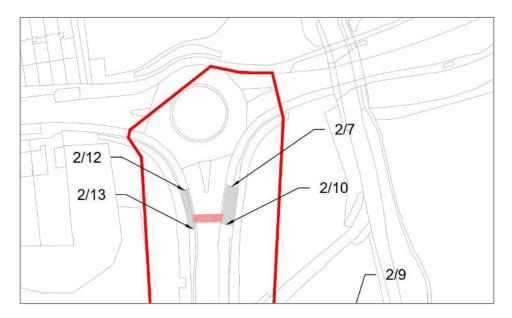


Figure 2-3: Extract of Rights of Way and Access Plans Sheet 3





Figure 2-4: View of the highway embankment (source: Google Street View)

2.4. Work Number 2G

2.4.1. This element is for the proposed B4082 detention basin that attenuates flows from the proposed highway drainage network. The entrance to the detention basin access track lies within the 100-year flood extent; however, will be constructed using gravel fill at existing grade and will not change the flood risk nor result in a loss of floodplain storage.

2.5. Work Number 3C

2.5.1. This element is for the reinstatement of existing timber fence where required and vegetation removal, as shown on sheet 2 of the works plans. As this is for the reinstatement of an existing fence it is considered that this will not impact / change the flood risk nor result in a loss of floodplain storage.



3. Flood Zone 3b

- 3.1.1. Annex A Drawing A-14 of the FRA demonstrates that the Scheme does not have an impact on FZ3a. Therefore, given the magnitude of the FZ3b flood extents, which by their nature are smaller, it can be inferred that there is no impact on FZ3b, as outlined above.
- 3.1.2. The FRA (Annex A) includes flood maps for the 1 in 2-year and 1 in 20-year events, extracts are provided in Figure 3-1 and Figure 3-2. These demonstrate that the flood extents for the 1 in 20-year event waters are within the Order Limits but are not impacted by the Scheme.
- 3.1.3. To demonstrate this position to the Planning Inspectorate an additional set of maps has been produced to show the extents of FZ2, FZ3a and FZ3b overlain with the Scheme General Arrangement, these are shown in Appendix A and an extract within Figure 3-3. This shows that the FZ3b extents are within the Order Limits; however, the Scheme work plans do not contain any works within FZ3b.

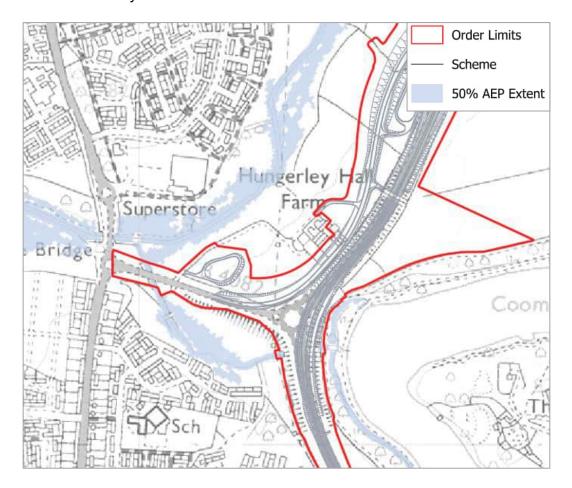


Figure 3-1: Extract of baseline 50% AEP (1 in 2-year) flood map



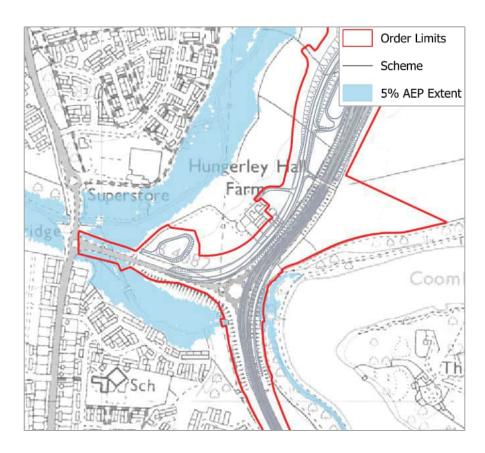


Figure 3-2: Extract of baseline 5% AEP (1 in 20-year flood map)

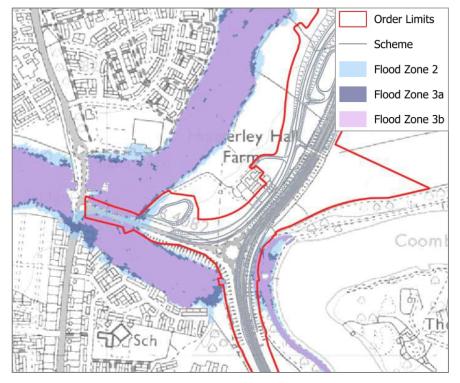


Figure 3-3 - Extract of the Flood Zone Comparison Map

3.1.4. A depth difference map for the 30-year event showing the change in flood depths between the baseline and Scheme results are shown in Appendix A



and Figure 3-4. These show that the Scheme would result in no increases in flood depths for the 30-year event (Flood Zone 3b).

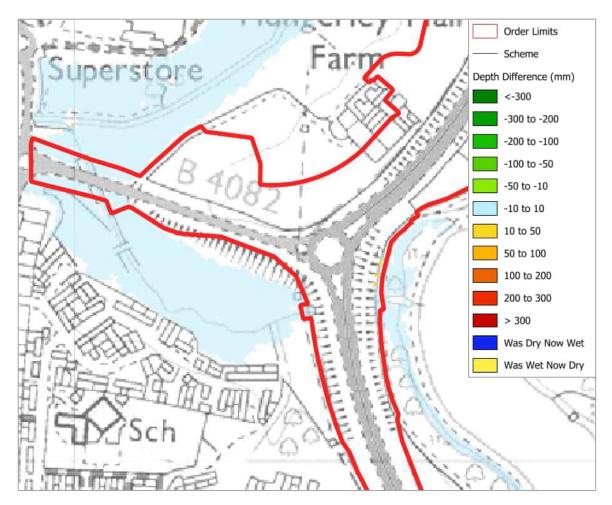


Figure 3-4: Flood Zone 3b depth difference

3.1.5. Figure 3-5 and Figure 3-6 shows a flow comparison for the 30-year event (Flood Zone 3b) between the baseline and Scheme events taken from the cross-sections immediately upstream (SMT1_0534) and downstream (SMT1_0451) of the A46 culvert.



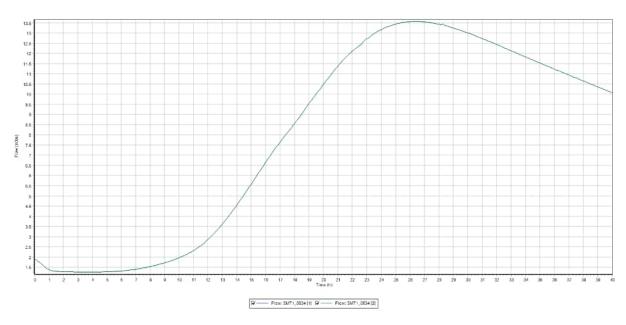


Figure 3-5: 30-year flow comparison for model cross-section SMT1_0534

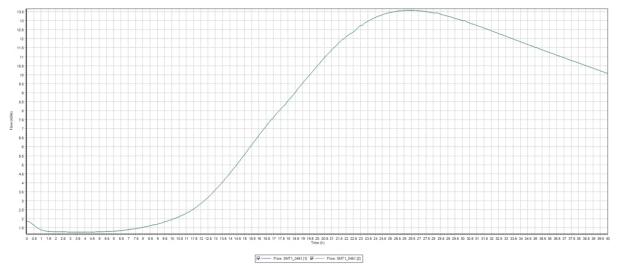


Figure 3-6: 30-year flow comparison for model cross-section SMT1_0451

3.1.6. Considering the above information, the Scheme is predicted to result in no impacts to downstream flows, flood levels or receptors within Flood Zone 3a or Flood Zone 3b. The design is therefore considered acceptable in terms of flood risk and no flood compensation is required.



4. Floodplain Compensation

4.1.1. The Applicant engaged in extensive liaison with the Environment Agency during the preparation of the FRA. This included reviews and approval of the hydraulic model and the FRA which concluded with the Environment Agency providing a formal response confirming that they are satisfied with the FRA and that there is no requirement for the provision of floodplain compensation. This letter is provided in Annex C of the FRA.



5. Exception Test

- 5.1.1. The FRA applies the Exception Test (paragraphs 3.1.4 to 3.1.7). Compliance with the first part are demonstrated in paragraphs 3.1.5 and 3.1.6. It is considered that the FRA (as outlined in paragraph 3.1.7) demonstrates the compliance with the second part. The clarifications and cross-references provided in this technical note demonstrate that the Scheme complies with the requirements for FZ3b of the Exception Test which are that essential infrastructure should be designed and constructed to:
 - remain operational and safe for users in times of flood (the works proposed as part of the Scheme will not result in changes to flood depths within / extents of the floodplain for the 1 in 30-year (FZ3b) or the 1 in 100-year plus climate change (FZ3a) events);
 - result in no net loss of floodplain storage (as agreed with the Environment Agency – Annex C of the FRA, there is no net loss of floodplain storage);
 - not impede water flows and not increase flood risk elsewhere (the Scheme does not change the flow regime – Smite Brook Culvert is unaffected by the proposed works, and there is no loss of floodplain storage).



Appendix A – Flood Zone 3b Maps

